THERMAL SPRAY COATINGS IN AEROSPACE AND MARINE APPLICATIONS

SOCIETY NEWS

JTST HIGHLIGHTS

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EDITORIAL OPPORTUNITIES FOR iTSSe IN 2016

The editorial focus for iTSSe in 2016 reflects established applications of thermal spray technology such as power generation and transportation, as well as new applications representing the latest opportunities for coatings and surface engineering.

April: Energy & Power Generation
August: Automotive & Industrial Applications
November: Emerging Technologies/ Applications & Case Studies

To contribute an article to one of these issues, contact the editors c/o Frances Richards at frances.richards@asminternational.org.

To advertise, contact Kelly Thomas, at kelly.thomas@asminternational.org.

THE OFFICIAL NEWSLETTER OF THE ASM THERMAL SPRAY SOCIETY

MAGNESIUM REPAIR ON LIGHTWEIGHT AEROSPACE COMPONENTS

THERMAL SPRAY ALUMINUM COATINGS FOR SPLASH ZONE STRUCTURES—PART II

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ABOUT THE COVER

Thermal spray aluminum coatings are applied on the splash zone of various offshore oil and gas platforms. The splash zone requires special protective care by exotic painting techniques because cathodic protection is ineffective against corrosion. Courtesy of L&T Hydrocarbon Engineering Ltd., Mumbai, India. Inthydrocarbon.com.
Attending the International Thermal Spray Conference & Exposition (ITSC) involves much more than simply arriving at the destination and going to lectures. We must think about our time and justify expenses, but we also need to consider how our efforts might positively influence the thermal spray community. As Thermal Spray Society members work with various partners for ITSC planning, we discuss past efforts, new programming ideas, interesting seminars, and associated activities. We also talk about students, different industries that use thermal spray, papers that will interest a diverse audience, and creating an exhibit floor that will provide an effective venue for suppliers.

Over the past several years, the Programming Committee members of ASM and DVS have seen an increase in paper contributions from Asia. Unfortunately, this trend is lower in the U.S. For those individuals serving in leadership positions with regard to surfacing technologies, it is important to recognize the contributions of many. Leaders can serve as ambassadors for the thermal spray community and encourage others to submit papers and become involved in industry activities.

Coming this May is the Far East ITSC tri-rotation in Shanghai. In addition to reading this issue of iTSSe, you can also go online to learn further details about ITSC and do your due diligence before heading east! For those preparing papers, think of how important your contribution is and about the possibility of reaching newcomers to the industry. Many of us involved in volunteering for the Thermal Spray Society cannot help mentioning the passion and hard work of both committee members and the leadership team. Many ASM staff members also work diligently to support the Society, which is the backbone that makes it possible to do what we do.

In this issue, you will see a focus on marine and aerospace applications. In the 1960s, the U.S. government gave substantial support to engineers to reach higher into the sky with R&D funding for new designs and materials. John F. Kennedy’s inspiring “moon speech” in September 1962 is a prime example of this era. It is this kind of support that laid the foundation for many of the technology advancements bearing fruit today.

Sincerely,
Charles Kay
Vice president, Marketing, ASB Industries Inc.
TSS COMMITTEE CHAIRS NAMED FOR 2015-2016 TERM

The ASM Thermal Spray Society Board appointed chairs to each of its committees for the 2015-2016 term. Christian Moreau, FASM, Concordia University, Montreal, continues as president of TSS. Luc Pouliot, Tecnar Automation Ltd., Quebec, Canada, still serves TSS as immediate past president and chair of the Nominating Committee. Robert C. Tucker, Jr., FASM, The Tucker Group, continues as chair of the Journal of Thermal Spray Technology Committee. Atin Sharma, Siemens Energy Inc., Charlotte, N.C., serves as chair of the Membership, Marketing and Outreach Committee. Douglas Puerta, Element Materials Technology, Portland, Ore., continues to serve as vice president of TSS and chair of the TSS Program Committee. Fardad Azarmi, North Dakota State University, Fargo, N.D., was named chair of the TSS Training Committee. Timothy N. McKechnie, FASM, Plasma Processes LLC, Huntsville, Ala., continues to serve as chair of the TSS Awards Committee. Shari Fowler-Hutchinson, Saint-Gobain, Worcester, Mass., serves as chair of the Exposition Committee and Richard Chromik, McGill University, Montreal, was named chair of the Accepted Practices Committee. If you are interested in serving on an affiliate society committee, contact the respective committee chair or email joanne.miller@asminternational.org.

