

Technologies and Processes for the Advancement of Materials

Thermal processing

ISSUE FOCUS ///

PYROMETRY / PROCESS CONTROL

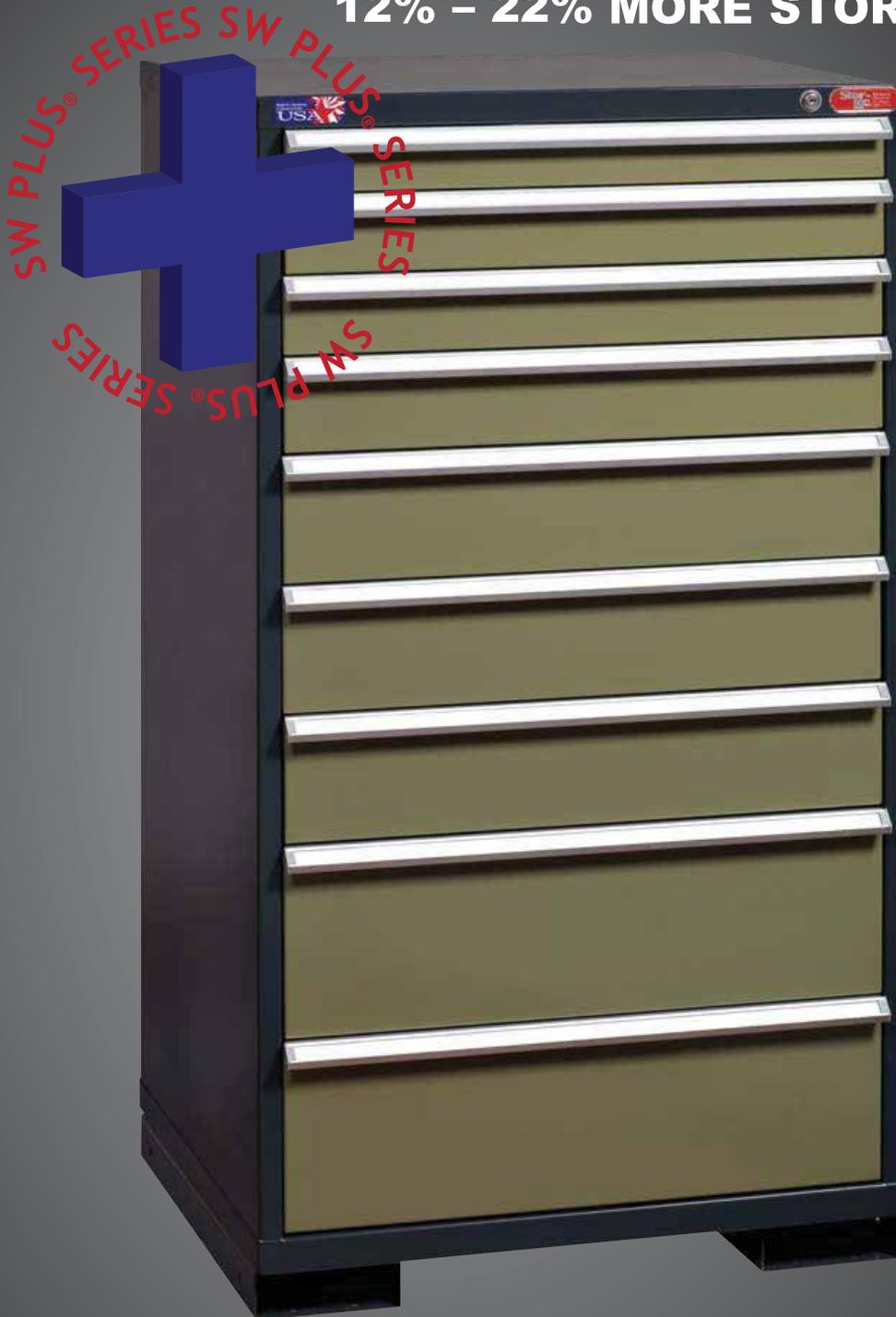
PYROMETRY – A DIFFERENT TAKE

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PYROMETRY – A DIFFERENT TAKE

Looking at how pyrometry may alter the structure of parts processed in a furnace overall, including upcoming revisions to AMS2750F.

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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. Copyright © 2006 by Media Solutions, Inc. All rights reserved.

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FROM THE EDITOR ///



Taking a look at pyrometry, process control

The March issue of *Thermal Processing* takes a deep dive into activities vital to the heat-treat industry, namely pyrometry and process control, and you'll find quite a few articles this month that deal comprehensively with those subjects.

Pyrometry is of particular interest to our good friend and frequent contributor Jason Schulze. In our cover article, Schulze looks at how pyrometry may alter the structure of parts processed in a furnace overall, including upcoming revisions to AMS2750F.

Also on the subject of pyrometry, Steve Duban of Super Systems shares his expertise on the temperature uniformity survey general practice for CQI-9 and AMS2750E.

And Timothy Kennamer with Ajax Tocco Magnethermic Corp. looks at process control, monitoring, and quality insurance specifics for induction heating.

And here's what you'll discover from our monthly columnists:

D. Scott Mackenzie continues his multi-part look at predicting hardness by the Grossman H-Value in this month's Hot Seat.

And in Quality Counts, I am pleased to introduce Tony Tenaglier, who will be sharing this popular column with regular contributor Schulze and a few other experts in the field. He's excited about being a columnist, so check out his inaugural article to see what he plans to share with you in the coming months.

In March's company profile, be sure you check out the history of Abbott Furnace and what they've been bringing to the heat-treat industry for more than three decades.

That's just a taste of what you'll find in this month's issue of *Thermal Processing*.

If you're looking for a forum to share your expertise, please hit me up with suggestions at the email below so we can continue to make Thermal Processing the best heat-treat source it can be.

As always, thanks for reading!

KENNETH CARTER, EDITOR

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PUBLISHED BY MEDIA SOLUTIONS, INC.

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Grieve No. 954 features inert atmosphere construction. (Courtesy: Grieve Corporation)

Grieve inert atmosphere furnace heat treats titanium

Grieve No. 954 is an electrically-heated 2,000°F (1,093°C) inert atmosphere heavy-duty box furnace from Grieve used for heat treating titanium at the customer's facility. 57 KW are installed in nickel chrome wire coils, supported by vacuum-formed ceramic fiber, to heat the load. Workspace dimensions are 30" wide x 48" deep x 30" high. The oven's 7-inch-thick insulated walls comprise 5 inches of 2,300°F ceramic fiber and 2 inches of 1,700°F ceramic fiber, while the

6-1/2-inch floor insulation comprises 4-1/2 inches of 2,300°F firebrick and 2 inches of 1,200°F block insulation.

The unit is equipped with a roof-mounted heat-resisting alloy recirculating fan, powered by a 1-HP motor with V-belt drive, motor-operated vertical lift door, 100-pound capacity alloy loading cart with cast alloy roller rails, 3-1/2-inch diameter cast alloy rollers, and a roller rail loading table with 4-inch diameter cast iron rollers.

This Grieve furnace also features inert atmosphere construction, consisting of a continuously welded outer shell, high-temperature door gasket, sealed heater terminal boxes, inert atmosphere inlet, inert atmosphere outlet, and inert atmosphere flowmeter.

Controls onboard No. 954 include a digital programming temperature controller, manual reset excess temperature controller with separate contactors, plus a strip chart recorder.

MORE INFO www.grievcorp.com

Gasbarre commissions furnace for U.S. heat treater

Gasbarre Thermal Processing Systems recently commissioned a precision gas nitriding and ferritic nitrocarburizing furnace for a prominent commercial heat-treating company in the Midwestern United States. The furnace uses Super Systems, Inc. controls for automatic KN and KC control to AMS 2759/10 and 2759/12 specifications. The furnace is designed to meet AMS 2750/E as a Class 2 furnace, which allows it to be used to perform nitrogen tempering and stress relieving processes. For cycle time improve-



Gasbarre Thermal Processing Systems recently commissioned a precision gas nitriding and ferritic nitrocarburizing furnace for a commercial heat-treating company. (Courtesy: Gasbarre)



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.

ments and consistent process control the furnace is equipped with a vacuum pump for purging processes, pre- and post-oxidation capabilities, and accelerated air and atmosphere cooling systems. It is capable of processing workloads that are 48" wide by 72" long by 40" high and weigh up to 7,000 pounds. Gasbarre Thermal Processing Systems says this complete system is engineered, manufactured, and serviced out of its United States locations, solidifying its position as a leader in equipment for the nitriding and FNC process.

With locations in Plymouth, Michigan; Cranston, Rhode Island; and St. Marys, Pennsylvania, Gasbarre Thermal Processing Systems has been designing, manufacturing, and servicing a full line of industrial thermal processing equipment for nearly 50 years. Gasbarre's product offering includes both batch and continuous heat-processing equipment and specializes in temper, tip up, mesh belt, box, car bottom, pit, and vacuum furnaces as well as a full line of replacement parts and auxiliary equipment that consists of atmosphere generators, quench tanks, and charge cars. Gasbarre's equipment is designed for the customer's process by experienced engineers and metallurgists.

MORE INFO www.gasbarre.com

Tenova to supply Consteel® EAF for Nippon Steel Corp.

Tenova, a Techint Group company specialized in innovative solutions for the metals and mining industries, was awarded a contract for the supply of a Consteel® EAF (Electric Arc Furnace) for Nippon Steel Corporation. This new Consteel EAF is the first one for the Nippon Steel Group in Japan, and it will be installed at their Hirohata works.

Production is targeted to start in the first half of the 2022 financial year.

"With this new installation, Hirohata plant will save about 400,000 tons per year of CO₂ emissions," said Mario Marcozzi, Tenova sales director for electric arc and ladle furnaces. "Moreover, this project consolidates Tenova presence in the important Asian market."

With more than 75 references worldwide, Tenova's Consteel EAF offers high-quality standards as well as an environmentally friendly approach to steel production com-



Tenova, a Techint Group company specialized in innovative solutions for the metals and mining industries, was awarded a contract for the supply of a Consteel® EAF (Electric Arc Furnace) for Nippon Steel Corporation. (Courtesy: Tenova)

pared to the other EAF technology. Tenova says its exclusive Consteel technology is the only fully proven industrial process that continuously heats and feeds metallic charge into the EAF, while simultaneously keeping gaseous emissions under control.

MORE INFO www.tenova.com



Stalmax, a manufacturer of fasteners, has decided to invest in a Seco/Warwick ATG processing line based on a belt furnace for tempering in a protective atmosphere. (Courtesy: Seco/Warwick)

Stalmax invests in Seco/Warwick processing line

In the world of heat treatment, Seco/Warwick strives to create innovative technological solutions for heat and thermo-chemical treatment. Stalmax, a manufacturer of fasteners, has decided to invest in one such

innovation, i.e. an ATG processing line based on a belt furnace for tempering in a protective atmosphere.

The provided equipment is designed for hardening fasteners, such as bolts and nuts, intended for the automotive industry. The main element of the line is a belt furnace equipped with a muffle, in which the heat process is conducted in a protective endothermic atmosphere.

The applied design solutions allow for a high evenness of temperature uniformity to be achieved. The automated process of the work of the line, equipped with a weighing system, enables a precise loading of the treated elements on the hardening furnace belt.

Seco/Warwick's experience as a manufacturer of furnaces for heat treatment makes it possible for the client to receive a custom-made product that meets their needs. It is also crucial to guarantee that the restrictive requirements of the automotive business, including for example CQI-9, will be fulfilled.

"Seco/Warwick with their solutions answers real manufacturing needs, and ATG-type line is a guaranteed fulfillment of the industry's and the clients' requirements," said Robert Je, Stalmax vice president. "The partner has not only offered an excellent furnace, but also protected us in case of an unwanted failure. In accordance with individual needs, components of element coding have been introduced and are connected to the alarm base (PLC) and electric documen-

tation of the control system. Such a solution allows to immediately identify the failure and the damaged element.”

“Technologically creating systems for heat treatment in protective atmospheres, Seco/Warwick relies on a solid foundation that is their extensive experience and expert knowledge,” said Jarosław Talerzak, VP, Thermal business segment at Seco/Warwick. “This makes it possible for them to offer technology that is reliable and designed for specific processes and needs. By choosing Seco/Warwick as their partner, Stalmax, a manufacturer of small appliances, invested in innovation and reliability of the manufacturing process. One of the deciding factors of the decision are our high levels of expertise in supporting a company from the very demanding part of the industry that is the automotive business.”

MORE INFO www.secowarwick.com

Tenney Environmental ships test chamber

Tenney Environmental, a division of Thermal Product Solutions, has shipped a UTC series reach-in test chamber and a remote testing chamber to the electronics industry. These test chambers are designed to condition electronic tilt sensors.

This test chamber has an operating temperature range of 0°C to 50°C when being used as an air conditioning system but has a range of -68°C to 180°C when being used as a chamber. The construction of the chamber includes a combination of fiberglass and polyurethane insulation surrounding the chamber to maximize insulating characteristic.

This specially designed model UTC test chamber can be used as either a reach-in test chamber, or as a conditioning air system (CAS) for a remote testing chamber. The remote test chamber consists of an insulated enclosure with interior dimensions of 20” H x 20” D x 20” H, and a single front-mounted hinged chamber door. Supply and return 4-inch diameter, 12-inch long insulated airflow ductwork connects the CAS and the remote test chamber. Unique conditioning specifications are defined for



Tenney’s specially designed model UTC test chamber can be used as either a reach-in test chamber, or as a conditioning air system (CAS) for a remote testing chamber. (Courtesy: Tenney)

each operational mode.

“Our customer contacted us with an application which involved the temperature conditioning of electronic tilt sensors. Due to the sensitivity of the sensors, there was concern the vibration levels generated by the chamber compressors would affect their accuracy. To alleviate their concern, we provided a test chamber with a CAS (conditioned air supply) package and a remote enclosure to condition the sensors and eliminate the vibration concern,” said Jeff Comitz, applications engineering manager.

- Features of this test chamber include:
- › 20-gauge stainless steel interior.
 - › Watlow F4T with INTUITION temperature process controller.
 - › TempGard IV over temperature protection control system.
 - › Low-mass Nichrome, open-wire heating elements.
 - › Two semi-hermetic reciprocating compressors.
 - › Two additional three wire Class A RTD sensors to monitor temperature.

