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The editorial focus for HTPro in 2016 reflects some key technology areas wherein opportunities exist to lower manufacturing and processing costs, reduce energy consumption, and improve performance of heat treated components through continual research and development.

**June** Testing and Process Control  
**October** Thermal Processing in Automotive Applications  
**November** Atmosphere/Vacuum Heat Treating

To contribute an article to one of the upcoming issues, contact Frances Richards at frances.richards@asminternational.org.

To advertise, contact Erik Klingerman at erik.klingerman@asminternational.org.
At the time I wrote my previous column last October, Heat Treat 2015 was right around the corner. It’s almost impossible to believe that was nearly six months ago. The show was a huge success with more than 7000 attendees from all around the world, over 140 presentations, and numerous networking opportunities. ASM’s Heat Treating Society (HTS) is now building on the momentum created at Heat Treat 2015 with two internationally flavored events in 2016.

In April, the 23rd IFHTSE Congress will be held in beautiful Savannah, Georgia, sponsored by HTS and the International Federation of Heat Treatment and Surface Engineering (IFHTSE). The meeting will bring together international experts to share some of the latest developments in thermal processing, heat treating, and surface engineering. These are critical topics because technological advancements in these areas are crucial to cost-effective manufacturing of products in almost every industry. Visit asminternational.org/web/ifhtse for more information.

Coming up in October is Heat Treat Mexico, a new international show taking place in Queretaro, an automotive and aerospace hub. More than 35 technical sessions will focus on topics such as induction heat treating, carburizing, nitriding, and more. Registration includes three full days of technical programming as well as a free “Metallurgy for the Non-Metallurgist” short course. Visit asminternational.org/web/htmexico to learn more.

Beyond events, HTS is busy aggressively updating our education courses to be able to meet the needs of our U.S. members as well as our international membership. We are also working more closely with other ASM affiliate societies to ensure that best practices are being implemented across the board. In addition, we are focusing on attracting younger members—both college age and young professionals—to the heat treating industry. Our goal is to capture, nurture, embrace, and encourage the excitement and passion of our younger cohort. They make HTS stronger and are our future leaders.

Finally, as I’ve mentioned before, we must have fun. We all spend many of our waking hours at work and work-related events. The more you put in, the more you get out. Being an active member of HTS provides a built-in network of industry peers and helps create the vibrant heat treating community we all benefit from.

I hope to see you in Savannah next month!

Stephen G. Kowalski
President, ASM Heat Treating Society

Busted!
This company’s QA program AND reputation

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Visit us on-site at IFHTSE or go to houghtonheattreat.com to download product data sheets and technical papers/presentations.
HEAT TREATING SOCIETY SEEKS BOARD NOMINATIONS

The ASM Heat Treating Society (HTS) Awards and Nominations Committee is seeking nominations for three directors, a student board member, and a young professional board member. Candidates must be an HTS member in good standing. Nominations should be made on the formal nomination form and can be submitted by a chapter, council, committee, HTS member, or an affiliate society. The HTS Nominating Committee may consider any HTS member, even those who have previously served on the HTS Board. Nominations for board members are due March 21.

For more information and the nomination form, visit hts.asminternational.org and click on Membership and Networking, then Board Nominations; or contact Joanne Miller at 440.338.5151 ext. 5513, joanne.miller@asminternational.org.

HTS SEEKS STUDENT BOARD MEMBER APPLICATIONS

HTS is continuing its successful Student Board Member Program and is looking for Material Advantage student members to provide insights and ideas to HTS.

Opportunities include:
- All expenses to attend meetings paid for by the Society
- Take an active role in shaping the future of your professional Society
- Actively participate in your professional Society’s board meetings
- Gain leadership skills to enhance your career
- Add a unique experience to your resume
- Represent Material Advantage and speak on behalf of students
- Work with leading professionals in the field

Application deadline is April 1. Visit asminternational.org/students/student-board-member-programs for complete form and rules.