SEEKING APPLICANTS FOR TSS STUDENT BOARD MEMBERS

The ASM Thermal Spray Society is seeking applicants for its two student board member positions. Nominations are due by April 1, 2016. Students must be a registered undergraduate or graduate during the 2015-2016 academic year and must be studying or involved in research in an area closely related to thermal spray technology. For more information on eligibility and benefits, visit tss.asminternational.org.

JOURNAL OF THERMAL SPRAY TECHNOLOGY ANOUNCES EDITORIAL TRANSITION

After 12 years of serving as editor-in-chief of the Journal of Thermal Spray Technology (JTST), Dr. Christian Moreau, FASM, TS HoF, has transferred his responsibilities to Dr. Armelle Vardelle, FASM, according to Dr. Robert C. Tucker, Jr., FASM, TS HoF, chair of the Journal of Thermal Spray Technology Committee. Vardelle has been Lead Editor of JTST since 2013 and prior to that was an associate editor of the journal from 2006 through 2012. She will be succeeded as Lead Editor by Dr. André McDonald.

Moreau became JTST editor in 2004, and led the journal through an extraordinary period of growth, in which the journal increased from a quarterly to six issues per year in 2007, then to eight issues per year in 2013. Building on the strong foundation laid by JTST Founding Editor Chris Berndt, FASM, TS HoF, Moreau enlarged the editorial staff to its current complement of five associate editors by identifying individuals who were both well qualified technically as well as representative of the journal’s international readership. Further, he created the position of Lead Editor to focus on special topical and event-related issues.

Throughout Moreau’s term as editor, the journal has continued to grow in number of submissions, quality, and articles published. Working closely with former JTST Committee chair Jockel Heberlein and Chris Berndt, Moreau brought into reality an annual special double issue containing invited and expanded papers originating from the International Thermal Spray Conference. He also led the journal through its transition into the publishing partnership with Springer, which has greatly increased the journal’s international visibility and accessibility.

A professor at Concordia University (Canada Research Chair, Thermal Spray and Surface Engineering), Moreau will continue to offer the journal the benefit of his experience by remaining involved as a member of the JTST Committee.

Mary Anne Fleming, ASM’s senior content developer, Journals, said, “On behalf of the ASM staff who have worked with Christian on JTST, I thank him for unceasingly providing his insight and dedication as he has skillfully led the journal for the past 12 years and for ensuring its future success by identifying a capable and qualified successor. We are delighted that Armelle has agreed to step into the editor position.”
Armelle Vardelle (D.Sc. 1987; Ph.D. 1979, M.Sc. 1975, B.Sc. 1973) is professor, University of Limoges, France. She is Co-Chair of the Department of Materials (Surface Treatments and Environment) at the Engineering School of the University of Limoges (Ecole Nationale Supérieure d’Ingénieurs de Limoges, ENSIL). She holds the title of Distinguished Professor and is involved in research in the laboratory of Sciences of Ceramics and Surface Treatment Processes, UMR-CNRS in the European Ceramic Center.

Her current research interests include thermal spray and thermal plasma processes, modeling of plasma processes and torch operation, transport and chemical rate phenomena at high temperature, thermal spray coatings, and green manufacturing. Her teaching interests include thermal spraying, surface engineering, thermal sciences, transport phenomena in surface engineering processes, materials properties, industrial ecology, and life cycle analysis.

Vardelle has authored or coauthored more than 111 peer-reviewed scientific journal publications, 141 publications in international and national conference proceedings, and seven book chapters. She has presented 42 invited lectures at international conferences and 11 invited seminars at foreign universities. She has been a member of the editorial board of Plasma Chemistry and Plasma Processing since 2009. She became a Fellow of the International Plasma Chemistry Society in 2015 and a Fellow of ASM International in 2012.

