FOURTH QUARTER 2016 / VOLUME 23

SPRAYTIME

PUBLISHED BY THE INTERNATIONAL THERMAL SPRAY ASSOCIATION, A STANDING COMMITTEE OF THE AMERICAN WELDING SOCIETY

Thermal Sprayed Zinc Anodes on Concrete

Forgotten Thermal Spray Applications

On the cover: Preparation of a job reference standard prior to commencing production work. (Photo courtesy of the Florida Department of Transportation.)

Correction for the Q3 issue of SPRAYTIME

In the article titled "**Thermal Spray Rules of Thumb**" a line incorrectly reads, "Wires for electric arc spraying should not have a cast of more than 30 in." It should read, "Wires for electric arc spraying should have a cast of more than 30 in.

Published by International Thermal Spray Association
A Standing Committee of the American Welding Society

Mission: To be the flagship thermal spray industry publication providing company, event, people, product, research, and membership news of interest to industrial leaders, engineers, researchers, scholars, policy-makers, and the public thermal spray community.

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THERMAL METAL COATING CREATED FOR ROYAL NAVY'S NEWEST AIRCRAFT CARRIERS

To protect the flight deck of Queen Elizabeth class aircraft carriers, a new thermal metal coating can resist high-temperature exhaust gases. This photo shows HMS Queen Elizabeth *in June 2015. (Courtesy of Aircraft Carrier Alliance.)*

A thermal metal coating has been developed by British companies to protect the flight deck of Queen Elizabeth class aircraft carriers from heat due to engine thrust of the new F-35B Lightning II fighter jets.

Specialist teams from across the Aircraft Carrier Alliance, a partner relationship between industry and the UK Ministry of Defence, have developed the protective coating. It is capable of resisting high-temperature exhaust gases emitted by these aircrafts during short take-off and vertical landings.

Using a combination of aluminum and titanium, the thermal metal coating can also withstand temperatures of up to 1500°C. Developed in partnership with Monitor Coatings in Tyne and Wear, England, it is expected to provide long-term protection through the carriers' lives. The coating represents part of the work to prepare *HMS Queen Elizabeth* for sea trials next year and flight trials in 2018.

"As the largest warships ever built for the Royal Navy, these powerful ambassadors will protect UK interests around the globe for the next 50 years," said Captain Simon Petitt, senior Naval officer of *HMS Queen Elizabeth*.

The thermal coating is being applied to sections of the *HMS Queen Elizabeth* flight deck using a robotic spray, which fires powdered metal through a jet of plasma at temperatures of almost 10,000°C. The molten droplets then flatten and solidify, creating a tough but rough coating 2–2.5 mm thick, bonded to the steel beneath. Approximately 2000 sq m of the 19,000 sq m flight deck will be coated, with the work due to be finished prior to sea trials in early 2017.

METALLIZING EQUIPMENT CO. CELEBRATES 50-YEAR MILESTONE

Metallizing Equipment Co. Pvt. Ltd., Jodhpur, India, a worldwide supplier of thermal spray equipment, consumables, and coating services, is entering its 50th year in business.

According to historical information on the company's website (*mecpl.com*), it began in 1967 and was founded by the late Shri Balchand Modi. His son, M. D. Modi, now serves as chairman while S. C. Modi is the managing director, and Ankur Modi is the executive director.

Company highlights include opening two branch offices in Mumbai and New Delhi, expanding to Hyderabad and Bangalore in 2000; starting overseas business with a 15% export of total sales, which is now more than 60%; forming business associations with various companies in the fields of thermal spray and automation; having flexible manufacturing and service facilities to make customized products or processes; and most recently earning AS9100 Revision C Certification, an accreditation recognized by the aerospace industry to fulfill requirements for aviation, space, and defense organizations, with the revision focused on timely product delivery.

FUSION FINISHES ITS LARGE-CAPACITY COATING BOOTH

Fusion, Inc., Houston, Tex., has completed its largest coating cell at 16 ft wide x 13 ft high x 51 ft long. It has the capability to handle customer components up to 100 in. in diameter x 28 ft long and up to 80,000 lb. Additional highlights include robotically coating large crankshaft rod journals; a roof that opens hydraulically to facilitate using an overhead crane for loading/unloading; interior cameras for customers to log on and view their individual components being coated live; and LED lighting. This booth was the idea and creation of Stratton Gillis, along with Engineers Bob Curd and Paul Curfman, and the help of intern Reese Chesnut.