MORE INFO www.tenney.com

FOBA upgrades portfolio with Y.0200-S model

FOBA Laser Marking + Engraving, a global leader in industrial laser part marking and engraving solutions, has introduced another laser marker for line integration: The new FOBA Y.0200-S model is an upgrade to the existing range of fiber laser marking systems. The powerful marking laser is characterized by its compact design and gives manufacturers a high amount of marking and mounting versatility.

FOBA understands manufacturers’ varying needs for direct part marking and intends to solve many of their unique laser identification requirements. The new system is ideal for demanding production schedules — especially in the electronics and automotive supplies or metal and plastics processing industries. FOBA’s Y.0200-S marking system can keep pace with the legal ID specifications and provide a high level of code contrast and durability, even on robust, high-density materials.

The 20-watt fiber laser provides increased operational freedom, flexibility, and application confidence. Users can select either a 6 mm marking head for high-speed production or a 10 mm marking head for parts marking with fine detail.

Improved data processing and high marking speed allow for enhanced productivity: Up to 1,300 characters per second can be achieved with the 6 mm marking head or up to 1,000 characters per second with the 10 mm marking head, depending on the application.

The new laser provides seamless integra-



The FOBA Y.0200-S marking unit can be controlled using the IP65-rated 10.1-inch color touchscreen laser controller. (Courtesy: FOBA)

tion into various production lines and users can choose to control the marking process using FOBA's Touch Control Software FOBA Go on the IP65-rated 10.1-inch color touchscreen or on most browser-based devices.

"Our customers have already received this lightweight, compact, and agile fiber laser solution very well," said Wen Xiao, FOBA general manager in the APAC region. "Having the choice between a zero- or 90-degree marking head orientation, they benefit from versatility in tight spaces and easy mounting of one of the smallest marking heads available."

MORE INFO www.fobalaser.com

Allied acquires WAM® AL II product line for aluminum production

Allied Mineral Products, LLC., a global refractory manufacturer, has purchased the intellectual property rights to a collection of industry-leading products for the aluminum industry previously owned by Westmoreland Advanced Materials, Inc.

The WAM® AL II line of patented products is internationally known for energy savings and resistance to corundum formation for aluminum producers. Allied will manufacture these products in their facilities in the United States, Europe, India, Russia, China, South Africa, Chile, and Brazil.

Allied will market its new products under existing trade names, such as WAM AL II castables. These products have excellent non-wetting properties which will complement Allied's existing product technology by helping increase refractory lining life and reducing maintenance costs.

"The acquisition of the WAM AL II line of products complements ongoing initiatives at Allied in the aluminum market and the unique characteristics provide outstanding value to aluminum customers," said Paul Jamieson, president of Allied Mineral Products. "We are excited to begin manufacturing and marketing these innovative products, which build out an existing line of installer-friendly products that will further enhance the refractory solutions we offer to our customers worldwide."

"Westmoreland Advanced Materials Inc.

is excited to be able to provide the WAM AL II technology to Allied. This provides a larger and more robust means of putting this unique technology in the hands of aluminum processors and producers on a global scale." said Dr. Ken McGowan, president of Westmoreland Advanced Materials, Inc. "It also allows Westmoreland to focus on pro-

viding optimized engineering, installation, and design solutions to OEMs and end users, as well as focusing on the development of new technologies for material and chemical containment in high temperature environments." 🌟

MORE INFO www.alliedmin.com

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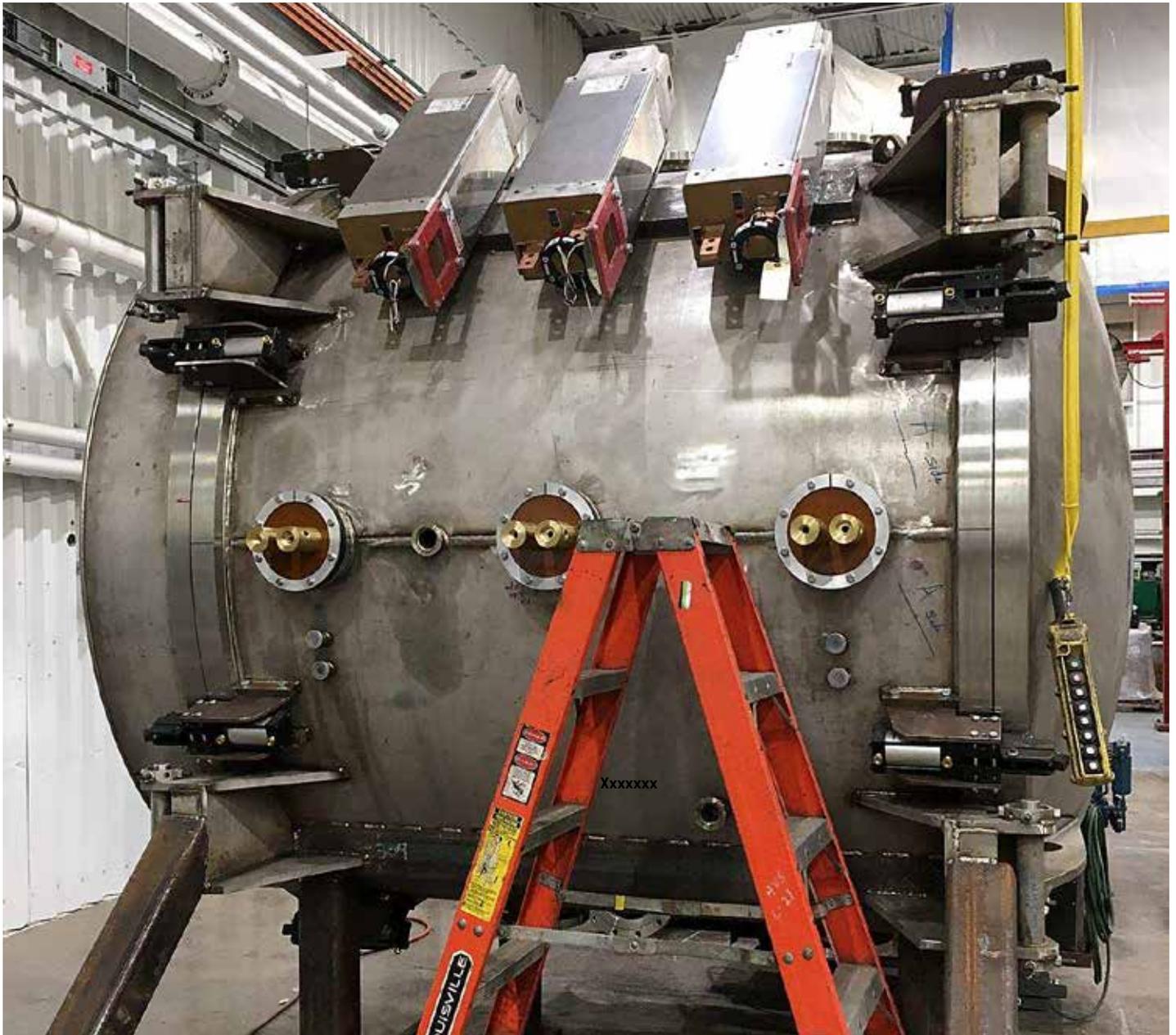
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IHEA welcomes a new member: RoMan Manufacturing, Inc.

By JIM GIBSON | Director of Global Sales & Marketing | 717-395-3066 | jgibson@romanmfg.com





Our value offering is aligned to the needs of today's furnace OEMs and heat treaters by offering standard and custom product and system solutions that improve processes and lead times and reduce material and maintenance costs.

high current DC output. DC heating is more efficient than AC heating, since the displacement power factor with IGBT/MFDC is close to unity at most setpoints. The operating frequency of the water-cooled DC power supply allows us to build very compact units that can be mounted directly on the furnace at the heating element terminals, eliminating the need for long water-cooled cable runs and also eliminating secondary cable inductance. The IGBT control provides a balanced three phase input and precise, multi-zone power control, as well as strong analytics capabilities communicated via Modbus and other protocols.

For the furnace OEM, power delivery systems from RoMan provide a high level of value to you and your customers including:

- › Compact footprint virtually eliminates overhead scaffolding and other VRT support structures that take up headroom.
- › Compact, lighter DC power supplies and close coupling design reduce shipping, maintenance and material costs.
- › Precise power control and analytics capabilities brings furnace power to the 21st century.

RoMan Manufacturing was founded in 1980 with a singular corporate commitment to manufacture water-cooled, high-current, low-voltage power sources, controls and power delivery systems used in resistance welding; melting, boosting, refining, and forming of glass; and in vacuum and atmospheric furnace OEM builds and retrofits. This commitment has made us an industry-leading manufacturer of AC and DC power sources and related specialty products.

Our innovative application-centric engineering, ISO certified and efficient lean manufacturing (Toyota Production System – TPS) processes produce the highest quality products. From three manufacturing facilities, we provide you with more than 7,000 designs, which gives us the flexibility to customize a product to any configuration, specification, or application requirements. We also offer value-added services such as technical and application support.

There is a consumer driven, cultural sea change toward materials and technologies that are – or are perceived to be – environmentally friendly. In most places, it is still environmentally cleaner (on global emission basis) to burn

fossil fuel than to use it to generate electricity; however, fossil fuel combustion technologies' rate of improvement in energy efficiency has all but flatlined. The contribution of electric renewal energy in the reduction of emissions is increasing rapidly and within 10 years, western Europe will have made a major move to renewables along with the rest of the world.

Our value offering is aligned to the needs of today's furnace OEMs and heat treaters by offering standard and custom product and system solutions that improve processes and lead times and reduce material and maintenance costs. This helps deliver significant energy efficiencies and utility savings.

Our IGBT/MFDC power delivery system replaces outdated SCR and VRT technologies. The IGBT/MFDC is an inverter system that creates 1,000 Hz output coupled with a DC transformer to the furnace. It utilizes a 3-phase input to a rectified bridge, which acts as a "shield" from load imbalances. The IGBT (insulated-gate bipolar transistor) is able to rapidly turn on-off high current at 1,000 Hz, creating a

DETAILS

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IHEA 2020 CALENDAR OF EVENTS

MARCH 12–16

IHEA 2020 Annual Meeting

Tampa, Florida – *Brilliance of the Seas*
www.ihea.org/event/AM2020

APRIL 6–9

Electrification 2020

Charlotte, North Carolina
www.electrification2020.com

APRIL 13–MAY 24

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A simple method of estimating the predicted hardness on several different diameters of material at different hardenability shows reasonable correlation. Its validity is still appropriate today.

Predicting hardness by the Grossman H-Value

In the last article, we described a method of calculating the Grossman H-Value [1]. In the article before last, we described a method of using the Lamont charts [2] to predict hardness based on the Jominy test, and an assumed Grossman H-Value. In this column, we are going to look at different methods of property prediction and see how they compare. In the first method, we are going to use the classical Grossman H-Value and the Lamont charts. In the second method, we are going to use the Swerea Smart Quench Integra [3]. We are going to use JMatPro [4] for the calculation of necessary data. We will then compare the results.

QUENCHANT

For the quenchant, we will use a medium speed general purpose quenchant (Figure 1). This quenchant has a cooling rate of 48.2°C/s at 705°C. Please note that Table 1 is different from the table in the previous article. This is due to a unit conversion error I made in the last article. I apologize for the mistake.

MATERIAL

For this article, we will use two alloys: SAE 1045 and SAE 5140 (Table 2). These alloys were chosen because they are commonly used for a wide variety of heat-treated parts, and the data is readily available. Since there is a range of hardenability for each of the alloys, we will use a Jominy End Quench curve that is in the middle of the range for each alloy (Figure 2). A bar diameter of 1.5" and 3" will be used. The Lamont [2] charts (Figure 3) are used from [6].

For reference, the Time-Temperature-Transformation curves of SAE 1045 (Figure 4) and SAE 5140 (Figure 5) have been included for reference.

CALCULATIONS

Now that we have all the necessary data needed, we can start the calculations.

GROSSMAN H-VALUE

From the calculated Grossman H-Value of Houghto-Quench G (0.45 in-1), we can determine the hardness as a function of depth for the 1.5" and 3.0" round bars. Looking at the Lamont chart (Figure 3), the Jominy distances for various depths can be determined (Table 3).

Once the Jominy distances are determined, then it is a simple matter of interpolation to determine the hardness for the desired alloy at

Product	Cooling Rate at 705°C (°C/s)	Calculated Grossman H-Value
Houghto-Quench 100	22.1	0.17
Houghto-Quench G	48.2	0.45
Houghto-Quench K	69.2	0.71
Water @ Ambient	144.7	1.56

Table 1: Grossman H-Values for typical slow, medium, and fast quench oils, plus water. Note that this table is different from the previous article. The data has been corrected to the proper units.

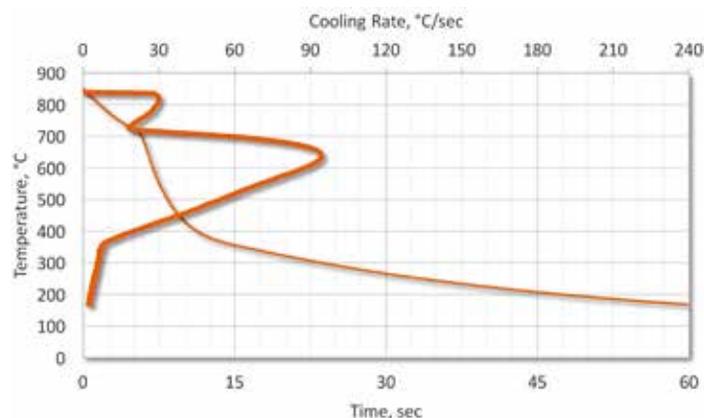


Figure 1: Typical cooling curve of a medium speed oil quenchant. Curve shown is for Houghto-Quench G at 60°C with no agitation. Tested per ASTM D6200 [5].

the specific Jominy distances. As can be expected, the SAE 1045 and the SAE 5140 1.5" round showed a relatively flat as-quenched hardness profile. From the hardness, it can be expected that the microstructure of the SAE 1045 is predominately ferrite and pearlite, while the SAE 5140 has a microstructure of predominately martensite and bainite.