As newly appointed editor-in-chief of JTST, Vardelle joins Tucker in announcing that McDonald has been named Lead Editor of the journal. McDonald is chair of the ASM Thermal Spray Society Training Committee, Lead Editor of the 2015 International Thermal Spray Conference Proceedings, and has served as a guest co-editor of the journal.

Currently an associate professor in the Department of Mechanical Engineering at the University of Alberta, McDonald received his BSME from the City College of New York (CCNY) in 2001, where he was the Dupont Mechanical Engineering Distinguished Graduate and won the Peggy Benline, Eliza Ford, and ALCOA awards. He was awarded his MSME from that same institution in 2002. He received his Ph.D. from the University of Toronto in 2007, followed by a short post-doctoral fellowship at the Industrial Materials Institute - National Research Council Canada (IMI-NRC) in Boucherville, Québec.

McDonald’s current research includes development of flame-sprayed coatings to provide wear and erosion resistance and to provide heating and structural health monitoring to polymer-based airfoil structures. In the area of cold-spraying, he has been working to develop a variety of metal matrix composite coatings with alumina or tungsten carbide as the reinforcing particle material.

Since 2006, his work has resulted in 33 peer-reviewed journal articles, 39 conference articles, a textbook on the practical design of thermo-fluids systems, an industrial manual for thermal spraying for the oil and gas industry, 26 industrial reports, and several awards including the International Thermal Spray Conference and Exposition Best Paper Award, the Harold C. Simmons Best Paper Award from ILASS-Americas, the Composites Conference Best in Track Technical Paper Award for Manufacturing, and the Association of Professional Engineers and Geoscientists of Alberta’s Early Accomplishment Award. Since becoming a professor, McDonald has trained 50 students, at both the graduate and undergraduate levels, in the areas of thermal spraying and/or heat transfer.

**THERMAL SPRAY SOCIETY EDUCATION COURSES**

Visit asminternational.org/learning to find out more about these valuable courses.

**Introduction to Thermal Spray**

*Date: March 21-22*

*Location: ASM World Headquarters, Materials Park, Ohio*

*Instructor: Richard A. Sayman*

As the thermal spray profession has changed, so has the need to ensure safe and consistent methods for thermal spray operators. ASM International brought together the leaders in the Thermal Spray Society to compile their knowledge and experience in a comprehensive, easy to understand course.

**Thermal Spray Technology**

*Date: July 26-27*

*Location: ASM World Headquarters, Materials Park, Ohio*

*Instructor: Chris Berndt, FASM*

Coating reliability and effectiveness requires overlay coatings to be selected, engineered, and applied correctly. This course provides a thorough grounding and understanding of thermal spray processes, depicts complex scientific concepts in terms of simple physical models, and integrates this knowledge into practical engineering applications and commonly accepted thermal spray practices.

**Advanced Thermal Spray Technology**

*Date: July 26-27*

*Location: ASM World Headquarters, Materials Park, Ohio*

*Instructor: Chris Berndt, FASM*

Thermal spray is increasingly used to manufacture net shapes, advanced sensors, and materials for the biomedical and energy/environmental industries. These and a vast array of emerging applications take advantage of the rapid and cost-effective capabilities of thermal spray technology in the OEM and repair industries.
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THERMAL SPRAY ALUMINUM COATINGS FOR SPLASH ZONE STRUCTURES—PART II

Recent advances in thermal spray techniques enable thermal spray aluminum coatings to reliably protect offshore structures in splash zones. Part I of this article appeared in the November/December 2015 issue of iTSSe.

Deepashri D. Nage, L&T Hydrocarbon Engineering Ltd., Mumbai, India

Offshore structures are exposed to various corrosion zones depending on sea level as datum. Both submerged steel surfaces and steel immersed in mud are typically not coated, instead relying solely on cathodic protection due to slow predicted corrosion rates. Splash zones in the -3 to +6 m range of Mean Sea Level (MSL) encounter the most severe degradation due to continuous contact with highly aerated sea water splashes. This zone requires special protective care by exotic painting techniques because cathodic protection is ineffective.

