Thermal Spray Coatings in the Automotive Industry/Industrial Applications

JTST Highlights
Society News

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Plasma Transferred Wire Arc Process Fortifies Aluminum Engine Blocks

Safety in Thermal Spray Settings: Part 1

Show Previews:
Cold Spray Conference & Aerospace Coatings

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About the cover
The SST family of cold spray equipment includes the series EP Cold Spray system, which comes complete with portable cabinet, HMI controls, pressurized feeder, and robotic style spray gun. Here it is used to repair an aluminum alloy wheel. Courtesy of Centerline Windsor Ltd., centerline.com.

Editorial Opportunities for iTSSe in 2014
The editorial focus for iTSSe in 2014 reflects established applications of thermal spray technology such as power generation and transportation, as well as new applications representing new opportunities for coatings and surface engineering.

November Emerging Technologies
To contribute an article to one of these issues, please contact the editors c/o Julie Kalista at Julie.Kalista@asminternational.org. To advertise, please contact Kelly Thomas, Kelly.Thomas@asminternational.org.
Thermal spray coatings play an important role in the automotive industry from the high-performance racing sector to domestic automotive production. North American automobile production is predicted to hit an 11-year high as stated in autoguide.com, June 2014. New vehicle production in North America continues to increase and according to two major forecasters, production will surpass the prior year’s total of 15.5 million units. LMC Automotive expects production to reach 16 million units while IHS Automotive predicts 16.1 million. If those forecasts come true, North American production will have crested levels not seen since 2002 when the auto industry turned out 16.5 million. This represents a considerable market opportunity for the coatings industry. Thermal spray parts and components for these vehicles involve a large network of organizations including automotive manufacturers, Tier 1 suppliers, thermal spray companies, equipment producers, and materials suppliers.

One recent success story in the automotive industry relates to the development of plasma transferred wire arc (PTWA) for aluminum engine blocks. Driven by the demand to increase fuel efficiency, automakers put a strong emphasis on decreasing overall vehicle weight as well as improving engine efficiency by reducing internal friction losses. Consequently, the last couple of decades have seen a strong push to produce engine blocks out of light cast alloys, such as aluminum. An article by Dr. Villafuerte, Centerline Windsor Ltd., is provided in this edition to discuss this development in the automotive industry. In addition to an automotive contribution, TSS is providing a two-part article on the importance of safety in thermal spray environments. In this August edition, we are providing Part 1 of this important safety article.

Important ASM TSS events coming up include the North American Cold Spray Conference (NACSC) 2014: Covering the World of Cold Spray, and the Aerospace Coatings Conference 2014: Development and Manufacturing Trends for the 21st Century. NACSC takes place September 16-17 in Bromont, Quebec, Canada. Attendees will gain a basic understanding of the cold spray process, get a chance to follow global R&D programs on cold spray technology, receive firsthand information on industrial applications, and network with international experts. Advancements in cold spray technology are helping expand the commercial and academic applications of this technically superior metal deposition process.

ASM’s third TSS Aerospace Coatings Conference will be held in Hartford, Conn., October 8-9. This symposium brings together thermal spray professionals involved in a wide range of responsibilities. Attendees will be able to understand future coating and process requirements, learn about cost reduction improvements related to quality and reliability factors, and gain an appreciation of existing thermal spray coatings for the aerospace industry. Job shop sprayers, engineers, technicians, end-users, suppliers of equipment and material, academicians, researchers, material scientists, marketing companies, and entrepreneurs will all benefit from this event. The is a great opportunity to gain a key perspective of the industry with exciting presentations from invited presenters including Rolls-Royce, Sulzer Metco, PWA, Curtiss-Wright Surface Technologies, LLC Surface Technologies, Delta Airlines Inc., Lufthansa Technik AG, Naval Aviation Department, Pratt & Whitney, KLM Engineering and Maintenance, and other leading organizations.

ASM members’ regular and active participation in these events is very important and ensures that we can keep organizing such world-class conferences in the future. We hope you will attend these events, we thank you in advance, and look forward to seeing you there.