IVF SMARTQUENCH INTEGRA

For the Smart Quench Integra [3] to properly calculate hardness and microstructure of a given alloy, it is first necessary to input the cooling curve of the desired quenchant. The curve in Figure 1 is the curve that was measured and input into Smart Quench Integra. It is then necessary to calculate the heat transfer coefficients as a function of surface temperature of the probe. The calculation of the surface coefficients is via the inverse-method [7] [8].

	C	Mn	P	S	Si	Cr	Ni	Mo	Cu
SAE 1045	0.42	0.79	0.019	0.023	0.22	0.11	0.18	0.04	0.04
SAE 5140	0.41	0.75	0.018	0.018	0.25	1.05	0.13	0.04	0.15

Table 2: Typical compositions of SAE 1045 and SAE 5140.

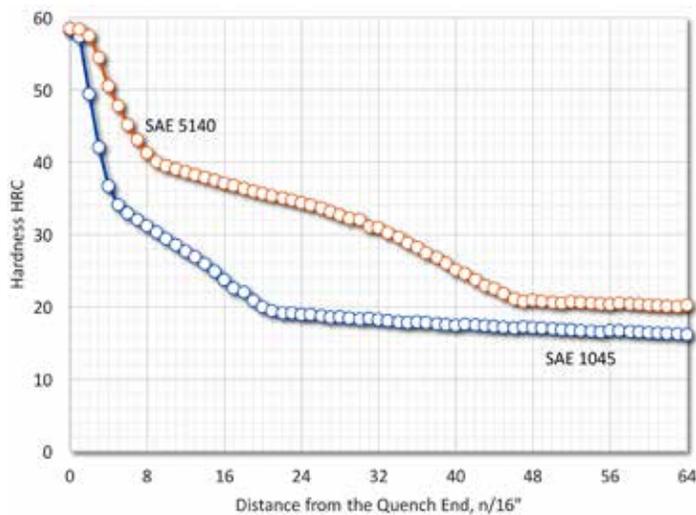


Figure 2: Jominy End Quench data as calculated by JMatPro.

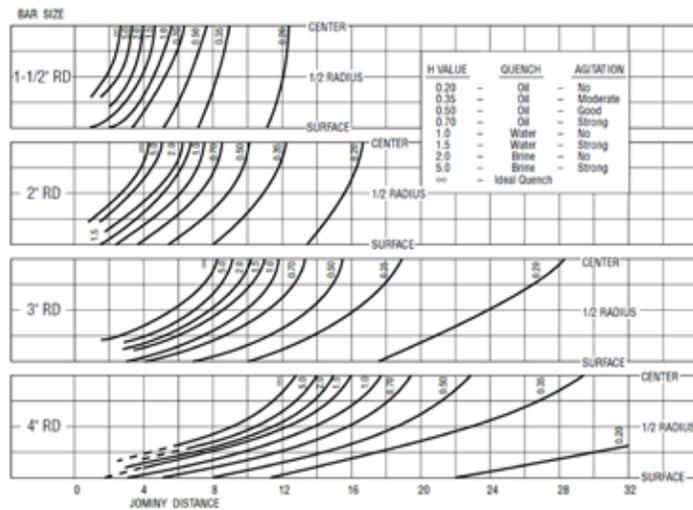


Figure 3: Lamont charts [2] used in the calculation of hardness profiles for simple round bars [6]. This chart will be used for our calculations.

Once the heat transfer coefficients have been determined, it is necessary to categorize the steel of interest. Thermophysical properties, chemistry and Time-Temperature-Transformation data is input into a new file.

This can be directly interpolated from published TTT curves [9], or data from JMatPro calculations [10] can be used. For this article, the calculations from JMatPro were used.

RESULTS

From the data, we can see that using the H-Value yields hardness

above the SQIntegra data for low hardenability steels, and below the predicted values for high hardenability steels (Table 4). However, the data is close, usually within 3.5 HRC (except for the 1.5” SAE 1045 at the center, where the hardness difference is 6.6 HRC).

The differences in the 1.5” SAE 5140 bar could be associated with the hardnesses estimated from the TTT curve and input to SQ Integra. For a simple method of calculating hardness, the old-school method of the H-Value provides a quick estimation of the expected hardness for a simple geometry.

If someone wants to duplicate the testing with a real bar of materi-

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Once the Jominy distances are determined, then it is a simple matter of interpolation to determine the hardness for the desired alloy at the specific Jominy distances.

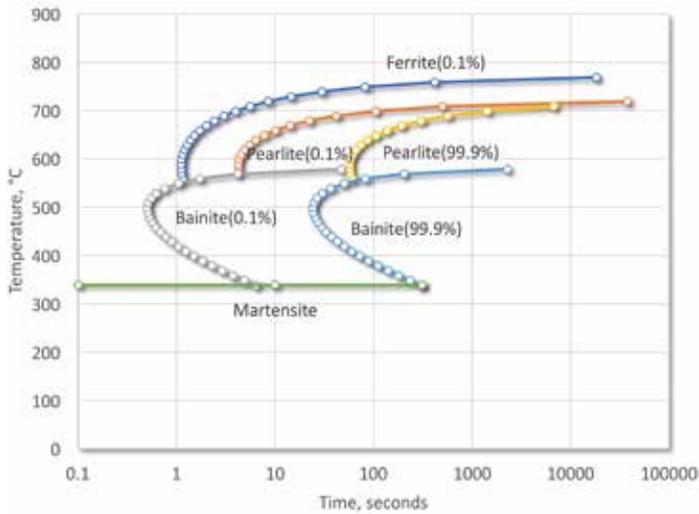


Figure 4: Time-Temperature-Transformation curves of SAE 1045 as calculated by JMatPro for the chemistry in Table 2.

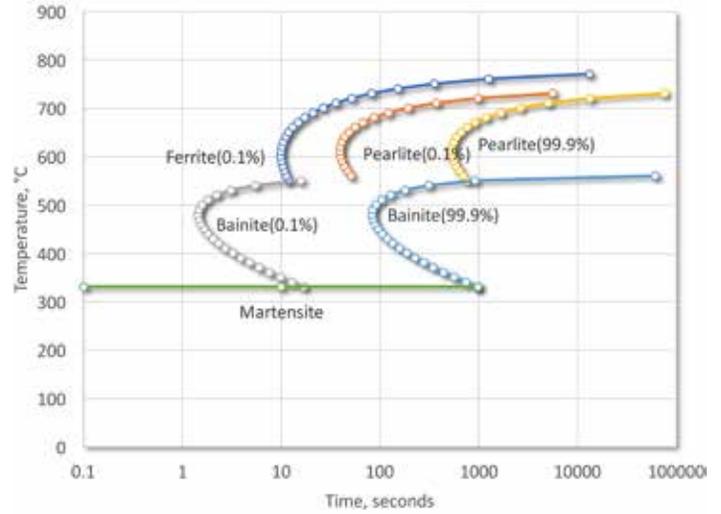


Figure 5: Time-Temperature-Transformation curve of SAE 5140 as calculated by JMatPro for the chemistry in Table 2.

al, and measure the data, I would love to see the results. Contact me if you are interested in verifying these theoretical predictions.

In conclusion, we have shown a simple method of estimating the predicted hardness on several different diameters of material at different hardenability.

Results show reasonable correlation to each other. Even though the method was developed by Grossman in 1940, and extended by Lamont in 1943, its validity is still appropriate for use today.

Should you have any questions regarding this or any other article, please contact the author or editor. ✉

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Jominy Distances	1.5" Round			3.0" Round		
	J = n/16	SAE 1045	SAE 5140	J = n/16	SAE 1045	SAE 5140
Center	7.6	31.5	42.5	15.5	24.0	37.3
1/4 Radius	7.2	32.0	43.0	15.0	28.3	37.5
1/2 Radius	6.8	32.5	43.5	13.5	26.4	38.0
3/4 Radius	6.0	32.9	45.2	11.0	28.5	39.0
Surface	5.2	34.1	47.7	6.9	32.1	43.0

Table 3: Resultant Jominy distances based on 1.5" and 3" round bars using a Grossman H-Value of 0.45. End quench distances used to calculate hardness from Jominy End Quench Data (Figure 2).

r/R	1.5" SAE 1045		3.0" SAE 1045		1.5" SAE 5140		3.0" SAE 5140	
	SQ Integra	H-Value						
0.00	26.4	31.5	25.8	24	49.1	42.5	40.9	37.3
0.25	27.9	32	25.8	28.3	49.2	43	41	37.5
0.50	29.1	32.5	25.7	26.4	49.3	43.5	41.4	38.0
0.75	30.2	32.9	25.7	28.5	49.5	45.2	41.9	39.0
1.00	30.6	34.0	25.8	32.1	49.8	47.7	42.6	43.0

Table 4: From the data, we can see that using the H-Value yields hardness above the SQ Integra data for low hardenability steels, and below the predicted values for high hardenability steels.

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Combining the theoretical aspects of material science with that of human relationships governs the way the process moves, and where it needs to get to in an organization.

The life of a heat treat process engineer

Editor's note: Beginning with this issue of *Thermal Processing*, there will be multiple contributors to the Quality Counts column. Conrad Kacsik's Jason Schulze will continue to write occasional columns. This month, meet Tony Tenagliere, heat treat process engineer at Hitchiner Manufacturing.

Before I get into the specifics of my views on and experience in process engineering, I'll start with a quick look at my life from a black and white perspective (the classic resume lens):

- › Heat treat engineer with four years' experience (ferrous and nonferrous alloys; vacuum, salt, carburizing, nitriding, HIP processes).

- › Experience with Nadcap and AS9100 audits.
- › Experience with AMS2750.
- › Process engineering.
- › Manager experience.

And my life with a little more color (a life size optical microscope lens):

- › Professional network of friends and work colleagues.

- › Adherence to the statement "say what you do, do what you say"; credibility, and a man of his word in all aspects of life.

- › Engineer inspired by marathon running work ethic (marathons in 12 of the 50 states).

- › kNowhere kidS band's drummer finding rhythms in the process of heat treat and manufacturing, and coordinating the overall song and dance of the process.

Process engineering isn't just about the consideration of technical details. It also requires engineering the relationships of people in a given process. Success, taught in school, is not the result of good luck, but rather good "skill." And it is the emphasis of good skill that has always resonated with me in my career as an engineer. It was my adviser who once taught me this after having gone through the courses of thermodynamics and kinetics, which I enjoyed most in my academic studies. One day in his office after discussing senior design possibilities, he associated thermodynamics — the knowledge of thermal (heat treat)/pressure (hot isostatic pressure) considerations in which a system of atoms wants to be energetically favorable — to the study of psychology. The premise was that humans, too, seek states of energy that are desirable in their lives and it is of importance to also acquire this knowledge.

Sure, it is important to have skills such as knowledge of the

Gibbs free energy considerations in binary phase diagrams to establish suitable heat treat temperatures of solution or annealing. But it is of equal importance to consider, in a working environment, the relationships with people — how binary relationships of people also govern the way the process moves and where it needs to get to in an organization.

This was the foundation to my engineering career. It was the first stepping stone that taught me to combine both theoretical aspects of material science with that of human relations. It was then that I went on to work at a steel manufacturing company in Ohio to help with the startup of an electric arc furnace. Practicing the skills of human relations, I took on the role of manager and created a team to develop a brand-new department and the techni-



Process engineering isn't just about the consideration of technical details. It also requires engineering the relationships of people in a given process. Success, taught in school, is not the result of good luck, but rather good "skill."

cal requirements needed.

However, at the time, I still needed to refine my skills of developing and maintaining human relations, as I got upset when a new incentive plan was initiated for the company – the idea that the “carrot” was placed out in front of the teams to run after and get. Now, I agree with some people being motivated by extrinsic rewards, but others are often motivated by intrinsic rewards to the same degree, meaning that the desire for doing something for the sake of doing it transcends that of monetary value. (I’m not suggesting that people work for free!) Rather, the hard work put into the team seemed to crumble fast when the extrinsic reward did not match the reality of the production capability. After losing my temper and being frustrated, I was let go. It was a lesson I needed to learn in life.

But for every experience, there is a lesson. It reminded me of the need to continually develop who I was as a person and how I interacted with others. From there, I was left unemployed and finished a book called *The Impression of a Good Life: Philosophical Engineering*. It was a job description I needed in order to get my life back on track and working toward the right things.

Shortly thereafter, a small family-owned heat-treat company in Cleveland, Ohio, found my resume and interviewed me. I will never forget my first interview with Katie, one of the owners at General Metal Heat Treat, and how we communicated so effortlessly. The idea that in a small company of about 25 employees, we both emphasized how important it was going to be for me to manage not only the development of heat-treat processes, but also that of the relations with the employees who worked there. During my time there, I found myself engaged in Nadcap audits, restructuring the company’s interpretations of AS9100 principles, and learning what

it meant to really be part of a team.

However, it isn’t just teamwork that is of value, and a few years later I found myself wanting to go home to New Hampshire, where I grew up and where my immediate family still lives. This is when I landed at Hitchiner Manufacturing and became its heat treat process engineer.

I feel honored to write in a technical journal sharing not only the positive things I’ve learned along the way, but how I’ve also learned from the negative. I’ve learned that the aspects of heat treat include and extend beyond binary phase diagrams, TTT curves, and AMS specifications, and that they really embrace more of the philosophy of AS9100 requirements for a workplace culture.

I’ve learned that work-life balance is important, but I also realized both are really one and the same. My drumming in the band can help my understanding of the rhythm for a process, or that specification review can help in my ability to develop proper marathon running training programs in making sure I cover all aspects that are required.

As I consider topics for future column topics, a few come to mind:

› The art of heat treat.

› Knowing the “why” in heat treat.

I’m sure other topics will spontaneously occur, and I’m looking forward to sharing ideas with *Thermal Processing* readers. ♣



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.

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ISSUE FOCUS ///

PYROMETRY / PROCESS CONTROL



PYROMETRY – A DIFFERENT TAKE

Looking at how pyrometry may alter the structure of parts processed in a furnace overall, including upcoming revisions to AMS2750F.

By JASON SCHULZE

Any article on pyrometry, as it applies to AMS2750 and thermal processing, usually gets a lot of attention. Typically filled with interpretation, clarification, and general discussion, it is understandable that pyrometry can be difficult to interpret at times, especially for someone new to the topic. Using my own experience in the industry, I have written plenty of articles that address specific topics in pyrometry attempting to convey my interpretation as well as suggestions on how to accomplish testing and conformance based on my own experience in the industry. This typically yields reader feedback and, most importantly, questions regarding more specific topics as well as questions about my interpretation. In the end, this allows discussions in which both sides learn something, and, hopefully, something positive is produced.