KEOUGH TO PRESENT AFS HONORARY LECTURE

John R. (Chip) Keough, FASM, of Applied Process Inc., Ann Arbor, Mich., was selected by the American Foundry Society (AFS) to present the Cast Iron Division Honorary Lecture at its upcoming Metalcasting Congress in April. The lecture was established in 1993 to honor distinguished members of AFS who have contributed to the knowledge base of cast iron. Keough was selected by the leadership of the Cast Iron Division Programs and Papers Committee to present the invited lecture. Past talks have been delivered by both metal casting professors and industry leaders. Keough’s lecture, entitled “The Stuff Matters,” will be held on April 17 at the AFS Metalcasting Congress in Minneapolis. Keough is director of the technologies division at Applied Process Inc. and also serves as ASM board liaison on the ASM Heat Treating Society Board. For more information, visit afsinc.org.

WPI RECEIVES BERNARD M. GORDON PRIZE

The 2016 Bernard M. Gordon Prize for Innovation in Engineering and Technology Education was awarded to Worcester Polytechnic Institute (WPI) educators Diran Apelian, FASM (pictured), Arthur Heinricher, Richard Vaz, and Kristin Wobbe “for a project-based engineering curriculum developing leadership, innovative problem-solving, interdisciplinary collaboration, and global competencies.”

The project-based engineering curriculum at WPI prepares 21st century leaders to tackle global issues through interdisciplinary collaboration, communication, and critical thinking. The Institute’s engineering program engages students with a specially designed sequence in which first-year students complete projects on topics such as energy and water; second-year capstones focus on the humanities and arts; junior-year interdisciplinary projects relate technology to society; and senior design projects are done in conjunction with external sponsors, providing relevant experience upon graduation.
Last year, WPI launched its Institute on Project-Based Learning, an initiative to help other colleges and universities make progress toward implementing project-based learning on their campuses. The Bernard M. Gordon Prize for Innovation in Engineering and Technology Education is one of the most prestigious awards in engineering education. For more information, visit wpi.edu.

**PRACTICAL HEAT TREATING TO BE HELD APRIL 4-7**

*Practical Heat Treating*, taught by William Mankins, FASM, will take place April 4-7 at ASM Headquarters in Materials Park, Ohio. This course focuses on the “how” of heat treating and includes a textbook, *Practical Heat Treating Second Edition*. Students will learn the heat treatment process of steel as well as what type of atmosphere is best for furnace operations for the safety of personnel and equipment. In addition, attendees will learn to recognize heat treating problems and establish quality control procedures. Plant managers, quality control specialists, and engineers alike will benefit from attending this four-day event. Upon completing the course, participants should be able to define and discuss the heat treatment process of steel and other materials; describe heat treat furnace operations and atmospheres for the safety of personnel and equipment as well as maintenance and control; and recognize heat treating problems and establish quality control procedures to produce satisfactory products.

**CONTACT US TODAY**

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[www.asminternational.org/publish](http://www.asminternational.org/publish)
George Pfaffmann was well known throughout the heat treating industry and was an active member of ASM International. He served on ASM’s Technology and Programming Committee and the ASM Materials Education Foundation, as well as the Heat Treating Society Board of Trustees and R&D Committee.

In September 2013, he presented a talk during the “Masters of Heat Treating Series” at the 27th ASM Heat Treating Society Conference and Exposition in Indianapolis. He spoke about Edwin F. Northrup (1866-1940), widely considered the “father of induction heating.” Some of George’s other accomplishments include:

- George H. Bodeen Heat Treating Achievement Award, 2003
- ASM Heat Treating Honorary International Symposium Award on Induction Hardening, 2003
- Served on the National Research Council committee to draft the DOE-ITP report, “Decreasing Energy Intensity in Manufacturing”
- Co-recipient of R&D Magazine’s R&D 100 Award for 2009
- Enlisted in the U.S. Army during WWII and served during the Korean war
- 38 U.S. patents and many more international patents
- Over 50 years of service to ASM

I worked with George for almost a decade. He loved technical research and would long to get to the office at six in the morning and work until late in the evening. Even during the last few weeks before he passed, George would follow the technical developments and contribute his thoughts and opinions. The last technical paper he co-authored, Induction Coupled Thermo-Magnetic Processing, was presented in October 2015 at the 28th ASM Heat Treating Society Conference and Exposition in Detroit.