A gantry-supported robot is among the many features in Fusion's new coating booth.

LEOPAD GROUP SELECTS IFS SOFTWARE TO IMPROVE PROJECT CONTROL

As an oil and gas services provider, the Leopad Group chose IFS software to consolidate operations along with ensuring better management of all its projects and resources.

IFS, High Wycombe, UK, a global enterprise applications company, recently announced that the Leopad Group, Malaysia, a provider of corrosion protection services and onshore/offshore services to the oil and gas sector, has opted to deploy its Applications™ 9 software. This system will be used to consolidate operations and deliver onshore/offshore project efficiencies through the following features: project, subcontractor, and asset management; financials; resource planning; and procurement. It will be implemented by IFS partner Measa Consulting Pvt. Ltd.

TRU-DESIGN AND POLYNT COMPOSITES USA PARTNER TO DEVELOP COATINGS FOR 3D-PRINTING APPLICATIONS

Tru-Design, LLC, Knoxville, Tenn., and Polynt Composites USA, Inc., Carpentersville, Ill., have united to develop advanced material coatings and finishes for 3D-printed components made by large-area additive manufacturing. This partnership combines the strengths of both companies to create and market materials that will enable broader commercial adoption of large-area additive manufacturing for industrial size parts, tools, and products requiring a smooth or vacuum-integrity finish.

"This industry is in its infancy, and new materials are needed to make it viable for many market segments," said Polynt's R&D Director Steve Voeks.

Upcoming Presentations

What Is Thermal Spray?

AWS INTERNATIONAL THERMAL SPRAY ASSOCIATION

To increase awareness of thermal spray coating technology and how it works, the following presentations will take place at the following key industry events. All ITSA-sponsored, thermal spray presentations are free to attendees. ITSA Company Members will be recognized as part of the presentations. Not an ITSA Company Member? For an ITSA Membership Application, visit www.thermalspray.org.

2016 Events:

- FABTECH: Las Vegas, NV, November 16-18, 2016
- Power-Gen: Orlando, FL, December 13-15, 2016

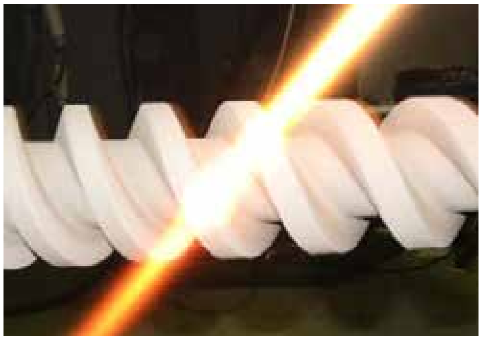
2017 Events:

- AISC – 2017 NASCC/NSBA Steel Conference: San Antonio, TX, March 22-24, 2017
- NACE Corrosion: New Orleans, LA, March 26-30, 2017

Presented by: James Weber, James K. Weber Consulting

For dates & times of the thermal spray presentations, visit the sponsor websites and look under education programs.

WEAR-RESISTANT NANOPARTICLE COATING TARGETS PLASTICATING SCREWS



Available for single and twin plasticating screws, the Xaloy® MPX™ thermal spray coating is made up of particles 5 microns in diameter. It also resists abrasive and corrosive wear. Particles, consisting primarily of tungsten carbide, are densely packed due to uniform spherical shape; their size, coating density, and application velocity promotes bond strength with the base metal screw. Containing near-zero porosity, the coating survives > 1000 h of salt fog testing. The standard layer thickness is 300 microns.

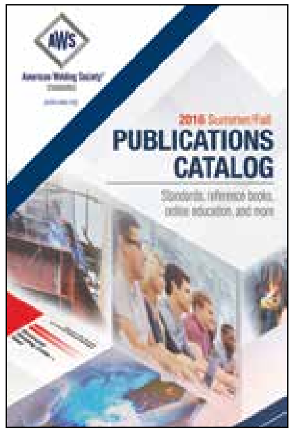
Nordson Corp.
nordson.com / (440) 892-1580

MASKING COMPOUND PERMITS THERMAL SPRAY TECHNICIANS TO MASK DEPRESSIONS

The NAS-HVC thermal spray masking compound is a two-part silicone compound. It enables thermal spray technicians to mask keyways, holes, and depressions. The product can endure all forms of thermal spray and grit blasting, including high-velocity oxygen fuel. In addition, it can be used as a plug, reused several times, and adheres to thermal spray tapes. The compound is offered in 1-, 2-, and 4-lb kits.