On rare occasions, I get asked, “Does it really have any effect on my specific product?”; as I do not have design authority over the specific product in question, it is not my place to answer with any authority, only my professional opinion. Conversations face-to-face regarding pyrometry (or nonconformances in pyrometry) tend to produce this question as well (and will usually give the same answer). The answer given is not to dodge the question in any way but is the only fair approach in those situations. While we may not be able to answer the “Does it really have any effect on my specific product?” question, what we can do is look at how pyrometry may alter the structure of parts processed in a furnace overall. I will also include some of the upcoming revisions in AMS2750F and explore how those specific changes may alter the structure of metallic materials processed.

THERMOCOUPLES

Microstructure changes due to heat treating is dependent on, among other things, heat transfer, whether direct or indirect and its subsequent cooling. Believe it or not, the subject of heat transfer can get quite involved when you start diving into the technical side. This will include plenty of formulas (including the 1st law of thermodynamics), which will explain the nonstationary temperature fields developed when heating and cooling over time. For now, we will not dive deep into this. The point being that heat transfer is an important part of any heat-treat process. Some industry specifications require that parts be held at temperature for, say, “30 minutes per 0.5” of material thickness.” This is a consequence of heat transfer. If a material is not held at temperature long enough, the product will not reach the desired temperature throughout and, therefore, will not have homogeneous properties throughout. Product temperature is measured using thermocouples, which is covered extensively in AMS2750.

Load thermocouple usage and replacement is described in AMS2750 in two categories: expendable and nonexpendable. The

usage categories are appropriate for both types in that, if a thermocouple has only fiber or plastic shielding, it is not as well protected as a metal sheathed thermocouple where the hot junction is not exposed. The limitations for thermocouple use are based on the fact that thermocouples degrade over time when cycled up and down in temperature. Atmosphere also affects the degradation of thermocouples. If the thermocouple degrades enough, it loses the ability to measure part temperature accurately. If a thermocouple is not reading the correct temperature, a process time may be started long before the part temperature actually reaches the desired point. This would potentially cause the properties of the material to be nonhomogeneous throughout. It would be difficult to detect this issue with hardness testing alone. A more destructive form of hardness testing would be needed. (See Figure 1)

Whether the degradation of thermocouples happens at a rate that merits the usage restrictions in AMS2750E and the upcoming more

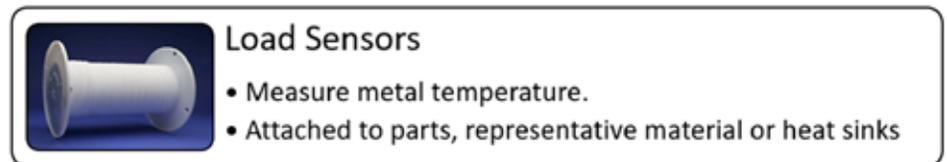


Figure 1

stringent requirements in AMS2750F is arguable based on many process variables as well as a lack of peer reviewed and repeated tests.

TEMPERATURE UNIFORMITY SURVEY

This is, in my opinion, the portion of AMS2750 that will have the most dramatic effect on product processed in furnaces. Let’s begin by taking a look at how poor uniformity in a furnace can affect the properties of aluminum during solution heat treating.

By definition, heat-treatable aluminum alloys are those that can be strengthened by a suitable thermal process for that particular material – for example, alloys that contain magnesium (Mg), as the addition of Mg provides solid solution strengthening without decreasing ductility. In general, solution heat treating takes advantage of the precipitation hardening reaction. Its objective is to take into solid solution the maximum practical amount of the soluble hardening elements in the alloy. This process also consists of soaking the alloy at a temperature sufficiently high and for a long enough time to achieve a nearly homogeneous solid solution. To obtain the maximum concentration of magnesium and silicon, the solution temperature must be as close as possible to the eutectic temperature – ideally 10-15°F below the eutectic temperature. Control of temperature is critical; if the melting point is exceeded, incipient melting (localized melting at the grain boundary) (Figure 2) may occur and mechanical properties may suffer. This condition is only detectable by metallographic examination and is irreversible. This is why furnaces used for aluminum solution heat treating are typi-

cally required to have a temperature uniformity of $\pm 10^\circ\text{F}$ or better.

Now we will look at vacuum brazing as an example. More specifically, a diffusion braze cycle that, after the standard braze cycle, is held at a temperature just below the solidus temperature that is intended to reduce the opportunity for alloy re-melt (and subsequent failure of the joint) once the product is put into service. Let's assume I have five samples on a ceramic plate in a vacuum furnace that I intend to put through this cycle. Each corner has a sample, and one sample is placed in the center of the ceramic plate. The goal is to process the samples in a furnace that will produce the same microstructure in each piece. Let's assume the cycle is as follows¹:

1. Ramp to $1,750^\circ\text{F} \pm 15^\circ\text{F}$ and hold for 15 minutes.
2. Ramp from $1,750^\circ\text{F}$ to $2,025^\circ\text{F} \pm 10^\circ\text{F}$ and hold at $2,025^\circ\text{F}$ for 6 minutes.
3. Vacuum cool from $2,025^\circ\text{F}$ to $1,800^\circ\text{F} \pm 10^\circ\text{F}$ and hold for 1 minute minimum.
4. Gas fan cool from $1,800^\circ\text{F}$ to ambient.

No. 2 is the standard braze step and No. 3 is the diffusion braze step. If the required uniformity of $\pm 10^\circ\text{F}$ is not achieved within the furnace at the time of the braze cycle, neither braze step will produce a conforming microstructure in the samples. In the end, the microstructure of the nonconforming part will show a lighter diffusion zone (1), minimal solid solution loops (2), and a larger eutectic matrix (3) (see Figure 3).

With these two examples, we can see the importance of temperature uniformity cannot be understated. It is apparent that, the more sensitive the metallurgical process is, the more stringent the uniformity requirements will be.

INSTRUMENT CALIBRATION AND SYSTEM ACCURACY TESTING

We all want our records to show accurate temperature readings. Our customers and auditors want to see this as well. An instrument calibration ensures the furnace and/or test instrument meets the accuracy requirements stated in AMS2750E when compared with an instrument of greater accuracy. A system accuracy test ensures that the entire furnace system (instrument, lead wire, and sensor) used, when compared to a test system (instrument, lead wire, and sensor), meets the tolerance of AMS2750 (Figure 4).

It is important to recognize that instrument calibration and system accuracy testing is not the same test. I am sometimes asked to explain why the two tests are performed if they "seem to be the same; testing the accuracy of the readings." This is not the case.

An instrument calibration is performed by transmitting a simulated mV reading into the instrument. If the alternate SAT is employed, those specific channels on the recording system must be calibrated at the point where the furnace thermocouple is connected. The simulated reading is coming from an instrument that has greater accuracy than the instrument being tested and should, theoretically, enable the user to identify that the accuracy of the furnace instrument is within the limitations of AMS2750.

A system accuracy test uses a test system more accurate than the furnace system. The key to this test is that a system is being tested, not just a thermocouple or an instrument. It is important to think of each as a system. In other words, an SAT is not being performed on the control, but the control system. This is apparent in the SAT section of AMS2750 as it states multiple times that the system includes the instrument, lead wire, and sensor (see Figure 4).

If the instrument being used (i.e. control and/or recording system) is not reading the temperature of the furnace/parts correctly or if the furnace control/recording system is not accurate, the product being processed may not achieve the metallurgical transformation

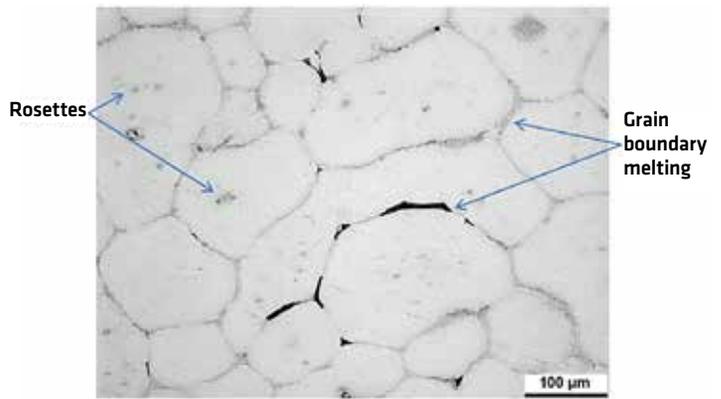


Figure 2

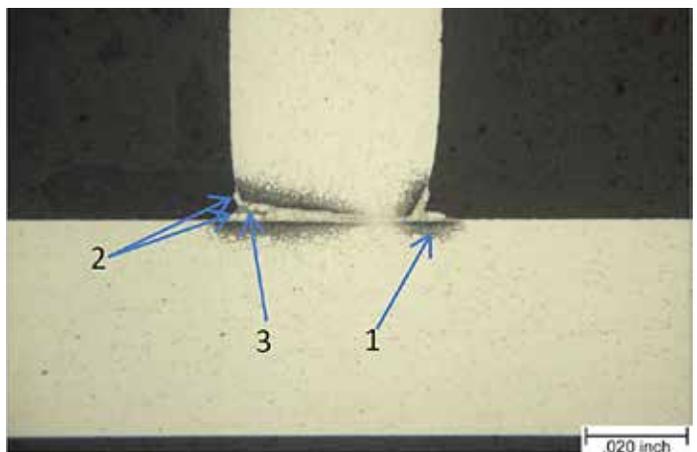
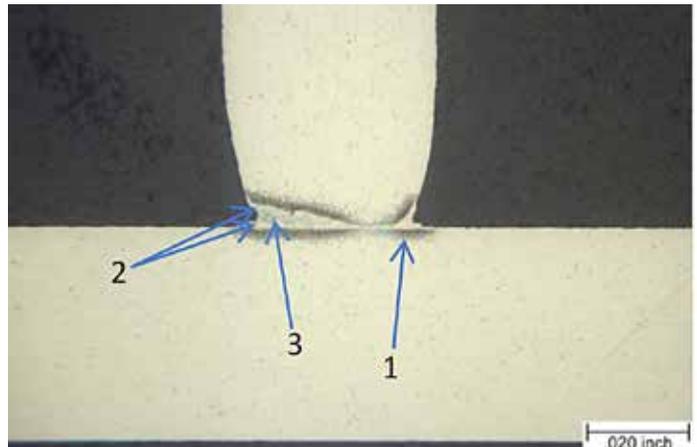


Figure 3: Nonconforming microstructure, top. Conforming microstructure, bottom.

intended. There is a correlation between the permitted SAT difference and the temperature uniformity. This is shown clearly in Tables 6 and 7 of AMS2750 (see Figure 5). The tighter the furnace class, the tighter the SAT difference. Or, put another way, the more sensitive the microstructure is during thermal processing, the tighter the uniformity and SAT difference allowance.

AMS2750F PROPOSED CHANGES

I won't be going into every change proposed for AMS2750F. I will, however, take a look at some proposed changes and discuss how those items may affect the microstructure of product processed in a thermal cycle. I would like to use this opportunity to state that, in general, the proposed changes to AMS2750 are logical, and quite a bit of the Nadcap pyrometry reference guide is being incorporated

into the specification, which I see as a positive move.

Thermocouples

It is proposed that expendable base metal (excluding Type N) SAT, TUS, and load thermocouples be limited to a single use above 500°F. This will be a major change for most processors and, inevitably, cause an increase in operating cost that will, no doubt, be flowed down to consumers in the end. As discussed earlier, the degradation of thermocouples over time must be controlled to ensure the readings obtained during processing are accurate to ensure the product has achieved the correct temperature for the required time. This change is based, in part, on a study that examined the drift in Type K thermocouples in an oxidizing atmosphere². It could be argued that the new expendable base metal (excluding Type N) thermocouple usage limitations proposed for AMS2750F are not in line with the experimental data, as the experiment used an oxidizing atmosphere, and the changes will apply to all atmospheres (i.e. vacuum, inert atmosphere, etc.).

Instrumentation

Furnace instruments will potentially need to be calibrated within ±1 minute/hour. This proposed requirement is especially important for those that process very short cycles, such as high temperature nickel brazing. Some Ni braze cycles can be between 4-7 minutes, making the timing function critical to the metallurgical transformation process. All of that aside, it is just good practice to calibrate the timer being used to certify the process run time.

System Accuracy Testing

A proposed change to the SAT section is for furnaces with multiple qualified operating ranges to have a periodic SAT performed in each

range at least annually. As stated, SAT measures the accuracy of the entire system being used to certify the product was a) at the correct temperature and b) for the correct time. The permitted SAT difference changes depending on the uniformity requirements (furnace class) for that particular range. That being the case, if a furnace is qualified, say, at ±25°F from 1,000°F to 1,800°F and ±5°F from 1,801°F to 1,950°F, the system would need to be more accurate at the higher range. This proposed change for AMS2750F will ensure processors account for each range and its relative permitted SAT difference. From a metallurgical perspective, this will ensure the required transformation in a more sensitive material occurs and conforming results are obtained.

Another potential change within the TUS section will require that, for vacuum furnaces using both vacuum and partial pressure during production, the furnace must be tested at least annually within the partial pressure range used during production. This is in addition to the periodic testing at vacuum. There is potential for uniformity variance once partial pressure is introduced. This will typically occur at the point where the gas enters the furnace. If a furnace is tested at vacuum and achieves, say, a +6°F/-3°F uniformity and the requirement is ±10°F, it will pass. If partial pressure is then introduced on select cycles, there is a chance the uniformity will vary. The uniformity may change drastically enough to where the furnace is unable to hold a ±10°F due to the inlet of the partial pressure gas used. As discussed earlier, nonconforming temperature uniformity can have a major effect on the microstructure of materials processed. While this requirement is logical, it could be argued that the frequency of this test should be treated like radiation surveys in that, if there is no mechanical, type, or flow changes to the delivery system, why perform the test annually?