The work cited below is from discussions with George’s colleague, Ron R. Akers, VP of R&D at Ajax Tocco Magnethermic Corp. In 2002, George retired as Ajax Tocco’s VP of Technology, after working for 50 years. He then rejoined the company as a consultant VP of Technology until November 22, 2015. George was part of widespread changes the U.S. automotive industry experienced over the past 50 years. The industry went from 100,000-mile automobile lifetimes to today where 100,000-mile warranties are common. Average mileage has doubled and performance has been enhanced to where most cars are at performance levels approaching previous muscle cars. George was in Detroit during this period and led much of the induction industry’s contributions to these changes.

His legacy includes the following:

- **Camshaft hardening**: George was involved in the conversion from flame hardening to induction hardening of camshafts in the early 1950s and later added high power density hardening to that technology.

- **Axle shaft hardening**: George was a leading contributor to the development of full length scan hardening of axle shafts, improving resistance to torsional fatigue by 200%.

- **Single shot axle hardening and tempering**: George was involved with introducing the single shot process, increasing the induction hardening production rate to allow the process to be put in line with other processes and improving the metallurgical pattern for many parts that were previously scanned.

- **Restraint axle hardening**: George was a leading member of the team that introduced restraint axle hardening to the automotive industry.

- **Valve seat hardening**: George invented the induction valve seat hardening process, which was the major breakthrough that paved the way for conversion from leaded to unleaded gasoline.

- **Gears**: George has many patents and achievements regarding gears, such as profile gear hardening and front wheel sprocket hardening.

- **Powdered metal atomization**: George was part of the early gas atomization process for the production of fine, pure, and high temperature metal powders.

- **Hot metal gas forming**: George was an integral part of the Auto Body Consortium in developing a process to replace hydroforming of auto body structural parts.
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USING VACUUM FURNACES TO PROCESS 3D-PRINTED PARTS

Vacuum heat treating is a crucial step in the additive manufacturing process cycle to meet required part quality specifications.

Robert Hill, FASM,* Solar Atmospheres of Western PA, Hermitage, Pa.

Additive manufacturing (AM), or 3D printing, is a revolutionary technology that involves converting a digital model into a net- or near-net shape metallic part by building up layers of powder or wrought feedstock. Many believe AM will change the world of manufacturing, while others believe it will never replace machining, otherwise known as subtractive manufacturing. The reality probably lies somewhere between the skepticism and hype.

OPPORTUNITIES AND CHALLENGES

The possibilities and benefits of AM are exciting. A huge advantage of the process is that it uses only the material needed to make the part. In addition, unlike subtractive manufacturing, AM has no design constraints, enabling freedom of design for functionality. AM also significantly reduces the time from part design to market: Part manufacturing often begins within one hour of final design.

The various methods of additive manufacturing are truly revolutionary technologies, which present many challenges. One of the main hurdles is the high cost of equipment, where a single printer with ancillary equipment can cost roughly $1 million. Printer feedstock materials are also expensive. For example, the price of metallic powders ranges from $300/lb for alloy steel to $1200/lb for titanium alloys.

The AM field also lacks industry-wide standards. AM metallurgy consists of multiple recast layers (versus traditional metallurgy of one homogenous melt of material), which can result in many inconsistencies. Issues that need to be resolved include how individual layers of deposited material are qualified, quantified, and inspected. Acceptable levels of porosity and density must also be defined. In addition, certain processes produce parts that exhibit different mechanical properties longitudinally with the deposit and transversely across the deposit.

Therefore, the big challenge facing the AM industry is to identify new, effective quality assurance techniques. In most cases, certification and validation initiatives for AM products are being driven by primary contractors such as General Electric Aviation and Lockheed Martin. Many aerospace OEMs have spent millions of dollars on the research and development of new opportunities, especially for the jet engine. With the design freedom that AM provides, aeronautical engineers can now model to the fit, form, and function of a particular part with minimal constraints. As more AM components continue to evolve from the lab into production, the benefits of greater strength, less weight, and significant fuel savings often outweigh the cost. (Fig. 1).

ADDITIVE PROCESSES

Direct metal laser sintering (DMLS) is a process in which metal powder is injected into a high-power (400-1000 W) focused laser beam operating under tightly controlled at-mospheric conditions. The laser beam melts the surface of the target material, generating a small molten pool of base material. Powder is delivered and absorbed into the pool, forming a deposit. Typically, the DMLS process is carried out in an inert chamber to control oxidation of the metallic pool. Materials processed via this method include titanium, Inco-nel, and cobalt-chromium alloys. The low deposition rate of DMLS enables production of fine details (Fig. 2).