To shield splash zone structures from corrosion and other environmental degradation, coating is the best protective measure. Coatings for this zone have evolved from Monel sheath to high build epoxy and other organic formulations. Recent advances in thermal spray techniques have found thermal spray aluminum coatings (TSAC) to be an effective protection method in splash zones. Although thermal spray of just a few microns thick offers corrosion resistance and functional properties in precision jobs, there is concern about whether or not it is effective when applied to very large structures. This article focuses on challenges as well as successful implementation of TSAC by arc spray on splash zone structures. Here we look at an oil and gas platform recently installed off the east coast of India.

Challenges faced in implementing TSAC

Coating of piping, equipment, and structural components is generally the final step in the sequence of fabricating equipment—or an entire plant—after all assembly/fabrication work is complete. Because TSA coating is a hot process with certain limitations, individual pieces should be coated at the component level with the connecting joints coated upon assembly. Although the companies and thermal spray applicators who are able to handle this magnitude of coating work are limited, a proper qualification and readiness was ensured within this particular project’s timeline and specifications.

Aluminum metallic coatings offer several advantages, including excellent corrosion protection of steel due to the cathodic protection phenomenon, consumables with no shelf life expiration, zero volatile organic compounds, and...
low lifecycle costs. These benefits outweigh the drawbacks, which include the necessity of using a hot process, sensitivity to dust, wind, and moisture, potential for operator error, and shock and noise hazards.

The procedural details, readiness report, and inspection checklist were prepared to ensure guaranteed quality in every aspect of this project. Thermal spray aluminum requires rigorous process control over the entire operational sequence, from initial blasting to spraying the final sealer coat. Specifications provided by the client, PMC, were quite stringent, with required parameters that are only achievable at laboratory scale. Interactions with PMC engineers regarding various technical issues served to make the process conditions less stringent while adhering to internationally accepted parameters. Issues such as adhesion bond strength, procedure qualification record, surface preparation, dew point, and final shade of sealer coat on the jacket splash zone were all successfully resolved.

Table 2 summarizes limitations of TSAC with respect to widely adopted organic coatings for the splash zone. When the coating application is to be done “in yard,” constraints are imposed such as absence of control over environmental conditions. Further, because in-yard application occurs in an open environment, safety is a top concern and the area must be barricaded. Operators and personnel in the vicinity must use ear protection and protective UV glasses. The process is labor intensive and proper ventilation must be in place for operator health. Further, aluminum metal dust is prone to cause electric shocks and must be appropriately contained. Once the coating process is underway, coated objects must be handled with care using canvas slings and shrink wrap. Proper masking to protect surfaces not to be coated is another vital step that must occur before TSAC application. Paying close attention to all of these parameters will enable successful achievement of bond strength for a long and maintenance-free service life with an optimized lifecycle cost.

**PROPER APPLICATION OF TSAC OVERCOMES CONSTRAINTS**

- Repair/touch-up/patchwork are very difficult once TSA application is complete, compared to conventional paint. Therefore, the structure was released for TSA coating only after all QA/QC reports were received and cleared. All QA/QC requirements of such structures were completed on time with the help of the QC team to avoid any downtime. The slings of the assembly cranes were wrapped with cloth and care was taken to avoid any repairs.