Robert Gansert, Ph.D.
iTSSe co-editor
Advanced Materials & Technology Services Inc.
**ITSC 2014 is an outstanding success**

ITSC 2014—Not Fiction: Thermal Spray the Key Technology in Modern Life! The International Thermal Spray Conference and Exhibition (ITSC) featured a three-day exposition, conference, poster session, education courses, young professional competition, social events, and much more. At ITSC, attendees found information about thermal spray equipment, research and specialist institutes, applied research, and the latest innovations conveniently located in one big forum. The exposition was held in the Palau de Congressos de Catalunya in northwest Barcelona, Spain, in May.

ITSC 2014 attendees enjoyed a networking reception on the exhibition floor.

**TSS members honored at ITSC**

Mitchell R. Dorfman, FASM, (left), was recently inducted into the TSS Hall of Fame. He was recognized for innovations in thermal spray turbine engine coatings, for exceptional contributions to the thermal spray industry and technical community, and for dedicated mentoring of the next generation of thermal sprayers. The award was presented to him by TSS President Luc Pouliot during ITSC 2014.

Charles M. Kay (left) received the 2014 TSS President’s Award for Meritorious Service for his many years of dedicated and outstanding service to TSS. The award was presented by TSS President Luc Pouliot during ITSC 2014.

The first plenary session at ITSC 2014, Plasma sprayed solutions: From the coating of the top to their integrated functionality on aeroengine components, by K. Ostolaza, ITP Technical Fellow Material and Processes, was well attended.

ITSC attendees enjoyed an awards banquet on Thursday, May 22.
Journal of Thermal Spray Technology Volume 22
Best Paper Awards

The Journal of Thermal Spray Technology (JTST) announces the winners of the JTST Volume 22 Best Papers Awards, as chosen by an international committee of expert judges. The awards were presented at the International Thermal Spray Conference & Exposition 2014, in Barcelona, Spain.


The Editorial Committee believes it is important to evaluate the quality of engineering and scientific contributions published in JTST and to provide recognition of excellent work and its publication. Each paper is reviewed and evaluated on its merits for scientific and engineering content, originality, and presentation style. The two papers are recognized as outstanding and the authors received awards of recognition for their excellent work.


Congratulations are extended to the winning authors from the JTST Editorial Board and the ASM Thermal Spray Society Executive Board of Directors.
Thermal spray technology was invented in the late 1800s to restore worn metal parts and provide surface protection. Initially known as “metallizing,” it became more popular during World War II for fast repair of tanks and other vehicles in high demand. Today, thermal spray encompasses a whole family of coating processes used to apply metals, polymers, ceramics, cermet, and other combinations of materials to a wide variety of metallic, polymeric, composite, and ceramic substrates.

Generally, feedstock materials are projected toward the substrate in a liquid, semi-liquid, or solid state to apply coatings with thicknesses greater than 100 µm. Traditionally, feedstock materials (in powder, wire, or rod forms) are melted by combustion or electric arc/plasma, and then accelerated against the substrate by a high-velocity gas jet. In newer thermal spray processes, such as cold spray, special feedstock materials are accelerated by a supersonic gas jet to conform a deposit in the solid-state.

Combustion-based thermal spray processes include powder flame spray, wire flame spray, detonation spray, high velocity oxygen fuel (HVOF), and warm spray (lower temperature HVOF that uses nitrogen to cool combustion gases). Electric arc-based processes include plasma spray, arc wire spray, and their variations. The extremely high temperatures (>10,000°C) of plasma spray make it suitable for depositing elevated temperature materials, such as ceramics. On the other end, the new cold spray family includes processes such as downstream injection (low pressure) and up-stream injection (high pressure) which rely on the ability of the materials to deform at high impact velocities and at low process temperatures.

Traditionally, thermal spray has been widely used in the aerospace industry. Over the past few decades, and driven by the need to improve fuel efficiency, thermal spray is increasingly used in a wide range of automotive applications requiring corrosion and wear resistance, elevated temperature resistance, enhanced lubricity, and dimensional restoration. Examples include:

- Plasma spraying of Molybdenum for piston heads
- Plasma spraying of Mo-Ni-Cr for performance valve seats
- Twin-arc spray of various materials on top of resistance spot welds to improve aesthetics in luxury cars

Plasma transferred wire arc process overview

One of the most recent success stories for thermal spray in the automotive industry involves the development of plasma transferred wire arc (PTWA) for aluminum engine blocks. Driven by the demand to increase fuel efficiency, automakers are placing emphasis on decreasing overall vehicle weight as well as improving engine efficiency by reducing internal friction losses. Consequently, over the past few decades there has been a strong push to produce engine blocks made of low silicon aluminum castings by utilizing the new all-aluminum engine block manufactured by Honsel uses Ford’s patented plasma transferred wire arc (PTWA) cylinder liner technology to reduce weight and increase efficiency.