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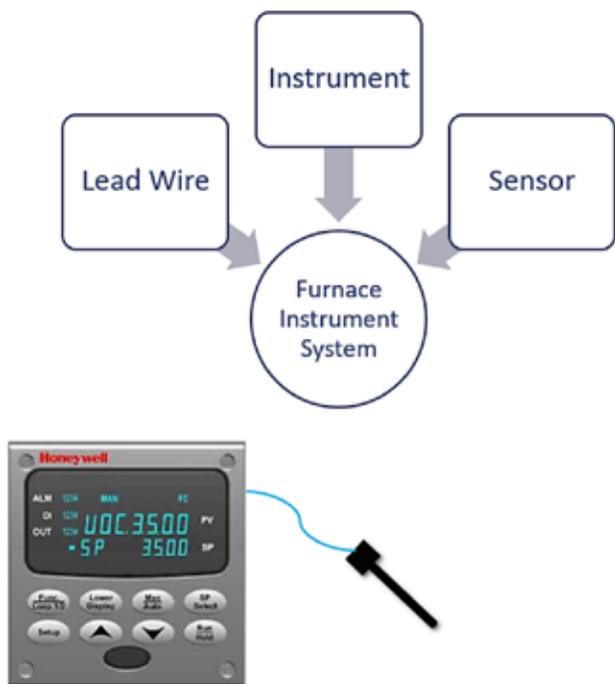


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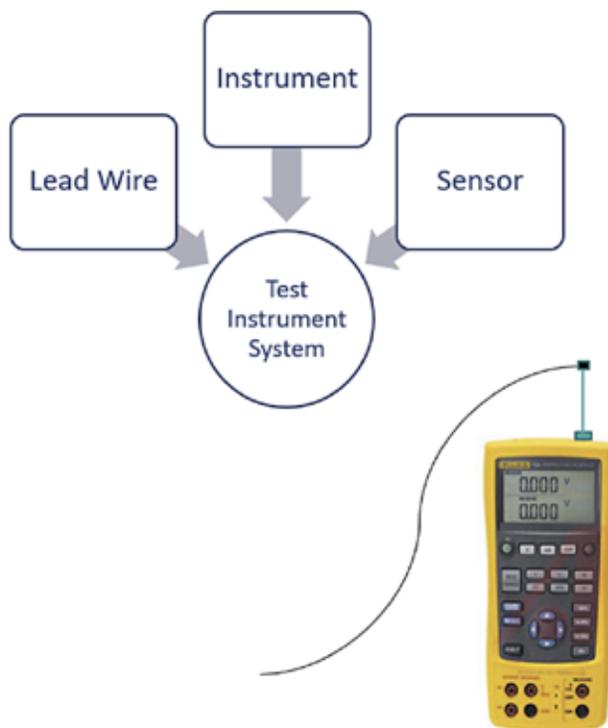


Figure 4

Offsets

This topic, in my experience, has previously produced quite a bit of ambiguity – not anymore. The proposed changes make the practice of implementing and using offsets as clear as they could be made. Of course, it is only my opinion, but the changes made to the offsets section is, from my view, the most well thought out and comprehensive changes made. As always, there are always varying opinions, especially on this topic. I will not be going into the details of the (what I see as) positive changes to offsets as it would take up the better part of a publication. Offsets, if not controlled, can have a negative effect of the quality of products’ microstructure. A combined offset amount within a control can be rather high, depending on the class of furnace, and, if not controlled and implemented correctly, will in turn indicate an inaccurate temperature. This scenario could cause the thermal cycle to start the soak time too early and not allow the microstructure to achieve the desired results.

SUMMARY

The “Does it really have any effect on my specific product?” question should be revisited at this point. While we can explain, in general, how aspects of pyrometry affect the microstructure of product, we cannot use that as justification to deviate from requirements. One may not feel that 0.5°F above the tolerance during an instrument calibration has any detrimental effect on product; it is, nonetheless, nonconforming and must be addressed. While considering the metallurgical effects of the different aspects of pyrometry is a useful tool in understanding pyrometry from a cause and effect point of view, it is incumbent on the processor to ensure confor-

Furnace Class	Instrumentation Type	Normal SAT Interval	Extended SAT Interval	Max SAT Difference(1)	Percent of Reading(1)
1	A	Biweekly	Monthly	±2°F	0.2%
	B, C	Weekly	Biweekly		
	D	Weekly	Weekly		
2	A	Monthly	Quarterly	±3°F	0.3%
	B, C	Biweekly	Monthly		
	D	Weekly	Weekly		
3	A	Quarterly	Semiannually	±4°F	0.4%
	B, C	Monthly	Quarterly		
	D	Biweekly	Monthly		
4	A	Quarterly	Semiannually	±4°F	0.4%
	B, C	Monthly	Quarterly		
	D	Biweekly	Monthly		
5	A	Quarterly	Semiannually	±5°F	0.5%
	B, C	Monthly	Quarterly		
	D	Biweekly	Monthly		
6	E	Semiannually	Semiannually	±10°F	1.0%
	Refrigeration & Quench	Semiannually	Semiannually	±5°F	N/A

Figure 5

mance to all aspects of pyrometry and Nadcap. This can only come from continuous training and experience. 📌

FOOTNOTES

- ¹User assumes all risk when attempting to repeat this cycle.
- ²E.S. Webster – Drift in Type K Bare-Wire Thermocouples from Different Manufacturers. 2017.



ABOUT THE AUTHOR

Jason Schulze is the director of technical services at Conrad Kacsik Instrument Systems, Inc. As a metallurgical engineer with 20-plus years in aerospace, he assists potential and existing Nadcap suppliers in conformance as well as metallurgical consulting. He is contracted by eQualearn to teach multiple PRI courses, including pyrometry, RCCA, and Checklists Review for heat treat. Contact him at jschulze@kacsik.com.

HEAT TREAT EVENTS 2020



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Ceramics Expo USA > May 5-6 | Cleveland, OH

WorldPM2020 > June 27-July 1 | Montreal, Canada

AMPM2020 > June 27-July 1 | Montreal, Canada

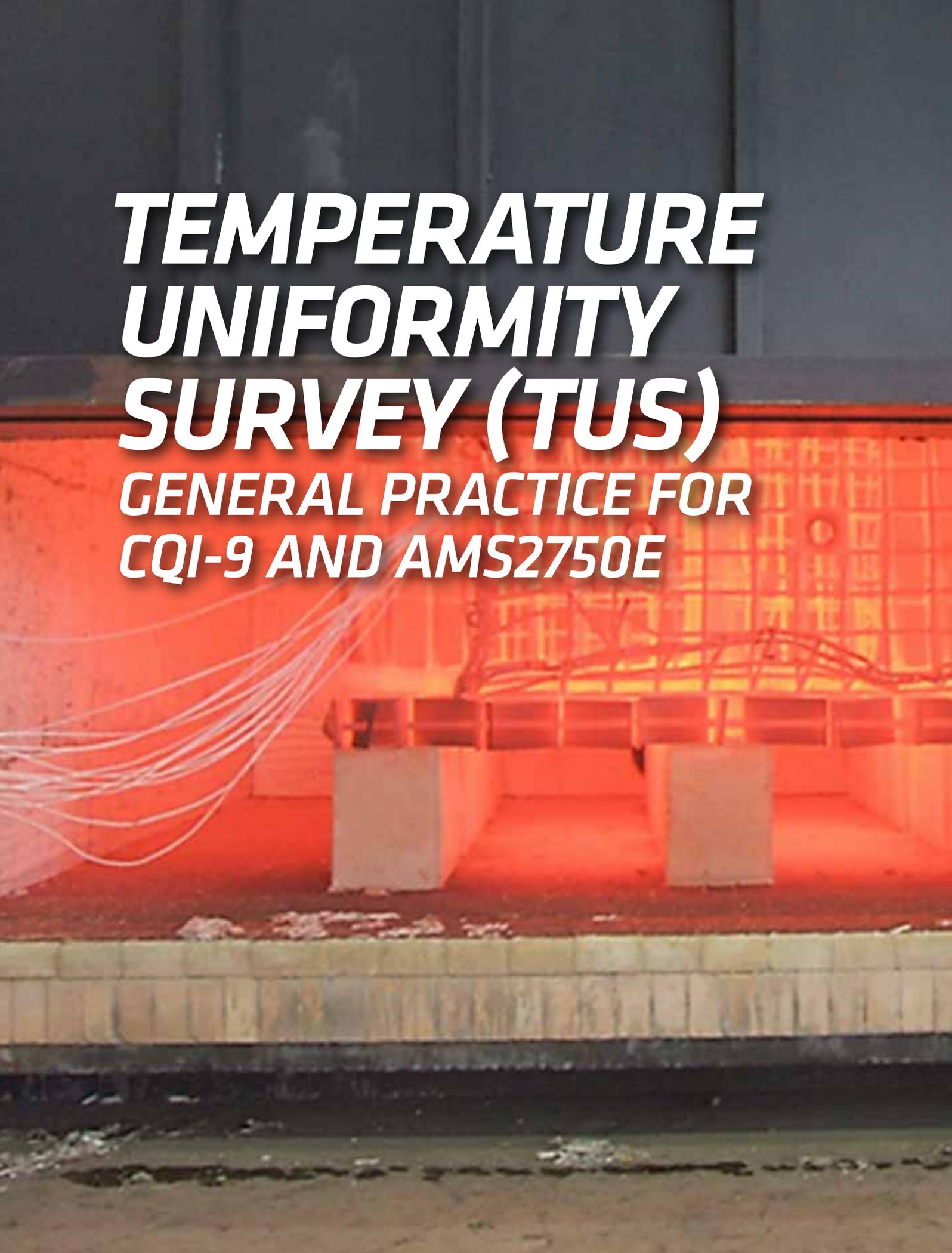
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TEMPERATURE UNIFORMITY SURVEY (TUS)

***GENERAL PRACTICE FOR
CQI-9 AND AMS2750E***

Performing a TUS validates the temperature uniformity characteristics of the qualified work zones and operating temperature ranges of furnaces or ovens used.

By STEVE DUBAN

In the automotive and aerospace manufacturing industry, CQI-9 and AMS2750 specifications are established as guidelines to:

“address pyrometric requirements for thermal processing equipment used for heat treatment. The document covers temperature sensors, instrumentation, thermal processing equipment, system accuracy tests, and temperature uniformity surveys. These are necessary to ensure that parts or raw materials are heat treated in accordance with the applicable specification(s).”

A critical part of the standards is the requirement to perform temperature uniformity surveys (TUSs). The TUS is performed to validate the temperature uniformity characteristics of the qualified work zones and operating temperature ranges of furnaces or ovens used. Ultimately, the TUS validates the temperature characteristics of the work zone and should closely match a typical heat-treat cycle with respect to ramp up speed and temperature.

To perform these surveys, heat treaters may use field instruments such as multi-channel chart recorders external to the furnace, or multi-channel chart recorders that ride in a basket on a continuous belt-type furnace (or oven). There are financial and physical considerations with both options. For example, the “thru-type” instruments have limitations regarding size of access (ingress and egress), duration, and temperature during the test process.

FURNACE CLASSIFICATION

One of the key considerations of a TUS is verifying the classification of the furnace and its qualified working zone. This determines the required ongoing testing schedule necessary to maintain conformity. The “qualified working zone” is the area of the furnace that will be used for the heat-treat process, and a TUS helps determine how close the working zone is to registering the desired temperature. The temperature uniformity range is described as a \pm degree value, as shown in Figure 1.

For example: A furnace is meant to run at 1,900°F and its qualified working zone ranges between 1,887°F and 1,913°F. This is a \pm range of 13 degrees, so it would qualify as Class 3. A higher-rated furnace classification (class 1 being the highest) means that the furnace is able to stay closer to its target temperature without variation.

SURVEY FREQUENCY

Based on the furnace classification (and instrumentation type used to conduct the TUS), the guidelines clearly determine the testing schedule necessary in order to maintain certification (see Figure 2).

Furnace Class	Temperature Uniformity Range (°F) (1)	Temperature Uniformity Range (°C)
1	± 5	± 3
2	± 10	± 6
3	± 15	± 8
4	± 20	± 10
5	± 25	± 14
6	± 50	± 28

Figure 1: Furnace Class/Uniformity Range Table.

PARTS FURNACE CLASS, INSTRUMENT TYPE, AND TEMPERATURE UNIFORMITY SURVEY INTERVAL						
Furnace Class	Temperature Uniformity		Minimum Instrument Type	Initial TUS Interval	Number of Successful Consecutive TUS (1)	Extended Periodic TUS Interval AMS 2750D = Reduced Periodic TUS Interval
	*F	*C				
1	± 5	± 3	D	Monthly	8	Bimonthly
			B, C	Monthly	4	Quarterly
			A	Monthly	2	Semiannually
2	± 10	± 6	D	Monthly	8	Bimonthly
			B, C	Monthly	4	Quarterly
			A	Monthly	2	Semiannually
3	± 15	± 8	D	Quarterly	4	Semiannually
			B, C	Quarterly	3	Semiannually
			A	Quarterly	2	Annually
4	± 20	± 10	D	Quarterly	4	Semiannually
			B, C	Quarterly	3	Semiannually
			A	Quarterly	2	Annually
5	± 25	± 14	D	Quarterly	4	Semiannually
			B, C	Quarterly	3	Semiannually
			A	Quarterly	2	Annually
6	± 50	± 28	E	Annually	Not Applicable	Annually

Refrigeration units and quench tanks do not require TUS (added)

Figure 2: Furnace Class/Instrument Type/Survey Interval Table.



The reporting process should be consistent, easy to access, and provide the proper data points.

For example: A Class 2 furnace with instrumentation type B is required to undergo a TUS on a monthly basis, whereas a Class 5 furnace with instrumentation type B only requires a quarterly TUS.

However, AMS 2750 rewards success. If a furnace completes a designated number of TUSs successfully, the interval between testing can be increased. In the above example, if the Class 2 furnace were to submit to four consecutive successful TUS surveys, the required testing frequency adjusts from monthly to quarterly.

And of course, performing fewer TUS surveys has many benefits, including decreased time spent on surveying, less documentation of the process, lower cost of labor/materials, and increased production/reduced downtime.

THERMOCOUPLE MEASURING POSITION

To perform the TUS survey, a TUS frame (or rack) must be constructed to locate the thermocouples over the standard work zone to match the form of the furnace (Figure 3). The TUS may be performed in an empty furnace (in which case thermocouples should be securely fixed to the rack or basket), or a furnace with a production load. Either method is acceptable, but once a procedure is established, subsequent surveys must be performed the same way on that equipment.