### TABLE 2—TSAC VERSUS CONVENTIONAL ORGANIC COATINGS

<table>
<thead>
<tr>
<th>Features</th>
<th>Organic coating system</th>
<th>TSA + sealer coat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface preparation</td>
<td>25-50 micron (S a 2 1/2)</td>
<td>&gt;65 micron (S a 3)</td>
</tr>
<tr>
<td>Process temperature</td>
<td>Ambient</td>
<td>Torch at &gt;1000°C, Metallizing at &gt;675°C, Substrate at 120-150°C</td>
</tr>
<tr>
<td>Productivity</td>
<td>200 m² per shift</td>
<td>20-25 m²/shift</td>
</tr>
<tr>
<td>Accessibility</td>
<td>Using brush can cover entire area</td>
<td>Coating of nooks and corners, T-welds, assembled components, and recess areas is nearly impossible.</td>
</tr>
<tr>
<td>Welding/repair/rework</td>
<td>Possible</td>
<td>Questionable</td>
</tr>
<tr>
<td>Hot permit</td>
<td>Not required</td>
<td>Required (even at later stage)</td>
</tr>
<tr>
<td>Safety</td>
<td>Minimum protection</td>
<td>Complete protection (metal fumes, UV, thermal radiation and noise hazard)</td>
</tr>
<tr>
<td>Contractors</td>
<td>Quality contractors are easily available</td>
<td>Limited vendor base with proven capability</td>
</tr>
<tr>
<td>Handling of coated components</td>
<td>Not an issue</td>
<td>Same quality cannot be restored</td>
</tr>
<tr>
<td>Corrosion protection in splash zone</td>
<td>Other proven coating systems are available. 1500 microns DFT are specified.</td>
<td>Adequate TSA coating (200 microns) for splash zone</td>
</tr>
<tr>
<td>Operator shift time</td>
<td>One operator can work continuously</td>
<td>Need to relieve operator after maximum of two hours</td>
</tr>
<tr>
<td>Top coat application</td>
<td>Primers are available where coating interval can vary up to six months</td>
<td>Immediate sealer coating (within six hours)</td>
</tr>
<tr>
<td>Rework on splash zone</td>
<td>Systems are available</td>
<td>Difficult to achieve surface finish and coating application in low tide duration</td>
</tr>
</tbody>
</table>
The structure was released for TSA coating after complete fabrication and an inspection release note was signed. After TSA coating, it was released for assembly.

Issues such as adhesion bond strength, surface preparation, dew point, and its impact on the project schedule were taken care of during execution. Relative humidity was a major constraint in achieving the desired bond strength of 1500 psi for this job. An additional twin wire electric arc thermal spray unit was mobilized to keep production on track.

All safety requirements were closely monitored. Operators were allowed to work in rotation with maximum two-hour shifts.

The coating process was performed in stages, with legs, cross bracings, guide cones, and other parts at a minimum rate of 100 m² per day, including surface preparation, coating, and sealer coat application. In spite of unpredictable weather, all coating operations were completed well within the schedule.

Fig. 5 — From left to right, dollies pasted for adhesion bond strength test (ASTM D4541) and photograph indicating strength level on dial gauge.

Fig. 6 — From left to right, TSAC application on actual job and completed job.
SUMMARY

Thermal spray aluminum coatings are one of the most effective ways to protect the corrosion-prone splash zones of offshore marine structures. TSACs offer a cost effective and reliable way to enhance the structure's service life when applied carefully. However, successful implementation that must adhere to a strict timeline requires a systematic approach for monitoring the process. Proper coordination with respect to planning and execution is essential. Monitoring includes extensive quality control and inspections at each step of the TSAC application process to ensure high coating quality and optimize lifecycle cost. 

For more information: Deepashri D. Nage is Deputy General Manager, L&T Hydrocarbon Engineering Ltd., R&D Building, Powai Campus, Gate No. 1, Saki Vihar Road, Powai, Mumbai - 400 072 (INDIA), +91 22 6705 2780, deepashri.Nage@larsentoubro.com, lnhydrocarbon.com

Fig. 7 — TSAC applied on splash zone of installed offshore platform.

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MAGNESIUM REPAIR ON LIGHTWEIGHT AEROSPACE COMPONENTS

REASON TO CONSIDER SURFACING
Magnesium components feature unique structural strength combined with lightweight attributes. However, these components are difficult to repair due to a heat-sensitive corrosion reaction. "Magnesium alloys have been developed that have good mechanical properties, low densities, can be cast into complex shapes, and also feature good machining characteristics. These characteristics make them ideal for use in weight-critical applications, especially in helicopters," explains Tim Eden, head of the Materials Processing Division, Penn State Applied Research Laboratory. "A disadvantage of magnesium alloys is that they have a very high anodic index, which means they are electrochemically active and very susceptible to galvanic corrosion when coupled to another metal. Care must be taken to apply coatings that isolate the magnesium alloys from other metals and to create an environmental barrier to prevent corrosion. Once the coating is damaged, corrosion is initiated and quickly propagates."