National Alloy Solutions
nationalalloysolutions.com / (713) 766-3666

AWS RELEASES 2016 SUMMER/FALL PUBLICATIONS CATALOG



The American Welding Society's (AWS) 2016 Summer/Fall Publications Catalog is available. This 52-page manual includes the following new editions: C7.3:2016, *Process Specification for Electron Beam Welding;* D17.3/D17.3M:2016, *Specification for Friction Stir Welding of Aluminum Alloys for Aerospace Applications;* C3.4M/C3.4:2016, *Specification for Torch Brazing;* C3.5M/C3.5:2016, *Specification for Induction Brazing;* C3.6M/C3.6:2016, *Specification for Furnace Brazing;* and G1.10M:2016, *Guide for the Evaluation of Thermoplastic Welds*. Its contents consist of professional and career development, reference materials, processes, industry application, materials, and more. The catalog can be accessed at the website listed below.

AWS
aws.org/catalog2016 / (888) 935-3464

REPORT REVEALS AEROSPACE INDUSTRY'S SHARE OF GLOBAL THERMAL SPRAY MARKET

Global Thermal Spray Market – Segmented by Coatings & Finishing, Materials, Equipment, End-User Sector, and Geography – Trends and Forecasts indicates that the thermal spray market was valued at $7.580 billion in 2015. It is also estimated to reach $77.8936 billion by 2021, growing at a compound annual growth rate of 7.79% during the forecast period from 2016 to 2021.

In 2015, the aerospace industry was the largest end-user sector and accounted for about 34% of the global thermal spray market, followed by industrial gas turbines. The automotive sector is estimated to be the fastest growing end-user sector with a growth rate of more than 8% during the forecast period. North America dominated the market in 2015, accounting for almost 32% of the global market. Asia-Pacific is expected to be the fastest growing region with a compound annual growth rate of 8.40% during the forecast period.

Mordor Intelligence
mordorintelligence.com / (617) 765-2493

OVERLAY USEFUL IN SLIDING WEAR ENVIRONMENTS

The Duroxite™ overlay is comprised of abrasion-resistant materials deposited on top of mild steel or Hardox® wear plate to create a wear-resistant compound material. Manufactured by SSAB, it works in sliding wear environments where small and hard materials are processed, such as coal with a high quartz content. Pictured is a coal discharge chute liner made with this 101 overlay, which improved wear life from seven days to six months. The product also serves as a wear-resistant material in high-temperature environments. It is delivered with an overlay thickness guaranteed within +10%. Consistent wear properties are guaranteed throughout the plate down to 75% of the overlay thickness; the remaining 25% of overlay is the transition layer to maintain good bonding to the base plate. A carbide composition ensures homogenous bonding between the base metal and overlay.

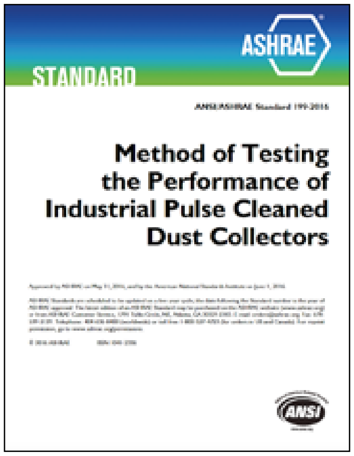
Hardox Wearparts
hardoxwearparts.com / (462) 437-1200

COATING ENABLES SMOOTH PROCESSING AT HIGH LINE SPEEDS

The SilForce™ SL7562S base polymer, a thermal solventless release coating for Glassine papers and filmic liners, provides a flat release profile and fast cure at a low level of catalyst, which can enable higher efficiency for label manufacturing, converting, and dispensing. The medium-low viscosity of the product's base polymer can help reduce silicone coat weight while maintaining coverage for stable release performance. It also possesses process ability, which can allow coating at high speed without misting.