Electron beam additive manufacturing (EBAM) directs a high-power electron beam to selectively fuse wire on a plate...
of similar material within a vacuum chamber. The process deposits material at a higher rate than DMLS, but the finished shape is not as fine. Material for EBAM parts that are vacuum heat treated is predominantly Ti-6Al-4V (Fig. 3).

**Binder jet process (BJP)** involves spraying a liquid binder onto a bed of powder at ambient temperature. The conglomeration of the binder and powder is solidified using a very low heat source equivalent to a heat lamp. Each layer is printed in a manner similar to a printer depositing ink on paper. The printed part is lowered after each layer solidifies until the component is complete (Fig. 4). This method has the lowest manufacturing cost of all additive processes—as much as 10 times less expensive. However, vacuum heat treating of BJP parts is more complicated.

**VACUUM HEAT TREATING AM PARTS**

AM is rapidly developing due to the demand for near-net shape parts with geometries that are impossible to machine. Because AM parts require very little material removal during downstream processing, it is imperative that finished parts do not have any decarburization or contaminated surfaces from subsequent thermal processing. Therefore, a crucial piece of equipment in the additive manufacturing industry is a well-maintained vacuum furnace, which operates totally devoid of oxygen, is equipped with diffusion pumps to achieve deep vacuum levels, and has very precise temperature control (Fig. 5).

One of the most important factors for successful inert vacuum heat treatment of AM parts is a leak-free furnace. Therefore, a leak rate of less than five microns per hour is imperative regardless of the chamber size. The furnace must also be thoroughly baked out at a minimum temperature of 2400°F prior to an AM furnace cycle. Overall temperature uniformity is critical for successful thermal processing of any parts, especially printed parts. For example, BJP components function as a type of thermocouple sensor. A BJP workpiece that does not reach or exceed a ±2°F temperature range exhibits a lack of temperature control in the form of excessive shrinkage or growth. Therefore, when sintering temperatures (around 2500°F) preclude attaching thermocouples to the workpiece, a Type S sensor must be strategically located within inches of the workpiece (Fig. 6). There is tremendous potential for scrap without precise temperature control.

Solar Atmospheres has processed AM parts of many shapes and sizes. The DMLS method generally requires...
three vacuum heat treating processes per various aerospace standards—vacuum annealing, vacuum aging, and vacuum stress relieving.

Typically, prior to heat treating, EBAM baseplates are severely warped due to high heat concentration of the electron beam on one side of the base material. To counteract the warping, AM companies are trying to simultaneously print on both sides of the base plate. Until the distortion can be better controlled, vacuum annealing and vacuum stress relieving processes are used to “creep form” the parts back into shape so they can be finish machined. Graphite plates, molds, and stainless steel weights are used to help accomplish this task (Fig. 7).

Because BJP involves very little heat during manufacturing, downstream heat treating is often challenging. As with metal injection molding (MIM) metallurgy, the BJP part must be fully densified by vacuum sintering. Sintering temperatures are often within 10°F of the melting point of the base material, so precise pyrometric control is critical. In addition, slow ramp-up rates and various holding times are crucial to bake off residual binders remaining within the de-lubed parts.

CONCLUSIONS

Global 3D printing industry revenues from products and services exceeded $2.2 billion in 2014. Revenues for the global market are expected to exceed $21 billion by the year 2020, according to the Wohlers Report on Additive Manufacturing and 3D Printing.

The aerospace industry is not the only niche market where AM is making its mark. AM in the medical device market has also grown significantly. The technology’s geometric design freedom is particularly useful in orthopedics, enabling the design of more natural anatomical shapes while printing the porous surfaces required for bone grafting purposes.

Additive manufacturing is not yet the manufacturing panacea portrayed by its enthusiasts. Today, 3D printing is not likely to replace traditional machining, because AM only eliminates some—and not all—machining. Even the best finish produced by printing requires final machining and/or grinding, especially for parts that need to be assembled to other components. Additive manufacturing is not about forcing manufacturers and heat treaters to abandon conventional manufacturing processes used for decades. However, it offers an exciting alternative manufacturing method, especially when savings can be realized in design flexibility and fewer manufacturing steps—or even billions of dollars in jet fuel.