Fig. 1 — Micrograph shows commercially pure aluminum applied via high pressure cold spray.

Fig. 2 — Hydraulic pump pad in the as-sprayed condition shows the AA4047 coating. Courtesy of Applied Research Laboratory, Penn State.

*Excerpt from Tim Eden’s contribution to “High Pressure Cold Spray: Principles and Applications,” a new book from ASM to be published in May.

Fig. 3 — Hydraulic pump pad after final machining of cold spray repair. Transmission is fully assembled and resting in the engine test stand. Courtesy of Applied Research Laboratory, Penn State.

Fig. 4 — Aluminum repair on magnesium sump. Courtesy of ASB Industries.
DeWAL Industries offers the highest quality, most complete line of thermal spray tapes — aluminum foil, fiberglass fabric, silicone-impregnated fiberglass, and combinations of these materials.

For wire arc and HVOF, DeWAL double-ply tapes reduce set-up time and withstand the harshest environments. DeWAL tapes can be single-ply or multi-layer.

DeWAL tapes adhere aggressively, ensuring sharp edges, resisting high temperatures, and removing cleanly after spraying.

Call DeWAL today, then thermal spray away.

Fig. 5 — Aluminum repair on lightweight aircraft panel. Courtesy of ASB Industries.

CASE STUDY

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Fig. 5 — Aluminum repair on lightweight aircraft panel. Courtesy of ASB Industries.

VALUE OF REPAIR

Limited repair options for damaged magnesium parts have led to a massive stockpile of unusable aerospace components, necessitating the purchase of costly replacement parts.

OPTION

High pressure cold spray (HPCS) using aluminum feedstock can be used to repair worn areas of aerospace components, which can then be easily machined to OEM specifications.

BENEFITS

• Allow stockpile of expensive worn components to be repaired.
• HPCS commercially pure aluminum exhibits a notably dense microstructure, highly bonded interface, and is easily machined.
• Components can be repaired multiple times.

For more information: Charles Kay is vice president, marketing, ASB Industries Inc., 1031 Lambert St., Barberton, OH 44303, 330.753.8458, cmkay@asbindustries.com, www.asbindustries.com.

For more information: Charles Kay is vice president, marketing, ASB Industries Inc., 1031 Lambert St., Barberton, OH 44303, 330.753.8458, cmkay@asbindustries.com, www.asbindustries.com.
ITSC PREVIEW

INTERNATIONAL THERMAL SPRAY CONFERENCE AND EXPOSITION 2016
May 10-12 • Shanghai

Plan now to attend the 2016 International Thermal Spray Conference and Exposition, the premier annual event for the global thermal spray community to meet, exchange information, and conduct business. This event presents the latest advancements in application, research, and development in the field of thermal spray. The theme of ITSC 2016 is Thermal Spray: Fostering a Sustainable World for a Better Life. In addition to the technical program, a three-day exhibition will include both an industrial forum and poster session.

ITSC 2016 will be held in the Shanghai International Convention Center connected to the Oriental Riverside Hotel. It is located in the heart of Lujiazui, the dynamic financial district of Shanghai, which offers easy access to all parts of the city. Shanghai is a popular tourist destination renowned for its historical landmarks such as The Bund, City God Temple, and Yu Garden as well as the extensive Lujiazui skyline and major museums including the Shanghai Museum and the China Art Museum.

CONFERENCE HIGHLIGHTS

Comprehensive Technical Programming
Tuesday, May 10 through Thursday, May 12

Attendees will learn about the latest research and development taking place in their specific field while gaining a global perspective from leading scientists and engineers from around the world. Visit asminternational.org/web/itsc-2016-expo/home for technical program details.

Exhibit Floor • Tuesday, May 10 through Thursday, May 12

The ITSC show floor offers an unparalleled exposition featuring the world’s largest gathering of thermal spray equipment suppliers, consumable and accessory suppliers, vendors, and service providers. You will find information about equipment for thermal spraying, research and specialist institutes, applied research, and the latest innovations conveniently located in one big forum.

Young Professionals Session • Tuesday, May 10 • 3:40 p.m.