Hyper-eutectic aluminum-silicon cast alloys with silicon content higher than 12.6 wt% offer excellent tribological properties for engine block applications. However, their high silicon content makes them difficult to cast and machine, and therefore too expensive to produce. Unfortunately, the generally preferred A356 hypo-eutectic alloy (around 7-8% silicon) displays poor tribological characteristics for engine applications compared to high silicon alloys but it is cheaper to produce. Therefore, low-silicon aluminum blocks require reinforcement of the cylinder liner.
bores, which is achieved by either using cast iron liners or electroplating with nickel and silicon carbide.

PTWA was co-developed by Ford Motor Co., Dearborn, Mich., and Flame-Spray Industries Inc., Port Washington, N.Y.,[1-7] in an effort to eliminate the need for cast iron liners and further reduce weight. In this process, a high temperature (>10,000°C) plasma jet is created between a nonconsumable electrode and a consumable composite ferrous wire with a 1.6 mm diameter (Fig. 1). The plasma melts and atomizes the ferrous wire, which is continuously fed into a rotating spray gun that fits within the cylinders (Fig. 2). Pressurized air atomizes and accelerates metal droplets (20 to 30 µm diameter) onto the internal surface of engine block cylinders. The molten composite wire oxidizes and builds up a rapidly solidified ferrous structure consisting of nanocrystalline iron and ferrous-oxide to a final thickness of about 150 µm.

The resulting surface structure of the composite coating promotes favorable lubrication, low friction, wear resistance, improved heat transfer, and decreased bore distortion. Ford implemented the technology in their 2011 GT500 Shelby Mustang 5.4-L V8 (Fig. 3)[8]. The PTWA process eliminated approximately 3.8 kg of cylinder liners compared with previous models[9].

For more information: Julio Villafuerte, Ph.D., P.Eng, is corporate technology strategist at CenterLine Windsor Ltd., 595 Morton Dr., Windsor, Ontario, Canada, 519.734.8868 ext. 474, julio.villafuerte@cntrline.com, cntrline.com/en.

References
Safety in Thermal Spray Settings: Part 1

Much of the following material was developed by members of ASM International’s Thermal Spray Society Safety Committee.

Workplace safety is not a subject that typically captivates an audience, but in the thermal spray trade, hazards of all types are faced on a daily basis. Safety talk is typically thought of as a matter of common sense, and formal programs to communicate and enforce safe practices can seem unnecessary or, in worst case scenarios, as an opportunity to issue penalties based on grudges, rather than evenhanded enforcement. Unlike truly dangerous workplaces, such as shipyards or construction sites, where situational awareness is necessary to stay alive and well, the extra cost and time safety programs consume can make them unattractive in comparatively comfortable thermal spray shops. However, compelling reasons to embrace the safety topic still exist.

For starters, maintaining a safe workplace is the law. Title 29 Part 1900 of the Code of Federal Regulations outlines the mandate, reach, and policies of the Occupational Safety and Health Administration (OSHA). Despite rumors that OSHA’s jurisdiction does not apply to shops below a certain size, there is not likely a thermal spray or welding shop immune to OSHA’s regulations.

Because of this, safety discussions can broaden awareness of operating requirements that some smaller facilities might not know. It is also important for frontline employees to be aware of the potential hazards faced daily in order to motivate them to voluntarily take appropriate precautions. The topic can be discussed clearly and concisely in this manner, making it easier to ensure requirements are met. Involving people at every operational level during the development of plant policies ensures that employee safety will not hinder workload.

Dust and fume hazards

Another reason safety discussions are especially important in the thermal spray workplace is that hazards appear throughout the coating operation, from incoming orders to final inspection. Dust and fume hazards are an excellent example. Technically speaking, dust consists of airborne fine solid particles such as fractured grit blasting media or thermal spray powders, which can irritate lungs and mucous membranes. Fumes are finer suspended particles released when materials are heated or burned, for example, when thermal spray feedstock enters the combustion zone or plasma plume of a spray gun.