Momentive Performance Materials, Inc.
momentive.com / (800) 295-2392

STANDARD FOR TESTING INDUSTRIAL PULSE-CLEANED DUST COLLECTORS OFFERED



The ANSI/ASHRAE Standard 199-2016, *Methods of Testing the Performance of Industrial Pulse Cleaned Dust Collectors*, provides a quantitative laboratory test method for determining the performance of these collectors using a test dust. This method of test applies to bag, cartridge, or envelope collectors that recondition the filter media by using a pulse of compressed air to discharge the dust cake from the filter media while the air cleaning device remains online. Included among the 22-page document are sections for test methodology, apparatus, and materials; qualification/maintenance of the test setup; and reporting specifics. The PDF and printed edition each cost the same at $46 ($39 for members), while purchasing both together costs $67 ($57 for members).

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techstreet.com / (800) 527-4723

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ITSA MISSION STATEMENT

The International Thermal Spray Association, a Standing Committee of The American Welding Society, is a professional industrial organization dedicated to expanding the use of thermal spray technologies for the benefit of industry and society. ITSA invites all interested companies to talk with our officers, and company representatives to better understand member benefits.

OFFICERS

Chairman: Jim Ryan, *Carpenter Powder Products*
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David Wright, *Accuwright Industries, Inc.*

ITSA MEMBER NEWS

Tradeshow Assessment for ITSA Member Eliminated

Earlier this year, ITSA Members were invited to participate in an ITSA Member Satisfaction Survey, in which they were asked to rate the value of various member benefits. Based on feedback received on the value of ITSA Booth participation at industry tradeshows, at its April 20, 2016, meeting, the ITSA Executive Committee unanimously decided to discontinue ITSA booth activity at tradeshows effective July 2016. As ITSA Members subsidized the cost of ITSA booth activity via annual assessments, this move will result in the elimination of these costly annual ITSA Member assessments going forward.

In lieu of booth representation at tradeshows, ITSA will proactively participate in alternative ways at key industry events. For example, a series of educational presentations promoting thermal spray are being scheduled as free, half-day sessions at tradeshows like FABTECH, POWER-GEN International, and CORROSION.

ITSA SCHOLARSHIP OPPORTUNITIES

The International Thermal Spray Association offers annual Graduate Scholarships. Since 1992, the ITSA scholarship program has contributed to the growth of the thermal spray community, especially in the development of new technologists and engineers. ITSA is very proud of this education partnership and encourages all eligible participants to apply. Please visit *www.thermalspray.org* for criteria information and a printable application form.

ITSA THERMAL SPRAY HISTORICAL COLLECTION

In April 2000, the International Thermal Spray Association announced the establishment of a Thermal Spray Historical Collection that is now on display at the State University of New York at Stony Brook in the Thermal Spray Research Center, USA.

Growing in size and value, there are now over 30 different spray guns and miscellaneous equipment, a variety of spray gun manuals, hundreds of photographs, and several historic thermal spray publications and reference books.

Future plans include a virtual tour of the collection on the ITSA website for the entire global community to visit. This is a worldwide industry collection and we welcome donations from the entire thermal spray community.

ITSA SPRAYTIME

Since 1992, the International Thermal Spray Association has been publishing *SPRAYTIME* for the thermal spray industry. The mission is to be the flagship thermal spray industry publication providing company, event, people, product, research, and membership news of interest to the thermal spray community.

JOIN THE INTERNATIONAL THERMAL SPRAY ASSOCIATION

ITSA is a professional, industrial association dedicated to expanding the use of thermal spray technologies for the benefit of industry and society. ITSA Membership is open to companies involved in all facets of the industry – equipment and materials suppliers, job shops, in-house facilities, educational institutions, industry consultants, and others.

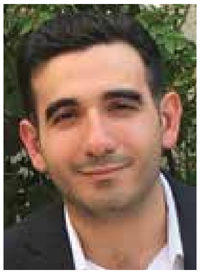
Engage with dozens of like-minded industry professionals at the Annual ITSA Membership Meeting, where there's ample time for business and personal discussions. Learn about industry advancements through the one-day technical program, participate in the half-day business meeting, and enjoy your peers in a relaxed atmosphere complete with fun social events.

Build awareness of your company and its products and services through valuable promotional opportunities – a centerfold listing in the SPRAYTIME Newsletter, exposure on the ITSA Website, and recognition at industry trade shows.