Note that a “typical” load weight and size is unpredictable for a commercial heat-treat operation, whereas a captive heat-treat operation may want to survey a furnace or oven with a specific part that it will run again and again. Due to safety practicalities, atmosphere is not required when performing a survey.

As required, the rack needs to be constructed to locate the thermocouples over the standard work zone to match the form of the furnace (Figures 4 and 5). The number of survey T/Cs are established by the workspace volume as indicated in Figure 6.

TIPS FOR INSTALLING THERMOCOUPLES

- › Ensure the insulation on the thermocouples is not damaged and avoid contact of the wires with bare metal.
- › For consistency, the tip or junction of the thermocouples should be welded and not twisted together.
- › When possible, avoid running thermocouples through the door, causing leakage points in the load chamber.
- › Try to keep the entry point where the thermocouples enter the oven constant. Shifts in the hot-to-cold transition points along the wire length can cause errors in readings.
- › Keep the tips of the thermocouple at least three inches away from any surface.
- › Avoid any sharp bends in the thermocouple – mechanical stress can cause an error in the calibration.

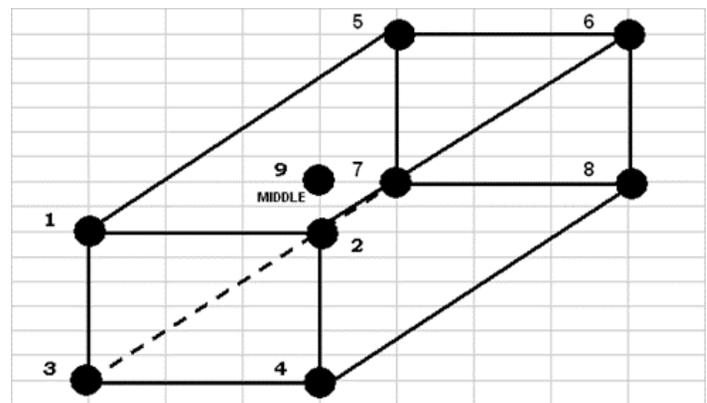
TIPS FOR A TUS

Establishing proper procedures and training will improve your efficiency for executing a survey with accurate results. Some common tips performing a TUS include:

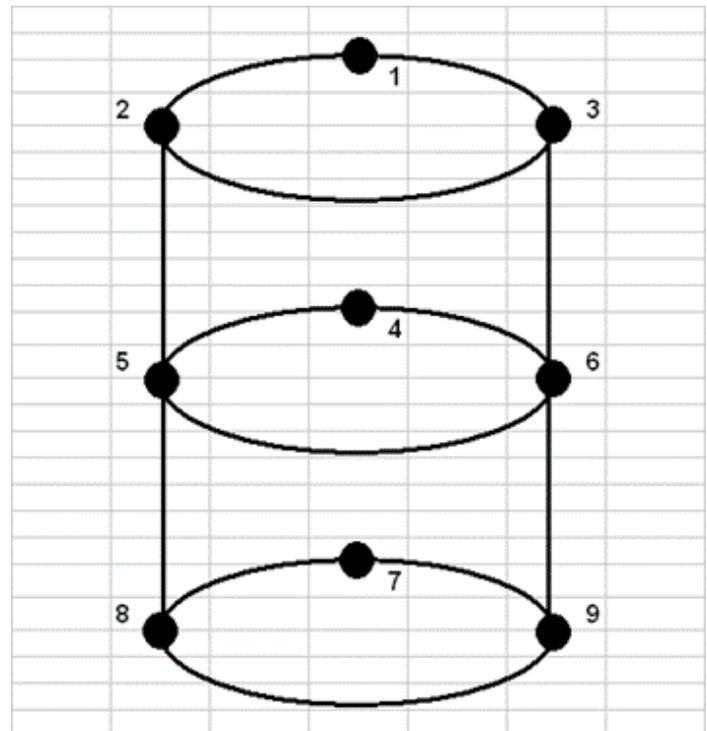
- › Verify the proper furnace classification is assigned to each asset. Remember that a furnace can be classified in more than one way. However, a furnace cannot be used for a process for which it has not met the required temperature uniformity.
- › Conduct the required number of survey-time data points, which specify two-minute intervals for each thermocouple. The data points must also include ramp (approach) and soak time.
- › Make sure the recorder or any other electrical instrument used in conducting the survey is properly grounded.
- › Be aware of any high-energy/high-frequency electrical equipment in the proximity of the survey (welding equipment, plasma cutters, EDM machines, etc.) as these types of equipment can be



Figure 3: Example of Survey Rack.



Working Zone 36" x 35" x 25"



Working Zone 18" x 16"

Figures 4 and 5: Examples of survey models.

NUMBER OF TUS SENSORS REQUIRED FOR BATCH FURNACES, SALT BATHS, CONTROLLED TEMPERATURE LIQUID BATHS, FLUIDIZED BED FURNACES, OR CONTINUOUS FURNACES TESTED USING THE VOLUMETRIC METHOD (2) (3)

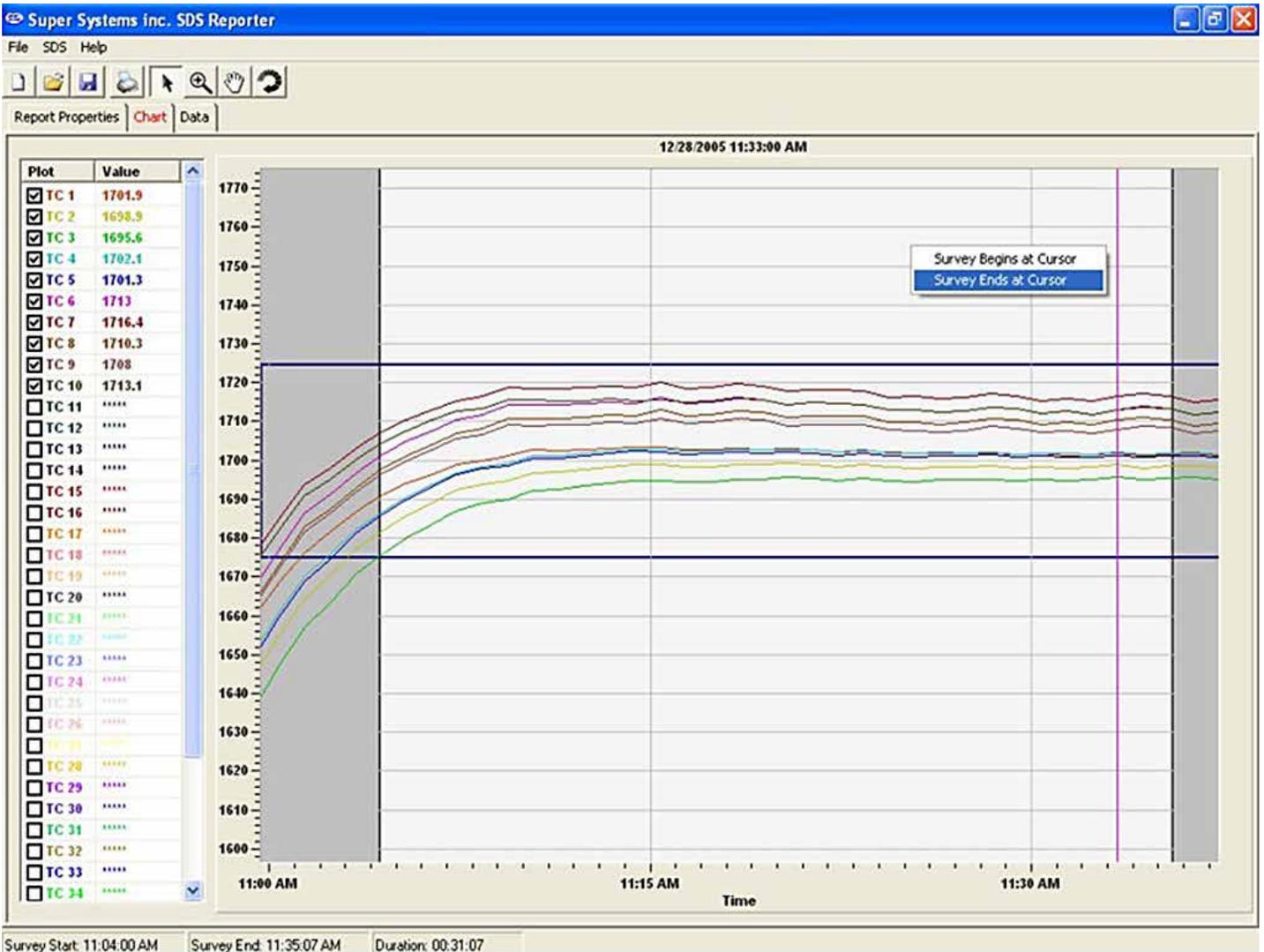
Workspace Volume Less Than	3 cubic feet (0.085 m ³)	225 cubic feet (6.4m ³)	300 cubic feet (8.5m ³)	400 cubic feet (11 m ³)	600 cubic feet (17 m ³)	800 cubic feet (23 m ³)	1000 cubic feet (28 m ³)	2000 cubic feet (57 m ³)	3000 cubic feet (85 m ³)	4000 cubic feet (113 m ³)
Number of Sensors (1) Classes 1 and 2	5	9	14	16	19	21	23	30	35	40
Number of Sensors (1) Classes 3 thru 6	5	9	12	13	14	15	16	20	23	25
Cubic feet per Sensor Classes 1 and 2	< 1	25	21	25	32	38	43	67	86	100
Cubic feet per Sensor Classes 3,4,5 and 6	< 1	25	25	31	43	53	63	100	130	160

Figure 6: Table of Required TUS Sensors.

(1) For Salt Bath Furnaces where a single probe is used for the TUS, the above numbers represent sensor locations.

(2) For furnace volumes greater than 4000 cubic feet (113 m³) use the appropriate class formula to calculate number of sensors.

- Classes 1 & 2: $9 + \frac{1}{2}$ times the square root of (Furnace Volume in cubic feet - 225 cubic feet) or $9 + \frac{1}{2}$ times the square root of [35.3 times (Furnace Volume in m³ - 6.4 m³)]



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Round this data off to the nearest degree.

TC Data	Time	TC1	TC2	TC3	TC4	TC5	TC6	TC7	TC8	TC9	TC10
▶	10:04:07 AM	701.4	664.1	647	664.6	661.5	700.1	699.6	686.1	691.9	707.3
	10:05:07 AM	704.5	666.5	649.2	666.9	663.9	701.7	701.2	687.8	693.6	709
	10:06:07 AM	707.8	670	652.4	670.1	667.2	705.6	705.2	691.8	697.5	712.7
	10:07:07 AM	710.5	672.5	654.9	672.5	669.7	707.5	707.1	693.7	699.4	714.5
	10:08:07 AM	712.2	675	657.3	674.8	672.1	709.7	709	696.1	701.6	716.6
	10:09:07 AM	713.6	677.2	659.5	676.9	674.3	711.8	711.1	698.3	703.6	718.7
	10:10:07 AM	714.8	679.1	661.5	678.8	676.3	713.8	713.2	700.4	705.7	720.3
	10:11:07 AM	716.1	681.6	664.2	681.1	678.7	716.6	715.9	703.3	708.6	722.9
	10:12:07 AM	717.1	683.6	666.2	683.1	680.8	718.1	717.2	704.6	709.8	724
	10:13:07 AM	717.3	684.5	667.3	684.1	681.7	720.1	719.3	706.9	712	725.8
	10:14:07 AM	718.2	686.1	669.2	685.6	683.3	721.2	720.1	708	713.1	726.7
	10:15:07 AM	720.5	688.9	672.1	688.7	686.3	722.5	721.7	709.4	714.9	728.3
	10:16:07 AM	725.2	691.8	674.9	692	689.7	725.6	725.1	711.9	718	731
	10:17:07 AM	733.8	696.5	679.1	697.2	694.5	730.3	730.4	716.9	723.7	736.5
	10:18:07 AM	747.1	702.7	684.4	704	701.1	737.5	738.5	723.8	731.9	744.7
	10:19:07 AM	765.6	712.6	692.6	714.2	710.7	752	749.1	733.4	742.9	755.9
	10:20:07 AM	791.9	726.2	703.9	727.7	724.1	764.8	767.3	749.4	756.8	770.5
	10:21:07 AM	819.8	741.8	716.8	743.4	739.2	784.3	787.5	768.1	777.1	792.2
	10:22:07 AM	849.9	760.2	731.8	761.1	756.7	802.5	806.9	786	796.1	812.6
	10:23:07 AM	882.4	781.9	750.7	782.1	777.4	826	831.2	809.1	820.9	838.1
	10:24:07 AM	915.9	805.7	771.7	805.5	800.7	850.4	857	833.6	846	864.6
	10:25:07 AM	950.2	830.9	794.6	830.5	825.7	878.2	886.1	860.9	874.9	894.1
	10:26:07 AM	986.4	860.9	821.9	860.1	855.4	909	917.4	889.4	906.3	926.3
	10:27:07 AM	1018.3	889.5	847.9	887.6	883.2	941.4	951	920.5	939.5	960
	10:28:07 AM	1051.9	920.8	878.1	919.3	914.8	973.9	983.6	950.4	971.8	993.5
	10:29:07 AM	1084.1	952	908.4	949.7	946.3	1006.1	1016.4	981.9	1004.6	1026.7
	10:30:07 AM	1116.5	984.1	939.8	981.8	978.8	1039.4	1050	1014.2	1037.9	1060.8
	10:31:07 AM	1148.6	1018	973.2	1015.9	1013.5	1074.1	1084.9	1048	1072.6	1095.8
	10:32:07 AM	1177.6	1049.6	1005.5	1047.6	1045.8	1107	1118	1080.8	1105.5	1130.4
	10:33:07 AM	1205.8	1081.2	1038	1080	1078.5	1139.1	1150.3	1113.8	1137	1162.8
	10:34:07 AM	1233.9	1114.2	1072.3	1113.6	1111.5	1171.8	1182.9	1147.9	1169.6	1196.1

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Sample Tabular Data Report

the source of EMF noise that may cause interference with the survey reading.

› Instrumentation (TUS device) calibration is mandatory, and the certification must state the calibration is met. The calibration documentation must state correction factors and identify the procedure for inputting these values into the report.