For more information: Robert Hill is President, Solar Atmospheres of Western PA, 30 Industrial Rd., Hermitage, PA 16148, 724.982.0660, ext. 2224, bobh@solarwpa.com, www.solaratm.com.
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MINIMIZING ALPHA CASE DURING VACUUM FURNACE HEAT TREATING

Understanding detrimental alpha case formation during heat treatment of titanium parts is increasingly important as titanium use in aerospace and medical applications continues to grow.


Alpha case is a diffusion reaction that occurs at the surface of titanium when processing at elevated temperature in atmospheres containing oxygen, nitrogen, and/or carbon, with oxygen as the prominent element associated with alpha case. Oxygen is solution strengthening at low concentrations, but greatly decreases ductility and forms alpha case at higher concentrations. Thus, alpha case is brittle and has a detrimental effect on part performance and longevity. Higher temperatures increase alpha case. Above 480°C (996°F), air or water vapor begins to produce alpha case. Temperatures less than 550°C (1022°F) limit oxygen mobility and keep the case depth from increasing[1].

To minimize alpha case, high integrity titanium parts are often heat treated in vacuum furnaces to avoid having to remove the case by machining or pickling. The majority of today’s production vacuum furnaces are insulated with graphite felt. At lower temperatures in vacuum, water vapor is the principal concern for oxidizing titanium when H₂O dissociates. It is known in industry that water vapor is difficult to “pump out” at low temperature in vacuum. As the temperature increases, water vapor present in the vacuum chamber will be “driven out,” oxidizing titanium on the ramp-up to the cycle hold temperature. At higher temperatures, water vapor decreases while CO₂ and CO increase, providing additional sources for alpha case formation[2].

In an attempt to minimize oxidation, industry practitioners slow down the ramp rate and incorporate temperature holds if outgassing occurs a certain pressure[3]. Sound practice requires an initial pumpdown to 1 x 10⁻⁴ torr or lower (AMS2769 specification) and relatively slow ramp at 600°F/hr; if outgassing occurs, hold until the pressure drops to 2 x 10⁻⁴ torr. Such procedures negatively affect production time. The current study looks at whether such protocols are reliably effective in reducing alpha case formation.

Color is often used as a post-welding and heat treatment criterion to indicate presence of alpha case. This study examines whether there is any correlation between color and extent of alpha case.

After polishing and etching, alpha case is visible under a microscope as a white-appearing microstructure zone, or alpha phase. The literature lists three principal etchants for revealing titanium alpha case: Kroll’s reagent, 2% HF, and Kroll’s reagent followed immediately by 2% ammonium bifluoride. Etchant dwell time is an important variable in obtaining reliable results.

PROCEDURE

Ti-6Al-4V sheet was cut into 13 coupons approximately 1.5 in. square. Twelve samples were divided into six pairs for use in six separate heat treat cycles. The 13th sample was retained as the non-heat-treated baseline (virgin) for metallographic analysis. Additional titanium sheet was used in Test 5 to increase surface area by a factor of nine compared to the other five tests.

The furnace used for all tests was a cylindrical, vertical vacuum furnace—10-in. diameter × 18 in. high—with graphite felt insulation and graphite heating elements. An Ametek residual gas analyzer (RGA) was attached to the furnace. The RGA captures a sample of residual gases in the furnace hot zone to provide a trend analysis of relative gas composition and pressure during the cycle.

Two ramp rates, one relatively slow and the other fast, and two hold temperatures were used for five test cycles. All cycles began after an initial pumpdown to 1 x 10⁻⁴ torr. The one-step fast ramp rate was 1200°F/hr to the hold temperature. The two-step slow ramp rate was 300°F/hr to 900°F, then 600°F/hr to the hold temperature. The two hold temperatures were 1450°F and 1750°F with a one-hour hold time. The sixth test cycle used a three-step ramp rate as follows: 300°F/hr to 600°F, one hour hold; 300°F/hr to 900°F, one hour hold; 600°F/hr to 1450°F, one hour hold.