Dust and fume exposure occurs during degreasing, blasting, powder handling, spraying, sealing, and even maintenance and cleaning. Some thermal spray fumes, such as hexavalent chromium, are known cancer causing agents. Vapors are emitted by liquids that evaporate at room temperature, including solvents such as acetone and trichloroethane, which are commonly used for cleaning and degreasing parts. Inhaling these vapors can damage the lungs and internal organs.

Most dusts and fumes common in spray shops irritate the lungs, but others have more reactive effects. For example, nickel, cobalt, and chromium can cause eczema and contact dermatitis. Fumes released during twin arc wire spraying of zinc can cause nausea, fever, and other flu-like symptoms, known as “zinc fever.” The hazard of the airborne carcinogen hexavalent chromium is so acute that the code places specific requirements on employers who are known generators. Part 1910.1026 requires regular physical testing of employees who may be exposed, and makes the provision and handling of specialized protective clothing, among other things, the employer’s responsibility.

As with all hazard categories, several methods to eliminate or remediate hazards caused by dust and fumes exist (Fig. 1). The most effective option is to eliminate the hazard altogether, though this is seldom an option. The next best alternative is to substitute a less hazardous material or process. Depending on the application, this may not be a viable alternative. Engineering controls are methods by which equipment can be added or a process design can be modified to reduce or eliminate the hazard to employees. In the case of dust and fumes, use of sufficient air filtration is an engineering control that can ensure contaminated air is drawn away from operators, removing the hazard. It also effectively cleans the air before it is reintroduced to the environment.

Administrative controls are the next layer of hazard mitigation available to employers. These consist of policies and procedures that mandate specific safe working practices for each workplace hazard. Training, signage, procedures, and employee exposure are all administrative controls that can aid in the mitigation of dust and fume hazards. Finally, personal protective equipment (PPE), such as dust masks and gloves, protect employees from harm when direct contact with a hazard is likely. Though it is perhaps the most common workplace safety measure, PPE is considered the least effective measure because it depends on employee participation and supervision.
Two exciting thermal spray conferences are coming up this fall!

North American Cold Spray 2014
September 16-17
Domaine Chateau-Bromont, Quebec, Canada

Plan today to attend the North American Cold Spray Conference and Exposition where attendees will gain basic understanding of the cold spray process, follow global R&D programs on cold spray technology, receive firsthand information on industrial applications, and network with international experts. Advancements in cold spray technology are helping to expand the commercial and academic applications of this technically superior metal deposition process.

Technical Program at-a-glance

Day 1 – September 16
8:30 a.m. – 6:00 p.m. Table-Top Exhibition
8:00 – 8:30 a.m. Continental Breakfast
8:30 – 9:15 a.m. Welcoming Remarks – André McDonald, University of Alberta
Keynote Speaker – Stephen Gaydos, Boeing Research and Technology

Session 1: Quality Control and Diagnostics
Session Chair: Luc Pouliot
9:15 – 9:45 a.m. Eric Irissou, National Research Council – Industrial Materials Institute
9:45 – 10:15 a.m. Matt Mordasky, United Technologies Research Center
10:15 – 10:30 a.m. Break; Visit Student Posters and Exhibitors

Session 2: Applications – Case Studies and Production
Session Chair: André McDonald
10:30 – 11:00 a.m. Phuong Vo, National Research Council – Industrial Materials Institute
11:00 – 11:30 a.m. Leonardo Ajdelsztajn, GE Global Research
11:30 a.m. – 12:00 p.m. Elvi Dalgaard, Pratt & Whitney Canada
12:00 – 1:00 p.m. Lunch; Visit Student Posters and Exhibitors

Session 3: Fundamentals – Physics and Science I
Session Chair: Christian Moreau
1:00 – 1:30 p.m. Bertrand Jodoin, University of Ottawa
1:30 – 2:00 p.m. Volf Leschchynsky, University of Windsor
2:00 – 2:30 p.m. Christian Widener, South Dakota School of Mines
2:30 – 3:00 p.m. Chang-Jiu Li, Xi’an Jiaotong University
3:00 – 3:15 p.m. Break; Visit Student Posters and Exhibitors