Now in its fifth year, ITSC 2016 organizers and Oerlikon Metco will sponsor a young innovative scientists/professionals
EXHIBITOR LIST

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Note: Exhibitor list current as of January 1.

competition-based awards program, which seeks to encourage participation of young scientists in ITSC and provide attractive opportunities in the global thermal spray community.

Networking Events

Each year, ITSC offers a wide variety of networking opportunities for attendees and exhibitors. From the exhibitor networking reception to a special boat trip on the Huangpu River, all attendees will have an opportunity to relax and socialize with colleagues and friends within the thermal spray community.

Industrial Forum • Wednesday, May 11 • 9:00 a.m.–5:00 p.m.

The Industrial Forum will be held in the Shanghai International Convention Center, 3C + 3D Room. Invited companies will present talks on industry-related topics and products during conference and exposition hours. All presentations are given in English and are limited to 20 minutes including question & answer sessions.

Industrial Tour—SICCAS—Shanghai Institute of Ceramics, Chinese Academy of Sciences • Friday, May 13 • 7:30 a.m.

EXPOSITION HOURS

Tuesday, May 10 • 12:00–7:00 p.m.
Wednesday, May 11 • 9:00 a.m.–5:00 p.m.
Thursday, May 12 • 9:00 a.m.–2:00 p.m.

Note: Exposition hours are subject to change.
The Journal of Thermal Spray Technology (JTST), the official journal of the ASM Thermal Spray Society, publishes contributions on all aspects—fundamental and practical—of thermal spray science, including processes, feedstock manufacture, testing, and characterization. As the primary vehicle for thermal spray information transfer, its mission is to synergize the rapidly advancing thermal spray industry and related industries by presenting research and development efforts leading to advancements in implementable engineering applications of the technology. Articles from the January issue, as selected by JTST Editor-in-Chief Armelle Vardelle and Lead Editor André McDonald, are highlighted here. This issue features papers based on presentations at ITSC 2015. In addition to the print publication, JTST is available online through springerlink.com. For more information, please visit www.asminternational.org/tss.

“PYRAMIDAL FIN ARRAYS PERFORMANCE USING STREAMWISE ANISOTROPIC MATERIALS BY COLD SPRAY ADDITIVE MANUFACTURING”
Yannick Cormier, Philippe Dupuis, Bertrand Jodoin, and Antoine Corbeil

This work evaluates the thermal and hydrodynamic performance of pyramidal fin arrays produced using cold spray as an additive manufacturing process. Near-net-shaped pyramidal fin arrays of pure aluminum, pure nickel, and stainless steel 304 were manufactured. Fin array characterization such as fin porosity level and surface roughness evaluation was performed. The thermal conductivities of the three different coating materials were measured by laser flash analysis. The results obtained show a lower thermal efficiency for stainless steel 304, whereas the performances of the aluminum and nickel fin arrays are similar. This result is explained by looking closely at the fin and substrate roughness induced by the cold gas dynamic additive manufacturing process. The multi-material fin array sample has a better thermal efficiency than stainless steel 304. The work demonstrates the potential of the process to produce streamwise anisotropic fin arrays as well as the benefits of such arrays.

“LASER PATTERNING PRE-TREATMENT BEFORE THERMAL SPRAYING—A TECHNIQUE TO ADAPT AND CONTROL THE SURFACE TOPOGRAPHY TO THERMO-MECHANICAL LOADING AND MATERIALS”
Robin Kromer, Sophie Costil, Jonathan Cormier, Laurent Berthe, Patrice Peyre, and Damien Courapied

Coating characteristics are highly dependent on substrate preparation and spray parameters. Hence, the surface must be adapted mechanically and physicochemically to favor coating/substrate adhesion. Conventional surface preparation methods such as grit blasting are limited by surface embrittlement and produce large plastic deformations throughout the surface resulting in compressive stress and potential cracks. However, laser patterning is suitable for preparing the surface of sensitive materials. No embedded grit particles are observed, and high quality coating can be achieved. Further, laser surface patterning adapts the impacted surface by creating a large anchoring area. Optimized surface topographies can then be elaborated according to the materials as well as their applications. This paper compares the adhesion bond strength for two surface preparation methods, namely grit blasting and laser surface patterning for two materials used
The new ASM Online Store has been reengineered for an easier navigation and shopping experience. The online store is open for business with a brand-new line of products and premium apparel that has you covered for any season!
**JTST HIGHLIGHTS**