› Survey equipment must meet specific accuracy requirements, and the TUS device must comply to a calibration accuracy of $\pm 1^\circ\text{F}$ or ± 0.1 percent reading in F.

› Thermocouple wire includes traceability certification. Calibration records must state the correction or error factor.

› Attention is to be paid to the selection and placement of the thermocouple on the survey rack. Assure the contact between the T/Cs and the rack.

› Clearly define the work zone in the survey. Parts not processed within the defined work zone are considered to be run in a non-conforming piece of equipment. If the work zone is larger than the rack, this will result in a major non-compliance citing.

› Establish and document TUS procedures for in-house survey technicians and third-party survey companies.

› It is not necessary to qualify a furnace for uniformity that is not required.

REPORTS

The reporting process should be consistent, easy to access, and pro-

vide the proper data points. AMS-2750E, 3.5.21.1 (below) mandates the items to be included in the survey report. AMS-2750 also provides a list of items that are not a required part of the uniformity survey report, but shall be accessible on site.

3.5.21.1 The following items shall be included in the temperature uniformity survey report:

- a. Furnace identification name or number.
- b. Survey temperatures.
- c. TUS sensor and location identification including a detailed diagram, description or photograph(s) of any load or rack used.
- d. Time and temperature data from all recorded sensors required for furnace instrumentation type for all zones tested (3.5.13.3.2).
- › Correction factors as well as corrected or uncorrected readings of all TUS sensors at each survey temperature. Readings shall be identified as corrected or uncorrected. (AMS 2750D)
- e. Correction factors for TUS sensors at each survey temperature.
- f. As found and as left TUS offsets (if used in production).
- g. Corrected or uncorrected readings of all TUS sensors at each survey temperature. Readings shall be identified as corrected or uncorrected.
- h. Testing company identification (if not performed in-house).
- i. Signature for the testing company (if not performed in-house).
- j. Identification of technician performing survey.
- k. Survey start date and time.
- l. Survey end date and time.



Understanding the TUS process will allow a heat-treat operation to be proactive regarding specific requirements and responsibilities and ultimately to be consistent and perform with reliable results.

- m. Survey test instrument identification number.
 - n. Indication of test pass or test fail.
 - o. When required, documentation of furnace survey sensor failures (See 3.5.16).
 - p. Summary of corrected plus and minus TUS readings at each test temperature after stabilization.
 - q. Quality Organization approval.
- 3.5.21.2 Although not a required part of the uniformity survey report, the following shall be accessible on site:
- a. Control instrument tuning parameters.
 - b. TUS sensor calibration report.
 - c. Control and recording sensor calibration report.
 - d. Diagrams of control and recording sensors, load and TUS sensor locations in three-dimensional space.

CONCLUSION

Temperature uniformity surveys (TUS) are essential to a well per-

forming heat-treat operation. Whether to conform to AMS2750E CQI-9, the goal is to ensure the heat-treating process is conducted to the tightest tolerances. Today's heat treaters must find ways to better organize the testing process for ease of surveying and improved accuracy. Because there are many requirements to performing the TUS, time, organization, planning, and coordination are required to successfully administer the survey. To minimize the production downtime, build best practices for the activities that surround the TUS.

Understanding the TUS process will allow a heat-treat operation to be proactive regarding specific requirements and responsibilities and ultimately to be consistent and perform with reliable results. Once familiar with the equipment and the specification, a heat treater can prepare for efficient transition for surveying, minimize downtime, and streamline the process of TUS testing. And, investing time up front to document the process for future surveys, one can save time and money by identifying problems before they are too late to prevent. Be prepared:

- a: organize paperwork.
- b: ensure quick and easy access to maintenance logs.
- c: fabricate and wire TUS racks in advance.
- d: properly communicate equipment calibration dates.
- e: develop reporting techniques for efficient review and signoff.

Best practices with proper planning and preparation can shave hours off the survey process. When multiplied by a large number of furnaces, the financial benefits become clear. 🔥



ABOUT THE AUTHOR

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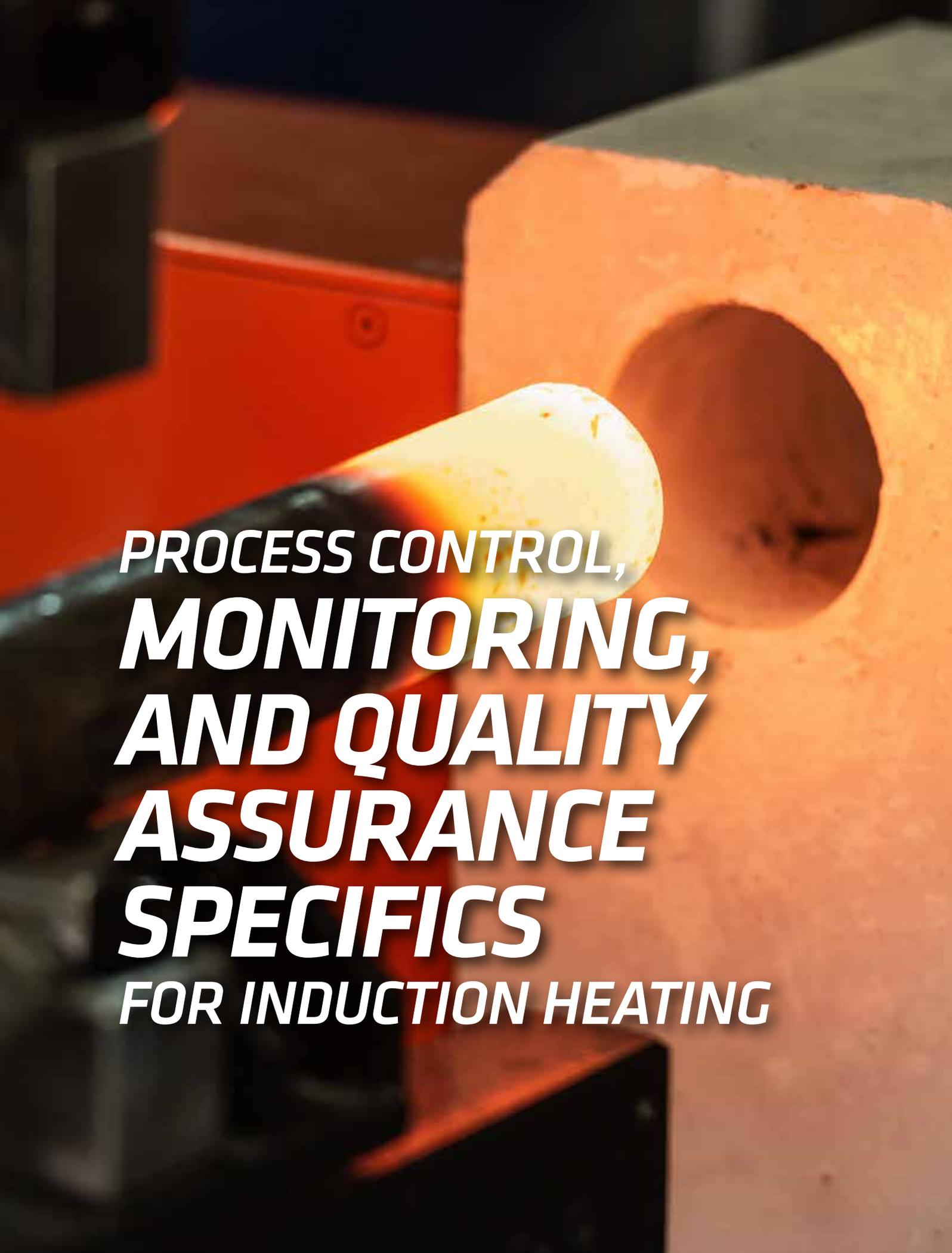


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A close-up photograph of a glowing orange metal part being heated by an induction coil. The metal part is cylindrical with a circular hole in the center. The induction coil is wrapped around the part, and a bright yellow and orange glow is visible at the point of contact, indicating the heat being generated. The background is dark and out of focus, showing some industrial equipment.

***PROCESS CONTROL,
MONITORING,
AND QUALITY
ASSURANCE
SPECIFICS
FOR INDUCTION HEATING***

Effective systems of quality control/quality assurance are essential for modern-day heat-treating practices.

By **TIMOTHY KENNAMER**

Controlling the induction-hardening process is a demanding application compared to most other thermal processes. The first and foremost requirement is to precisely control the energy delivered to the part in a reliable and repeatable manner and to deliver that energy to a precise location within the part to assure that the heat-treat pattern is per the specifications. The challenge with induction hardening is that the time elements are measured in seconds and fractions of seconds, and the power densities are measured in 10s of kilowatts per inch squared, in some cases raising the surface temperature of the part at rates as much as 2,200°C/s (4,000°F/s) or higher to a temperature accuracy typically better than 2 percent. Temperature rises at this rate occur in rapid scanning operations, for example 10.16 cm/s (4 inch/s) scan rates with a 2.54 cm (1 inch) long coil, or with small parts with shallow case depths in static heating operations where the heat times can be 0.5 seconds or less.

Equally critical is the precise control of the quenchant to cool the part at the required rate to obtain the desired metallurgical structure. Also, this process control must be implemented in a noisy electromagnetic environment generally in concert with complex and rapid machine control functions and with an independent process and part monitoring system to assure product quality. This makes control of the induction-hardening process one of the most challenging industrial control applications.

Effective systems of quality control/quality assurance are essential for modern-day heat-treating practices. The essentials of an effective control program include:

- › An independent quality assurance department.
- › Standards of quality that reflect customer needs.
- › Written procedures covering all phases of the heat-treating process, starting with prototype qualification through inspection approval for shipment.
 - › Process control documentation.
 - › Methods of maintaining part identification through heat treating and keeping written inspection records.
 - › Inspection procedures including frequency sampling, and identification and segregation procedures for nonconforming products.
 - › Schedules for calibration of test equipment.
 - › Schedules and procedures for record retention.
 - › Identification of training needed and implementation of training programs.
 - › Systems for control of documentation including review and distribution.
 - › Periodic audits.

The production of a system that meets the metallurgical specification at a production rate that meets the requirements of the customers when dealing with small time increments requires the control designer to consider all elements of the system, including the time response and characteristics of the proper controls and also the characteristics of the external elements of the system such as power supplies, valves, motion controllers, pumps, and so forth. Controls requirements can range in complexity from a small lift

rotate machine with 5 kW or less of power and a single motion that can be controlled with a simple small programmable logic controller (PLC), to sophisticated oil industry quench-and-temper lines that may be distributed over hundreds of feet, include up to 10 discrete individual machines, and have 10s of megawatts of power, multiple drives, PLCs with multiple proportional-integral-derivative (PID) loops and computers, and include distributed or Ethernet IO.

All elements of the control design are critical — from the approach to the ladder logic needed to properly, reliably, and safely control the process, to the machine wiring having proper grounding and separation of power leads from control leads, low-signal-level wiring from higher-signal levels, and isolation of servo controls from all other signals.

The control designer must also consider the manufacturing procedures and environment that will exist in the final equipment installation. If the machine is to be installed in a job shop environment where only one or two operators will be responsible for the machine and will understand the characteristics of the process and the machine, the control design can be simpler than if it will be installed in a major production environment where the machine will be operated by multiple operators who basically are unfamiliar with the operation and controls. The system then must be “foolproof.”

Another consideration is whether the machine will be installed in a facility that is unfamiliar with the induction-hardening process. Many operators will recognize that increasing the power level will increase the case depth, but they may not realize that an equally similar change in the heat time possibly caused by a change in the machine functioning will have the same or a similar effect on the process. The goal is to control energy, which is the integral of power and time, whether it is the heat run time with a static application or a change in scan speed in a scanning application.

Process monitoring with an independent monitoring system is common in many applications, especially in the automotive industry. The preferred method of monitoring should be as physically close to the end process as possible. For instance, voltage and current feedback from the coil terminals can be fed to both a signature monitoring system and an integrating circuit to produce a signal proportional to coil energy. Monitoring at the coil eliminates power circuit variables such as loose bolts and deteriorating load matching components such as capacitors and transformers. It is also prone to secondary variables. Integrating circuits for high-frequency applications are often sensitive to temperature variations of the integrating circuit components and can drift during the process, causing variations not related to the process. Although many suppliers have resolved these issues, most have migrated to coil volts squared as energy to the load measured. This greatly reduces the variables, is less expensive, and is much less error prone.

Process monitoring is a necessary quality requirement, but what many customers overlook is the diagnostic contribution of the process monitors. If the data is recorded and stored for each cycle, preferably energy and a signature, it becomes a powerful tool to diagnose process variations or to review the cause when out-of-specification



Figure 1: Vertical scanning system.

parts are observed downstream from the heat-treating equipment. If the data is available, it can be analyzed after the fact for process variation. In this regard, the preferred data is a signature from each cycle. Very few operations have the skilled personnel or the tenacity to use signature monitoring as a quality accept-reject parameter. However, as a diagnostic tool, it is powerful, and those that use it find it reduces the cost of destructive testing considerably.

Typical automotive heat treating specifications such as the AIAG Specification CQI-9, “Special Process: Heat Treat System Assessment, 3rd Edition” [1], and the Ford W-HTX heat treat specification [2] have not allowed the replacement of destructive testing with monitoring processes, but suppliers have been successful with approved self-assessment programs to replace destructive testing with proven monitoring techniques.

PROCESS CONTROL MODES

Control modes for heat treating discrete automotive, truck, or off-highway parts are typical in an open-loop mode (no feedback loop), either set up on a scanner as a power level and scan rate or in the dwell mode for static applications as a power level and a heat time. The open-loop control then depends on the power supplies for the closed-loop control (feedback to a set point) to assure that the power level requested is the power level delivered. The common modes are closed-loop control at constant voltage, constant power, or constant current.

The basic elements of control design are safety, process control, process verification, machine control, productivity, repeatability, and ease of setup. The controls for the more common types of induction hardeners include:

Scanner Systems: Scanners are widely used for induction heating. Scanners are very versatile and can be used for either vertical or horizontal applications. Typical scanners are either servo or computer numerically controlled (CNC), which allows for accurate position, speed, power, rotation, and quench control. See Figure 1 and 2 for an example of a scanning system and controls.

Lift and rotate systems: These can range from simple, single-position mechanisms that permit out-of-the-coil loading with the part to be heated either lifted or dropped into the coil. Quenching can be done within the coil or out of the coil.