PLUS, ITSA Membership comes with an American Welding Society (AWS) Supporting Company Membership and up to five AWS Individual Memberships to give to your best employees, colleagues or customers. Visit *www.aws.org/membership/supportingcompany* for a complete listing of additional AWS benefits.

For more information, contact Cassie Burrell at 800.443.9353 Ext 253, or itsa@thermalspray.org. For an ITSA Membership Application, visit the membership section at *www.thermalspray.org*.

LINEAGE ALLOYS ANNOUNCES GENERAL MANAGER

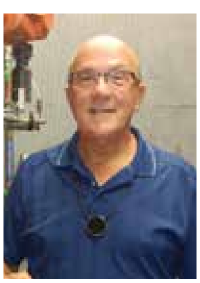


Lineage Alloys, Baytown, Tex., has appointed Adel Djam to general manager. Djam's responsibilities will include managing policy deployment in the areas of lean manufacturing techniques, quality, cost reduction, delivery, safety, customer satisfaction, employee relations, visual controls, and plant performance measures. In addition, he will help expand the company's customer base and manage material requirements. Djam has experience working with lean manufacturing processes and thermal spray technology. He holds a bachelor's in engineering science with a specialization in materials science from Stony Brook University.

OERLIKON METCO APPOINTS VICE PRESIDENT, SALES

Oerlikon Metco, Westbury, N.Y., has named Richard Farbaniec as vice president, regional head of sales in the Americas. He will be responsible for all leadership functions for the North, Central, and South American teams. Additionally, he will grow strategic customer accounts and partner relationships. Farbaniec has more than 20 years of market experience with 14 years in sales and business development roles at industrial enterprise organizations. He has an engineering background and holds a master's in business administration from Drexel University.

BRYCOAT HIRES COATINGS EXPERT



BryCoat, Inc., Oldsmar, Fla., has hired Raymond "Ray" Sinatra as principal technical expert. Sinatra will add his experience in thermal spray coatings and surface technology to the company. He has more than 47 years of experience in industrial processing and surface technology. He spent 21 years as a senior specialist for the Rolls-Royce Corp., where he developed multiple patents in surface technology. Over the last ten years, he has concentrated on thermal spray abradable seal coatings and the pursuit of new material formulations for future engine applications that require higher temperature and longer service life.

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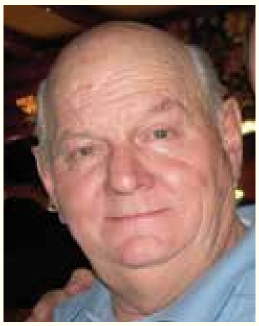
OBITUARY

HERBERT G. HOYNE



Herbert G. Hoyne of South Windsor, Conn., passed away on July 23. Hoyne was a native of Long Island and served in the U.S. Navy. After an honorable discharge from the Navy, he went on to earn a degree in electrical engineering from the University of New York. He worked for the New York City Transit Authority, Xerox Corp., Metco, and Plasma Technology, Inc., before starting his own business, HGH Industries, in 1988. In 2005, after losing his wife to heart disease, Hoyne took a step back and allowed his son, John, to oversee daily operations of the company while he continued to travel occasionally for business. Hoyne is survived by three sons, a stepson, a stepdaughter, two siblings, and several grandchildren, nieces, and nephews.

JOHN R. EGAN

John R. Egan of Matawan, N.J., passed away on September 3. Egan was plant manager of Plasma Powders & Systems, Inc., Marlboro, N.J. He coordinated field service and product development for the company for more than ten years and possessed extensive expertise in thermal spray solutions, systems, and materials. He is survived by his wife, Frances (Franco) Egan, his mother, Mary (Lanik) Egan Mayer, and three sisters.

FORGOTTEN THERMAL SPRAY — PUBLIC TRANSIT SYSTEMS

How thermal spraying kept street cars in operation during World War II

By James K. Weber

In 1942, during the early days of World War II and soon after the United States entered the war, vast resources were needed for defense. This meant that all resources essential to winning the war were either taken away from nonessential industries or severely rationed. Companies that made cars, appliances, buses, clothing, and thousands of other products were now mandated to manufacture things needed to support the war.