Session 4: Powders and Consumables
Session Chair: Charles Kay
3:15 – 3:45 p.m. Jun Akedo, National Institute of Advanced Industrial Science & Technology
3:45 – 4:15 p.m. Satya Kudapa, Sulzer Metco
4:15 – 4:45 p.m. Kazuto Sato, Fujimi Inc.
5:00 – 6:00 p.m. Round Table Event and Discussion

Master of Ceremony: Jean-Gabriel Legoux and Luc Pouliot

6:00 – 9:00 p.m. Dinner and Awards Banquet
Student Poster Presentations: Sponsored by TECNAR Automation

Day 2 – September 17
8:30 a.m. – 5:00 p.m. Table-Top Exhibition
8:00 – 8:30 a.m. Continental Breakfast

Session 5: Characterization I
Session Chair: Julio Villafuerte
8:30 – 9:00 a.m. Tim Eden, Penn State
9:00 – 9:30 a.m. Heli Koivuluoto, Tampere University of Technology
9:30 – 10:00 a.m. Stephen Yue, McGill University
10:00 – 10:15 a.m. Break; Visit Student Posters and Exhibitors

Session 6: Equipment, Parts & Modifications
Session Chair: Jean-Gabriel Legoux
10:15 – 10:45 a.m. Julio Villafuerte, SST Centerline Ltd.
10:45 – 11:15 a.m. Hirotaka Fukanuma, Plasma Giken Co. Ltd.
11:15 – 11:45 a.m. Peter Richter, Jr., Impact Innovations GmbH
11:45 a.m. – 12:15 p.m. Jeganathan Karthikeyan, ASB Industries
12:15 – 1:00 p.m. Lunch

Session 7: Modeling and Fundamentals – Physics and Science II
Session Chair: Bertrand Jodoin
1:00 – 1:30 p.m. Thomas Klassen, Helmut Schmidt University
1:30 – 2:00 p.m. Xuemei Wang, United Technologies Research Center
2:00 – 2:30 p.m. Dominique Poirier, National Research Council – Industrial Materials Institute
2:30 – 3:00 p.m. André McDonald, University of Alberta
3:00 – 3:15 p.m. Break; Visit Student Posters and Exhibitors

Session 8: Characterization II
Session Chair: Jeganathan Karthikeyan
3:15 – 3:45 p.m. Richard Chronik, McGill University
3:45 – 4:15 p.m. Kumar Sridharan, University of Wisconsin - Madison
4:15 – 4:45 p.m. Wilson Wong, Sulzer Metco
Aerospace Coatings:
Development and Manufacturing Trends for the 21st Century
October 8-9
Sheraton Bradley Airport Hotel, Hartford, Conn.

From sprayers to coating designers, this symposium brings together a wide variety of thermal spray professionals. The event will aid understanding future coating and process requirements, cost reduction improvements related to quality and reliability factors, and also provides an in-depth review of existing thermal spray coatings. Gain key perspectives with exciting presentations from invited presenters including Rolls-Royce, PWA, Curtiss-Wright Surface Technologies, LLC Surface Technologies, Delta Airlines Inc., Lufthansa Technik AG, Naval Aviation Department, Pratt & Whitney, KLM Engineering and Maintenance, and other leading organizations.