The basic elements of control design are safety, process control, process verification, machine control, productivity, repeatability, and ease of setup.



Figure 2: Typical vertical scanning monitoring system.

Static Heating Systems: Static heating machines provide no part movement. The part is placed in or in proximity of an induction coil. The part is heated and quenched in place.

PROCESS MONITORING REQUIREMENTS

The system requirements vary with different induction processes and requirements. Figure 3 shows the process signatures of some items that require control and may require monitoring.

METALLURGICAL DESTRUCTIVE TESTING VS. MONITORING

A case can be made that if all process parameters are monitored accurately, then destructive testing can be greatly reduced. In-line inspection still has problems with false indications of faults, and with items such as automotive safety parts having a requirement

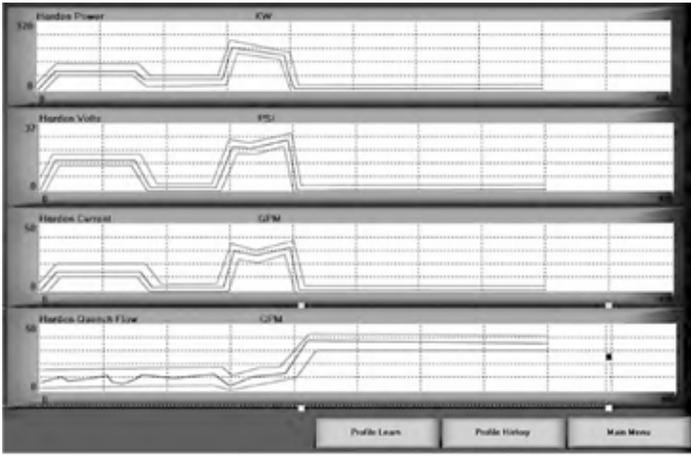


Figure 3: Process signatures.

of no defects, some destructive testing is still recommended. This monitoring incorporates all the previous items discussed.

Key factors that affect metallurgy in induction heating are the amount of power transferred to the part, the length of time the power is transferred, the amount of quench applied, the time duration of quench, and the time between end of heating to start of quenching. Changes in the power will produce parts that have a shallow case, deep case, and so forth. Changes in the quench will produce parts with varying hardness readings. If these variables can be controlled and monitored accurately, then the need for destructive testing can be reduced or eliminated. These factors, along with the normal tight control of material hardenability and structure, and quench concen-

tration and temperature, will produce total control of the process.

PROGRAMMABLE LOGIC CONTROLLERS

Programmable logic controllers (PLCs) have evolved greatly in the past few decades. Early generations allowed very simple programming basically replacing relays. Ladder logic was mostly limited to normally open or normally closed contacts and outputs. This mimicked the operation of relays and the ladder logic was similar to relay wiring diagrams, making it much easier for technicians to adapt. As PLC computer technology advanced, so did PLCs, from very basic to very sophisticated units. As math functions became available in the PLC as well as hardware advancements, PLCs became much more efficient in machine control and monitoring. Now instead of simply being able to monitor the on-off state or only have control of on/off states, designers have an array of possibilities. 🔥

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ABOUT THE AUTHOR

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COMPANY PROFILE ///

ABBOTT FURNACE COMPANY

***EXCELLING IN
ATMOSPHERIC
FURNACE
PRODUCTION***



Abbott Furnace Company is an industrial furnace manufacturer with more than 35 years of experience designing and producing some of the industry's most reliable and high performing industrial continuous belt furnaces.

By **KENNETH CARTER**, Thermal Processing editor

A good measure of success is repeat business. For a company that builds industrial furnaces, repeat customers become even more impressive.

For Abbott Furnace Company, that repeat business is indicative of just what kind of company it is.

"We have several customers who have purchased several dozen furnaces from us," said Dan Reardon, director of technical sales for Abbott Furnace. "We have many more that have purchased multiple furnaces. To me, this illustrates how well our furnaces perform and that we have a very good commitment to our customers to provide excellent service after the sale."

Abbott has, to date, produced 875 furnaces that are currently in service in a variety of industries, according to Reardon.

"Our philosophy is to be the market leader in the design, production, and service of continuous process industrial furnaces," he said. "And we do this by focusing our resources on the development of new technology to meet our customer's specifications."

ATMOSPHERIC APPLICATIONS

Abbott's furnaces run a gamut of applications, but for heat treating, Reardon said Abbott excels in atmospheric furnaces.

"We have very good troubleshooting skills, field service, and we're ISO 17025 certified for doing temperature calibrations," he said. "We're also capable of doing onsite training on our equipment and thermal processes. We can do that several different ways: We can provide that via the web through WebEx-type applications or come to your facility and present it one-on-one. We're very big into the sintering market in the PM fields."

Abbott also offers brazing furnaces, according to Reardon.

"We do a lot of brazing furnaces, and we especially excel in continuous stainless-steel brazing furnaces because we're very good at atmosphere control," he said.

Abbott has a variety of pusher furnaces with temperatures up to 2,900 degrees Fahrenheit, according to Reardon, and the company can produce roller hearth furnaces with a variety of atmospheres.

"We do continuous heat-treat furnaces like your typical oil quench furnace and all the ancillary equipment that goes with those — the washers, dryers, temper furnaces," he said. "We can do the whole line front to back."

Abbott also makes lab-scale furnaces, atmosphere generators, box furnaces, and car bottom furnaces, according to Reardon.

"We also offer some specialized batch furnaces, particularly if they require some kind of atmosphere control," he said. "Our forte is atmosphere control. But if there's something outside that market that's

required and that we can utilize our skills on, then we'll tackle that as well."

TAILOR-MADE SOLUTIONS

That means Abbott has the capabilities to tailor equipment to meet its customers' needs.

"Particularly, when we talk to a customer, you'll always hear us ask them, 'What are your time-at-temperature requirements and your atmosphere requirements?'" Reardon said. "Because, once we define what they're trying to do from a temperature and atmosphere point of view, it leads us down the path of what kind of equipment we need."

Reardon points out that involves getting with the customer and



A sintering furnace offered by Abbott. (Courtesy: Abbott Furnace)

asking specific questions to tackle the challenge, such as:

- › What is the product?
- › What is the size?
- › How do you plan on loading it on a furnace?
- › How is it going to be unloaded?

"Then we ask them to define their challenges that they have currently — if it's an existing product or if it's a new product and what they expect the challenges to be, so that, hopefully, we can design as much of the challenge out of the system as we can," he said.

If that means a new untested product, Abbott will work with them to develop a needed profile by running trials on actual production equipment, according to Reardon, which will help determine if the trial was effective and ensure the proposed process meets the customer's requirements.

INDUSTRY INNOVATIONS

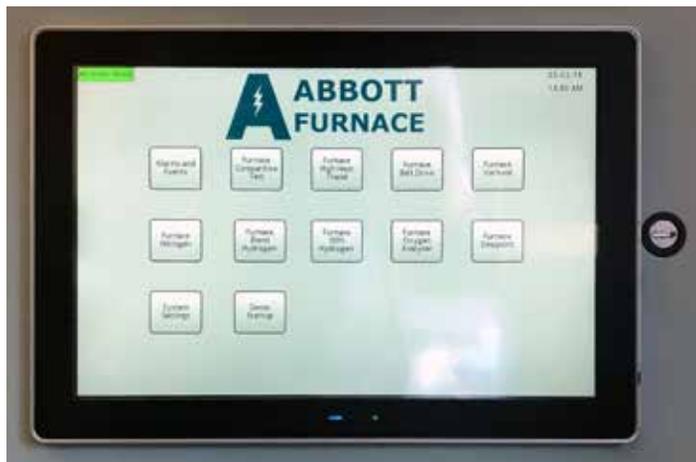
Abbott continues to push the envelope in an ever-changing industry, and has several innovations to show for it.

"We have been ISO 17025 accredited for 15 years," Reardon said. "We've also developed several furnaces to manufacture solid oxide fuel cells. In our time since 1982, we've become a market leader in

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“What we’re seeing happen now is that the industry’s becoming much more data-driven.”



Abbott Furnace's Vulcan System can perform the de-lubrication process of powder metal components more effectively. (Courtesy: Abbott Furnace)



Abbott Furnace's SMART System can save time and money by providing monthly or quarterly tests to validate equipment performance. (Courtesy: Abbott Furnace)

the powder metal business as well as a leader in supplying equipment in the stainless-steel brazing world and other brazing technologies. We've recently had two new developments at Abbott. We've developed what we call the Abbott SMART System (Self-Monitoring, Analysis and Reporting Technology). It is designed to help meet the stringent requirements that come along with heat treatment standards like the AIAG CQI-9 and other systems that require data collection.”

The SMART System can save time and money by providing monthly or quarterly tests to validate equipment performance, according to Reardon.

“We've also recently designed a new piece of equipment called the Vulcan System and if you're into the powder metal world at all, you know one of our biggest challenges is getting a lubricant out of the part,” he said. “That has been the issue for my whole career at Abbott for sure, so we tried to design a piece of equipment that would aid in that technology where we could isolate the variables required to perform the de-lubrication process more effectively. And we've designed a new system that does that quite well and efficiently. We now have four or five of them in the field, and all of them are working beyond expectations.”

MORE THAN 35 YEARS OF EXPERIENCE

Abbott has come a long way since it began in 1982 as Abbott Control Systems when it was primarily providing service for other manufacturers' equipment while building some control panels, according to Reardon. When the owner realized there was hardly any new advancements in furnace technology, he began to manufacture them himself, building its first one in 1986.

Now, Abbott Furnace has about 80 employees working in a 75,000-square-foot manufacturing facility in St. Mary's, Pennsylvania, and is still privately owned and operated. And Reardon points out that during that time, the industry has changed dramatically in the past 30-plus years.

“When we first started, we were pretty much the new kid on the block, and we had to really prove ourselves in our process and service abilities to even succeed in the industry,” he said.

A large part of that change is the move toward more data-driven equipment and processes, according to Reardon.

“What we're seeing happen now is that the industry's becoming much more data-driven,” he said. “It's not so much of a black art or witchcraft-type science as it used to be and, this is leading the industry into a new direction. We continue to try and advance our furnace technology to provide better process control and monitoring to help industry meet the Industry 4.0 challenges that you see going into the future.”

But Abbott Furnace doesn't plan on shying away from embracing the challenges brought on by Industry 4.0. On the contrary, Reardon said Abbott will continue to focus on improving its people, processes, and products, such as the Vulcan and SMART System, in order to meet the ever-changing thermal processing market's needs.

“We do this by trying to stay abreast of all the best technology that's out there and build it into our equipment to help make it more energy efficient and to try and reduce operating costs such as atmosphere costs and electrical usage for our customers,” he said. ♪

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Q&A /// INTERVIEW WITH AN INDUSTRY INSIDER

GREG JENNINGS /// PRESIDENT/CEO /// THERMAL PRODUCT SOLUTIONS AND WISCONSIN OVEN

“We’re looking to provide the market with an offering that gives customers comfort that their equipment is going to perform optimally and ensure uptime throughout its life cycle.”

What’s a typical day like for you at Wisconsin Oven?

My typical day is quite a bit of fun. I’ve got three kids, and it’s important for me to be present and involved as much as possible. Every morning I try to make breakfast before heading into the office. It’s a really good way to start the day no matter what’s ahead for me within the workday.

When I come in, it’s a combination of calls and meetings with the various business leaders and employees across TPS. With TPS having four manufacturing locations and multiple brands within them, it’s critical to have an open line of communication. I stepped in as the CEO in the summer of 2019, so from that point to today, it was really a time where we spent a lot of time collectively thinking about the brands, locations, and the paths forward making sure everyone has a clear picture on where we’re going as an organization.

Obviously, it’s an ongoing process, but I’m happy with the progress the team has made. At the end of the day, I get to work with a lot of great people that take tremendous pride in what they do, so it’s pretty easy to come into work every day.

Although my primary office is at the Wisconsin Oven location in East Troy, Wisconsin, I travel frequently to the other TPS locations in Pennsylvania, Michigan, and California.

What is Wisconsin Oven doing to adapt to this Industrial Internet of Things?

We’ve obviously seen the trajectory of the Industrial Internet of Things and Industry 4.0. Wisconsin Oven has been able to engage with our customers and collectively get feedback regarding the benefits of IIoT. Ultimately, we see that the demands can be different from customer to customer, so we spent time working with customers to better understand their perspective. Even though we’re still in the developmental and testing stages, the progress on the initiative has been incredible. We’re looking to provide the market with an offering that gives customers comfort that their equipment is going to perform optimally and ensure uptime throughout its life cycle.

What is Wisconsin Oven doing to enable its ovens to support the Industrial Internet of Things?

Currently, there are a number of sensors on the equipment. What’s going to differentiate what is on the equipment now to what we’re



going to provide is the additional sensors, the frequency of data collection, the retention of data, and the ability to monitor the data within a cloud solution. We understand that customers are rightfully sensitive to data security, so in addition to a cloud solution, we will also provide the ability to collect the data and not transfer it without direct interaction.

Ultimately, these pieces of equipment can be installed for 20 to 30 years. And just with any piece of capital equipment, over time, it needs maintenance. Maybe it’s been done over the course of time and maybe it hasn’t, but we want to make sure the customer is still able to meet their manufacturing needs.

The ability to track data within set criteria is critical to that. We can set alerts to variances that may occur, thus enabling a pre-emptive response that can save a customer from un-warranted downtime.

By having sensors that can upload alerts to the cloud, is this the next step into preventive maintenance?

I think it’s a very, very significant step. Again, the ability to see any variance in performance of key items such as temperature, uniformity, pressure, and vibration may be an indication that there is a deviation from peak performance. Being able to identify that as quickly as possible is critical.

Will this involve any special training, and will it actually make processes easier to understand, monitor, and control?

We’re not expecting that any significant training should be needed. We’re looking to make things easier and faster than historical approaches. We’ve identified a very simple and intuitive interface that has garnered positive feedback.

What kind of plans does Wisconsin Oven have to help retrofit older ovens?

Wisconsin Oven is absolutely looking to provide a solution that may be added to equipment that is already in the field. Obtaining the data on a new oven is critical, but just as critical is the ability to connect and collect this information on older ovens. Again, thinking about these pieces of equipment over time, the faster we’re able to identify any variance in performance, the better. ♣

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