**“MODULAR COATING FOR FLEXIBLE GAS TURBINE OPERATION”**


In heavy-duty gas turbines, the loading boundary conditions of MCrAlY systems are weighted differently for various operation regimes as well as for each turbine component or individual part locations. For overall optimized component protection, it is of interest to produce coatings with flexible and individually tailored properties. In this context, ALSTOM developed an Advanced Modular Coating Technology (AMCOTEC) based on several powder constituents, each imparting specific properties to the final coating, in combination with a new application method, allowing in-situ compositional changes. With this approach, coating properties such as oxidation, corrosion, and cyclic lifetime can be modularly adjusted for individual component types and areas. For demonstration purposes, a MCrAlY coating with modular ductility increase was produced using the AMCOTEC methodology. The method was proven to be cost effective and highly flexible, enabling fast compositional screening. A calculation method for final coating composition was defined and validated. The modular addition of a ductility agent enabled increasing the coating ductility with up to factor 3 with only a slight decrease in oxidation resistance. An optimum composition with respect to ductility is reached with the addition of 20 wt% of the ductility agent.

**“THERMAL GRADIENT BEHAVIOUR OF TBCs SUBJECTED TO A LASER GRADIENT TEST RIG: SIMULATING AN AIR-TO-AIR COMBAT FLIGHT”**

Rogerio S. Lima, Basil R. Marple, and P. Marcoux

A computer-controlled laser test rig (using a CO₂ laser) offers an interesting alternative to traditional flame-based thermal gradient rigs in evaluating thermal barrier coatings (TBCs). The temperature gradient between the top and back surfaces of a TBC system can be controlled based on the laser power and a forced air back-face cooling system, enabling the temperature history of complete aircraft missions to be simulated. An air plasma spray-deposited TBC was tested and, based on experimental data available in the literature, the temperature gradients across the TBC system (ZrO₂-Y₂O₃ YSZ top coat/Co-NiCrAlY bond coat/Inconel 625 substrate) and their respective frequencies during air-to-air combat missions of fighter jets were replicated. The missions included (i) idle/taxi on the runway, (ii) take-off and climbing, (iii) cruise trajectory to rendezvous zone, (iv) air-to-air combat maneuvering, (v) cruise...
trajectory back to runway, and (vi) idle/taxi after landing. The results show that the TBC thermal gradient experimental data in turbine engines can be replicated in the laser gradient rig, leading to an important tool to better engineer TBCs.

“PLASMA-SPRAYED THERMAL BARRIER COATINGS WITH ENHANCED SPLAT BONDING FOR CMAS AND CORROSION PROTECTION”
Tao Liu, Shu-Wei Yao, Li-Shuang Wang, Guan-Jun Yang, Cheng-Xin Li, and Chang-Jiu Li

The infiltration of molten CMAS in thermal barrier coatings (TBCs) at high temperature is significantly affected by the microstructure of the ceramic coating. Enhancing the bonding ratio between splats can reduce the interconnected pores and suppress infiltration of the molten CMAS into the coating. In this study, a dual-layered (DL) TBC with the dense 8YSZ on top of the conventional porous 8YSZ was proposed to enhance CMAS corrosion of atmospheric plasma-sprayed YSZ. The dense YSZ coating with improved lamellar bonding was deposited at a higher deposition temperature. The microstructure of the coatings before and after the CMAS attack test was characterized by scanning electron microscopy. It was revealed that by adjusting the microstructure and applying a dense ceramic layer with the improved interface bonding on top of porous TBC, infiltration of CMAS into the porous YSZ coating can be effectively suppressed. Moreover, by designing DL TBCs, the thermal conductivity of the TBC system exhibits a limited increase. Thus with the design of the DL structure, TBCs with high CMAS corrosion resistance and low thermal conductivity can be achieved.

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