Two coupons were hung on separate molybdenum wires attached to the lid of the furnace for each cycle. One coupon was intended to be color analyzed using a HunterLab spectrophotometer. The second coupon was used for metallographic analysis of alpha case. Specimens were etched using either Kroll’s reagent, 2% HF, or Kroll’s followed immediately by 2% ammonium bifluoride. Comparisons were made as to which etchant best delineated alpha case along with the effect of dwell time.

RESULTS AND DISCUSSION

The appearance of coupons from all tests reveals that color is not a distinguishing material attribute (Fig. 1). It is more accurate to say that the samples vary in reflectivity...
more than color. As a result, the spectrophotometer was not useful for its intended function. However, differences in reflectivity proved meaningful, showing that bright-appearing samples can exhibit more alpha case than non-bright samples. Figure 1 summarizes these results. The two coupons heated to 1450°F show a yellowish tint. The two coupons heated to 1750°F are matte gray. The coupon of Cycle 5 appears as bright as the virgin piece. Based on appearance, the sample from Cycle 5 might suggest that there is no alpha case. However, Test Piece 5 exhibits considerably more alpha case than the yellow tinted samples from Tests 2 and 4.

RGA data reveals that water vapor is the primary oxidizing residual gas resulting in alpha case. As temperature rises, the partial pressure of carbon monoxide and carbon dioxide increase to contribute to alpha case formation. Yet ultimately, the trends show a continuous decrease in partial pressure of furnace gases due to the strong gettering effect of titanium (Fig. 2).

Metallographic results show that visual inspection cannot reliably be used as an indication of alpha case. Varying the ramp rate or incorporating intermittent temperature holds did not affect the amount of alpha case formed in the low temperature cycles (Fig. 3) or high temperature cycles (Fig. 4). Comparison of Cycles 3 and 5, which were one-step fast ramps to 1750°F, shows that increased surface area reduces the amount of alpha case formation (Fig. 5).

Evaluation of three different metallographic etchants indicate that 2% HF best distinguishes the delineation between alpha case and base metal (Fig. 6). However, etching time is all-important in generating an accurate reading.
Fig. 6 — Etchant effect on delineation of alpha case.

regardless of which etchant is used. Etchant times between six and 10 seconds using 2% HF delineate comparable alpha case when etched immediately after polishing. Etching times longer than 10 seconds cause the case to appear shallower in depth (Fig. 7).

CONCLUSIONS

The surface color or reflectivity of titanium after heat treatment is independent of the underlying alpha case. Varying ramp rates or instituting intermediate temperature holds during outgassing did not minimize the formation of alpha case, owing to the strong gettering effect of titanium as revealed by the RGA. Temperature, time, surface area, and furnace cleanliness all contribute to the extent of alpha case formation.

RGA data reveals that water vapor is the primary oxidizing residual gas. As temperature increases, carbon monoxide and carbon dioxide contribute to alpha case formation in a graphite-insulated vacuum furnace. Introduction of sacrificial gettering surface area decreased the amount of alpha case on any given test coupon. Thus, it is most beneficial to process as many parts (surface area) as feasible in a heat treatment load. Ramping directly to the hold temperature is beneficial to production efficiency.

Metallographic comparisons of three etchants indicate that etchant type and dwell time can considerably influence the observed depth of alpha case.


References
The ASM Heat Treating Society and the International Federation of Heat Treatment and Surface Engineering have partnered to present an exciting event focused on thermal processing, heat treating and surface engineering.

REGISTRATION PRICE INCLUDES:

- 3-Day Technical Program featuring over 120 presentations and a special symposium on residual stress
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- Welcome Reception with Exhibitors (Monday)
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- Access to Online Conference Proceedings

EARLY BIRD REGISTRATION ENDS MARCH 11

Save $100 off registration on or before March 11. To take advantage of this deal, visit: asminternational.org/ifhtse
Plan now to attend the 23rd iteration of the IFHTSE Congress, an exciting global event focused on thermal processing, heat treating, and surface engineering organized by the ASM Heat Treating Society and the International Federation of Heat Treatment and Surface Engineering (IFHTSE). The event takes place this April in Savannah, Georgia, and is expected to draw attendees and exhibitors alike for record attendance.