THE NEED FOR THERMAL SPRAY

This lack of resources proved to be a big problem for public transit companies like the New Orleans Public Service. With the war going on and the need to move thousands of war workers each day, how were they to keep their equipment rolling? The lack of replacement parts especially affected the streetcar line, which was operating 24 hours a day, every day, and without a large spare parts infrastructure like their buses. Much of the equipment was more than 20 years old and spare parts were no longer available. In addition to these factors, the operators also needed to stretch scheduled maintenance times due to nearly 100% utilization. Longer intervals between preventive maintenance tasks were causing more wear than during nonwartime operation.

The public transit's New Orleans Carrollton workshops had begun experimenting with German-made thermal spray equipment in 1940, and by 1941, they had purchased several U.S.-made systems. When war broke out, their experimentation evolved into full-scale implementation. In 1953, the general foreman, overhaul foreman, and thermal spray operator for the Carrollton shops were interviewed. All three stated that thermal spray kept the company from shutting down completely during World War II, and they would metalize anything that couldn't be replaced, including almost all working parts. This meant not only parts on the streetcar, but many parts on the buses as well.

One of the more interesting thermal spray applications were the driving axle journals. These were 4.5 in. (114 mm) OD and 8.5 in. (216 mm) long. These journals revolved inside greased Babbitt bearing shells and supported the entire dynamic weight of the streetcar. When in use, they would wear in a tapered fashion, with more than 0.5 in. (12 mm) of wear near the wheel and 0.25 in. (6 mm) near the ends. If the journals wore too much, the axle would be too thin to safely support the streetcar. A worn journal also affected the mesh of the driving gears and braking system.

The operators had a dilemma — how could they repair the worn journal? On their worn bus crankshafts, they could grind the worn area perhaps 0.030 in. (760 µm) undersized and then use an oversized bearing. However, with the journals this wasn't an option due to the axle strength needed for safe operation. Also, if they cut the journal to a parallel ≈4 in. (102 mm) OD, the axle would soon wear to an even smaller 3.5-in. (90-mm) taper and be even more unsafe.

Welding metal back onto the journals was a possible repair method; however, the high temperature of the process could warp the axle and possibly add postweld internal stresses to the axle. This could mean that after welding, the axle would need straightening, heat treating, and possible postheat treatment straightening. This all takes a lot of time and possibly resources that were committed to the military. The thermal spray repair method they developed was simple and very effective.

After first truing the wheel and removing any flat spots, they degreased the worn journal very thoroughly and carefully machined off only enough material to remove any deep scoring. They did not remove the taper because this would have weakened the journal even further. It should be noted that with thermal spray nowadays, the applicator usually prepares the surface for coating by abrasive blasting with sharp, angular media. Before the 1970s, it was quite popular to employ alternative methods to blasting.

The Carrollton shops preferred not to abrasive blast on the journal. Therefore, they cut a rough, 16-pitch (1.58 per mm) thread across the surface, with the threading tool angled in such a way that the threads had a poorly cut surface (tear-out). The tear-out and the threads added surface area needed for thermal spray adhesion to the journal. In addition to this, they sometimes added a rough knurl on top of the thread. This knurling deforms the top of the treads. This surface-preparation method, along with the coating system applied, is illustrated in Fig. 1.

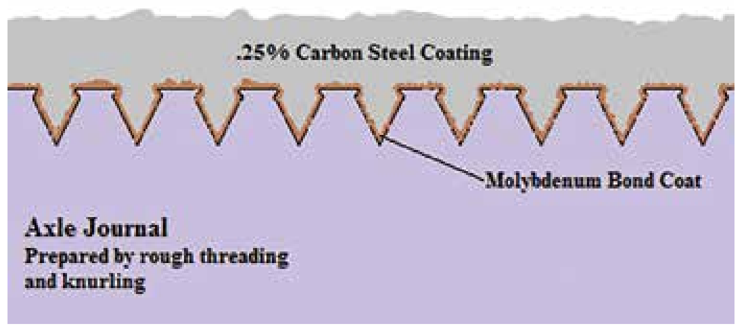


Fig. 1 — Molybdenum bond coat and 0.25% carbon steel applied over the threaded and knurled journal.

This rough threaded surface was then coated with about 0.003 in. (75 µm) of molybdenum (moly) bond coat. This was done in two spray passes. With each pass, the wire flame spray gun was rotated slightly left and right so that the coating adhered better to the threads and reached into the undercuts if knurled. Moly melts and atomizes off the wire tip at 4753°F (2623°C). When these white hot particles impact the substrate, they micro-fuse to the surface. Coatings like moly are considered "self bonding" and greatly enhance the adhesion of coatings applied to nonabrasive blasted surfaces. In addition to being self bonding, the moly surface is rough with many nooks and crannies for any topcoat to adhere to.