Technical Program at-a-glance

Day 1 – October 8
8:30 a.m. – 5:00 p.m. Table-Top Exhibition
7:30 – 7:45 a.m. Continental Breakfast
7:45 – 7:50 a.m. Welcoming Remarks – Luc Pouliot
7:50 – 8:00 a.m. Richard Bajan – Curtiss Wright
8:00 – 8:40 a.m. Session Chair: Howard Wallar
Albert Feuerstein – Praxair
Dave Hawley – Sulzer Metco
Adrian Vogel – AMT
8:40 – 9:00 a.m. Exhibit/Coffee break
9:00 – 9:30 a.m. Session Chair: Mike Maloney – Pratt & Whitney
Albert Feuerstein – Praxair
Dave Hawley – Sulzer Metco
Adrian Vogel – AMT
9:30 – 10:00 a.m. Lunch
10:00 – 10:30 a.m. Session Chair: Steve Glancy – Flame Spray Technologies
Lars Ostergren – GKN Aerospace
Nicole Zelazny – Moog Aerospace
Francis Moverie-Moulin – SAFRAN
10:30 – 11:00 a.m. Keynote Speaker 1 – Ray Sinatra – Rolls-Royce
11:00 – 11:30 a.m. Nick Cortese – Delta Airlines
11:30 a.m. – 12:30 p.m. Lunch
12:30 – 1:00 p.m. Marc Froning – The Boeing Co.
1:00 – 1:30 p.m. Ross Lunato – Component Repair Technologies
1:30 – 2:00 p.m. Ann Bolcavage – Rolls-Royce
2:00 – 2:15 p.m. Exhibit/Coffee break
2:15 – 2:45 p.m. Lars Ostergren – GKN Aerospace
2:45 – 3:15 p.m. Nicole Zelazny – Moog Aerospace
3:15 – 3:45 p.m. Francis Moverie-Moulin – SAFRAN
3:45 – 4:15 p.m. Keynote Speaker 1 – Ray Sinatra – Rolls-Royce
4:15 – 4:45 p.m. Robert Vassen – Juelich
6:00 – 8:00 p.m. Dinner

Day 2 – October 9
8:00 a.m. – 5:00 p.m. Table-Top Exhibition
7:10 – 7:25 a.m. Continental Breakfast
7:25 – 8:05 a.m. Session Chair: Rick Sisson – Worcester Polytechnic
Keith Legg – Rowan Technology Group
8:05 – 8:35 a.m. Jeff Smith – Material Processing Technology, LLC
8:35 – 9:05 a.m. Eric Jordan – University of Connecticut
9:05 – 10:35 a.m. Rogerio Lima – NRC, Canada
10:35 – 11:05 a.m. Dongming Zhu – NASA
11:05 – 12:20 p.m. Lunch
11:20 – 11:50 a.m. Al Matarese – Technical Metal Finishing
11:50 a.m. – 12:20 p.m. David Fairbourn – Aeromet Technologies Inc.
12:20 – 12:50 p.m. Keith Parker – Coherent Inc.
1:50 – 2:20 p.m. Mo VandenBerg – VandenBerg & Associates
2:20 – 2:50 p.m. Frank Accornero – Robotic Synergy
2:50 – 3:20 p.m. Troy McAlister – McAlister Design Inc.
3:20 – 3:35 p.m. Exhibit/Coffee break
3:35 – 4:05 p.m. Stephen Tefft – GE Aviation
4:05 – 4:30 p.m. John Sauer – Sauer Engineering
4:30 – 5:00 p.m. Wally Birtch – Centerline Engineering
5:00 – 5:30 p.m. Richard Blackwell – Buehler
5:45 p.m. – 7:15 p.m. Curtiss-Wright Plant Tour

For additional information on either conference, please contact Kelly Thomas at 440.338.1733 or via email at kelly.thomas@asminternational.org.
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 June and August issues, as selected by JTST Editor-in-Chief Christian Moreau, are highlighted here. In addition to the print publication, JTST is available online through springerlink.com. For more information, visit asminternational.org/tss.

Join the TSS discussion group
The TSS email discussion group is an email-based discussion list, wherein subscribers only may post messages to the group. Messages are received individually by the subscribers, or a subscriber can select a once-daily digest. Individuals may subscribe and unsubscribe as they wish. Visit asminternational.org/web/tss/membership/forum to learn more.

“Laser-Assisted Cold-Sprayed Corrosion- and Wear-Resistant Coatings: A Review”
E.O. Olakanmi and M. Doyoyo
Laser-assisted cold spray (LACS) processes are likely to increase in use for coating deposition due to its unique advantages—solid-state dense, homogeneous, and pore-free coatings are deposited onto a range of substrates; and high build rates at reduced operating costs are achieved without use of expensive inert gases. Depositing coatings via LACS demands accurate knowledge and control of processing and material variables. By varying process parameters and their interactions, functional properties of coatings can be manipulated. In order to provide a basis for follow-on research that leads to development of high-productivity LACS coatings, this review focuses on the latest developments in depositing corrosion- and wear-resistant coatings with an emphasis on the composition, structure, and mechanical and functional properties.
“Synchronization of Suspension Plasma Spray Injection with the Arc Fluctuations”
J. Krowka, V. Rat, S. Goutier, and J.F. Coudert

Some difficulties encountered in suspension plasma spray include poorly controlled heat and momentum transfers between the plasma and material and plasma instability. To improve this method, arc fluctuations are often reduced. This paper offers an alternative to the injection of reactive material in an arc jet. The principle is to produce a pulsed laminar plasma jet combined with phased injection of liquid droplets.