The technical program is now live and registration is open to the public. Registration includes access to the three-day technical program, daily lunch and refreshment breaks, an exhibitors welcome reception on Monday, a reception/dinner on Wednesday, dedicated networking time with exhibitors, and access to online conference proceedings. An optional riverboat cruise takes place Tuesday evening.

CONFERENCE HIGHLIGHTS

Keynote Presentations, Tuesday, April 19

Very Short and Very Long Heat-Treatments in the Processing of Steel
9:00 a.m.

Presented by Prof. H.K.D.H. Bhadeshia, Dept. of Materials Science and Metallurgy, University of Cambridge

Harry Bhadeshia is the TATA Steel Professor of Metallurgy at the University of Cambridge. His research is concerned with the theory of solid-state transformations in metals, particularly multicomponent steels, with the goal of creating novel alloys and processes with the minimum use of resources.

Alloying Element Nitride Development in Ferritic Fe-based Materials upon Nitriding
10:00 a.m.

Presented by Mr. Tobias Steiner

Tobias Steiner is a materials expert for stainless steels at Robert Bosch GmbH in the department GS/ECC-FA. His research is mainly focused on the nitriding behavior of ternary Fe-Cr-Mo alloys and the evolution of the XRD peak shape upon nitriding of ferritic alloys.

Surface Treatment by Electron Beam in Combination with Other Heat Treatment Technologies
11:00 a.m.

Presented by Prof. Dr.-Ing. habil. Rolf Zenker, Zenker Consult Mittweida

Rolf Zenker is Honorary Professor at TU Bergakademie Freiberg and Managing Director of Zenker-Consult Mittweida.

Residual Stress Symposium

This special symposium will provide an overview of the current state of the art for residual stress prediction, measurement, and control in industry. Presentations will be given by major aerospace OEMs and experts in the field of residual stress modeling and measurement.

Technical Program

Technical program topics include vacuum processes and technology, advanced thermal processing, ferrous and non-ferrous mechanical properties, materials characterization, quenching and quenchants, nitriding, and tribology and wear of engineered surfaces.
NETWORKING OPPORTUNITIES
Welcome Reception with Exhibitors
Monday, April 18, 5:30-7:30 p.m.
Hyatt Regency Savannah
Relax, meet with exhibitors, and enjoy light appetizers and drinks.

Savannah Riverboat Cruise
Tuesday, April 19, 6:30-9:00 p.m.
Tickets: $85.00 each (pre-registration required)
Don’t miss this exciting night aboard the Savannah Riverboat Cruise with a delicious buffet dinner featuring local cuisine. Venture onto the top deck and capture an amazing evening view of one of the most famous waterfronts in the world.

Reception and Dinner
Wednesday, April 20, 6:00-8:00 p.m.
Hyatt Regency Savannah
One ticket is included with registration. Additional tickets are $70.00 each.
Enjoy a night with friends and colleagues at the IFHTSE 2016 Dinner Reception.

Spouse Program
Wednesday, April 20, 10:30 a.m.-2:00 p.m
Tickets: $75.00 each (pre-registration required)
View beautiful downtown Savannah on this 90-minute guided history trolley tour and enjoy lunch at The Lady & Sons. Program includes on/off trolley access after the tour for the rest of the day.

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- Houghton International Inc.
- Sajjan Precision Castings
- SECO/WARWICK CORP.
- Thermo-Calc Software Inc.
- Wickert Hydraulic Presses USA
- WPX Faserkeramik GmbH

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Thermal Processing Box Furnace

Standard Features & Benefits

• Temperature range to 2000°F with exceptional uniformity
• Low maintenance
• Low watt density RO elements provide longer life and reduced maintenance costs
• Lightweight ceramic block insulation is energy efficient
• Pneumatically operated door for ease of use
• Circulating fan units maximize temperature and atmosphere uniformity

Options

• Endothermic or exothermic atmosphere system
• Dissociated ammonia system
• Nitrogen atmosphere system
• Retorts, dew point control and roller hearth rail

A Proven Leader in Thermal Processing Box Furnaces.

The Lindberg/MPH Rod Overbend Box Furnace provides you with a fast heating rate, heavy load capacity, and reliability so you can achieve increased productivity.

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