With the surface now coated with moly, the journal was ready for top-coating with a 0.25% carbon steel flame spray wire. This particular carbon steel has a hardness in the RB 94 range, is easily

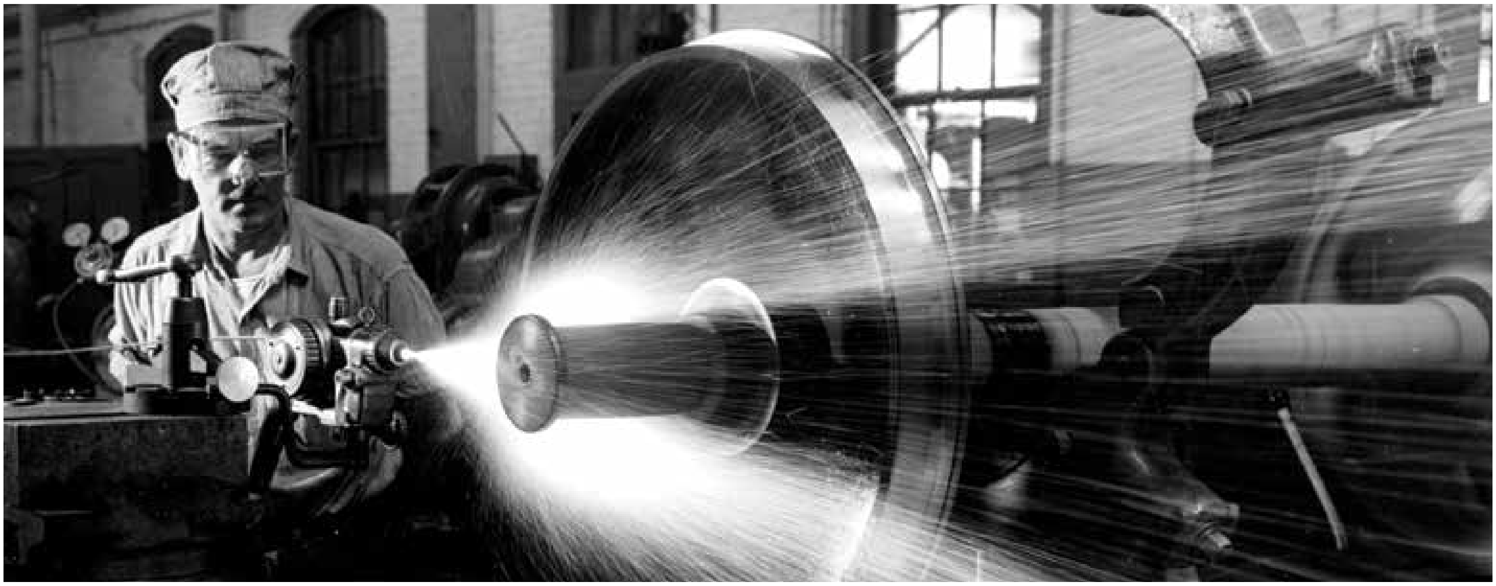


Fig. 2 — A New Orleans Public Transit employee oversees 0.25% carbon steel applied over the molybdenum-coated journal.

machined, has no sprayed thickness limit (low stress), and the sprayed microstructure is a combination of soft carbon steel for ductility, hard oxides for wear resistance, and porosity that is good for entraining lubricants at the surface. An added bonus was that this was a very low-cost material.

The carbon steel wire was first thinly sprayed across the entire moly-coated surface, but after a few passes, the applicator would focus the coating buildup closer to the wheel so that the taper could be reduced. When parallelism was achieved across the journal, the applicator would add another 0.040 in. (1 mm) of coating so that the journal would have enough coating to clean up nicely when subsequently machined. The metal spraying process took less than 30 min. Figure 2 shows the moly-coated journal getting its first passes of carbon steel.

Figure 3 shows the carbon steel getting turned down on a lathe. This material machines easily, and it only took a few cuts and less than 30 min to finish the journal to size. The entire journal could be fully restored in one shift.