The particular design of the plasma torch works at moderate power and follows a resonant mode. Droplets are injected using a piezoelectric device, based on drop-on-demand method, triggered by the voltage signal sampled at the torch connections. Results are evaluated by a time-resolved imaging technique that shows how trajectories are influenced the moment at which droplets penetrate the plasma jet.

“Low Thermal Conductivity Yttria-Stabilized Zirconia Thermal Barrier Coatings Using the Solution Precursor Plasma Spray Process”
Eric H. Jordan, Chen Jiang, Jeffrey Roth, and Maurice Gell

Thermal barrier coatings (TBCs) primarily insulate underlying metal from high temperature gases in gas turbine engines. As a result, low thermal conductivity and high durability are the primary properties of interest. In this work, the solution precursor...
plasma spray (SPPS) created layered porosity, called inter-pass boundaries, in yttria-stabilized zirconia (YSZ) TBCs. IPBs have been shown to be effective in reducing thermal conductivity. Optimization of the IPB microstructure by SPPS produces YSZ TBCs with a thermal conductivity of 0.6 W/mK, approximately a 50% reduction compared to standard air plasma spray (APS) coatings. Preliminary tests show SPPS YSZ with IPBs exhibit equal or greater furnace thermal cycles and erosion resistance compared to regular SPPS and commercially made APS YSZ TBCs.

“Deposition Behavior of Semi-Molten Spray Particles During Flame Spraying of Porous Metal Alloy”  
Jian-Tao Yao, Jun-Qiang Ren, Hui-Bin Huo, Guan-Jun Yang, Cheng-Xin Li, and Chang-Jiu Li

To understand semi-molten spray particle deposition behavior, porous 316L stainless steel deposits were fabricated by flame spray with semi-molten particles with different melting degrees and spray angles. The effects of spray angle relative to deposition efficiency and deposit porosity were investigated. The morphology of individual splats deposited on flat surfaces at different angles was examined. Results show that spray angle significantly influences deposit porosity, pore structure, and deposition efficiency. The slipping of solid cores in semi-molten spray particles was clearly observed when semi-molten particles impact the polished substrate with an inclined angle. A random model simulated the particle deposition process and, after considering the effects of both solid particle slipping upon impact and particle melting degree, simulated porosity calculations agreed well with the experimental observation.

“Numerical Analysis of Multicomponent Suspension Droplets in High-Velocity Flame Spray Process”  
Ebrahim Gozali, Mahrukh Mahrukh, Sai Gu, and Spyros Kamnis

The liquid feedstock or suspension as a different mixture of liquid fuel ethanol and water is numerically studied in the high-velocity suspension flame spray (HVSFS) process, and results for homogenous liquid feedstock of ethanol and water are compared. The mixture’s effects on droplet aerodynamic breakup, evaporation, combustion, and gas dynamics of the HVSFS process are thoroughly investigated. The exact location where particle heating is initiated (above the carrier liquid boiling point) can be controlled by increasing water content in the mixture. In this way, particle inflight time in the high-temperature gas regions can be adjusted to avoid adverse effects from surface chemical transformations. The mixture is modeled as a multi-component droplet, and a convection/diffusion model, which takes into account the convective flow of evaporating material from the droplet surface, is used to simulate the suspension evaporation. The model consists of several sub-models that include premixed combustion of propane-oxygen, non-premixed ethanol-oxygen combustion, modeling of multicomponent droplet breakup and evaporation, as well as heat and mass transfer between the liquid droplets and gas phase.

ASM Handbook, Volume 5A: Thermal Spray Technology

Volume 5A is a replacement for the Handbook of Thermal Spray Technology, edited by J.R. Davis (2004). It provides an introduction to modern thermal spray processes including plasma spray, high-velocity oxy-fuel, and detonation gun deposition, as well as a description of coating properties and their wear, corrosion, and thermal barrier characteristics. Principles, types of coatings, applications, performance, and testing/analysis also are covered.

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