THERMAL SPRAYING PROVES SUCCESSFUL

In 1953, New Orleans Public Transit reported it had 100 thermal spray-coated journals in operation and never had a failure. Workers believed the coated journals, along with the 150 coated driver axles, would last the life of the streetcar, whereas the uncoated parts wore out in several years.

They also reported coating many parts on their buses. One part in particular, the air compressor crankshaft main bearing and throw surfaces, could be run two times longer than a noncoated part before it wore out. Figure 4 shows one of these crankshafts being coated with 0.25% carbon steel. However, in this case they used steel grit abrasive blasting to prepare the surface and did not need to use the moly bond coat.

During the war, New Orleans Public Transit employees had coated nearly any part that wore. There is documentation showing carbon steel coatings being applied to bus parts, such as steering arm spindles, clutch shafts, brake cams, water pump shafts, throughout bearing shafts, and more. On the streetcars they

Fig. 3 — Thermal spray coated journal being machined back to size.

repaired similar parts and also repaired armature bearings with Tobin bronze, a copper-zinc-tin alloy. New Orleans was not the only public transit system using thermal spray to keep its equipment rolling. There are historical documents showing an all-out effort was being put forth in Philadelphia, Pa., Cincinnati, Ohio, and Newark, N.J., among other cities.

CONCLUSION

Nowadays, with enormously improved materials, lubricants, and no war effort, these types of repairs seem to be no longer needed. I recently visited the Carrollton shops and learned they haven't

Fig. 4 — A worker oversees 0.25% carbon steel applied over an abrasive blasted crankshaft main bearing. (Note: In current safety practices, protective gear would have been worn.)

done any thermal spray there since the 1970s. The lathe they used to coat the journals in 1942 is still there; however, with the newer axle forgings not wearing like in the old days, it sits idle. With today's advanced fabrication techniques, new parts can seemingly be more easily made than restored. The machinists at the current Carrollton yard were quite impressed when I showed them what was done more than 50 years ago, but they see no need to bring these methods back today.

It is important to remember that these methods do still exist and these coatings did work and help win the war. With the current war seeming to be the battle to reduce man's carbon footprint, along with the growing need to keep aging factories and machinery working, and adding to that the call for improving service life and reliability of machines tasked with around-the-clock performance, perhaps the renewing of parts like these with thermal spray instead of replacing them will make more sense in the coming years as we strive to live in a more renewable society. I challenge you to look around your place of business and at your customers' facilities through the eyes of the struggling transit companies of World War II. Do you see any opportunities for thermal spray repairs?

WORKS CONSULTED

1. Interviews with John Ruck, general foreman; Emil Frisard, overhaul foreman; and John G. Wehlen Jr., Metco operator. April 17, 1953. Metallizing Engineering Co., Inc. Long Island City, N.Y. Developed by Metallizing Engineering Co., and cleared by James O. Peck Co.

2. New Orleans Public Service, Inc., Carollton Shops. New Orleans, La. Cleared by James O. Peck Co.

JAMES K. WEBER* (jweber5@optonline.net) *is president of James K. Weber Consulting, LLC, Bay Shore, N.Y.

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See pages 10 – 11

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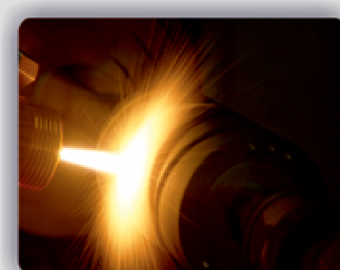

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UPDATE ON THERMAL SPRAYED ZINC ANODES ON STEEL-REINFORCED CONCRETE

A recently revised AWS specification provides minimum requirements for proper installation of thermally sprayed zinc anodes on concrete using both the arc and flame spray methods

By Ivan R. Lasa

In the transportation infrastructure industry, thermal spray is commonly used as a protective coating for structural steel components and to protect the rebar in steel-reinforced concrete from corrosion.

For reinforced-concrete structures, the process provides protection to the reinforcement by making it a cathode in relation to an external anode that is applied to the concrete surface by thermal spray methods. However, for this procedure to be effective, proper materials and application methods must be used. The American Welding Society (AWS) recently published an updated version of Specification C2.20, which provides guidance for the effective application of the procedure — Fig. 1. This document is discussed later in this article.

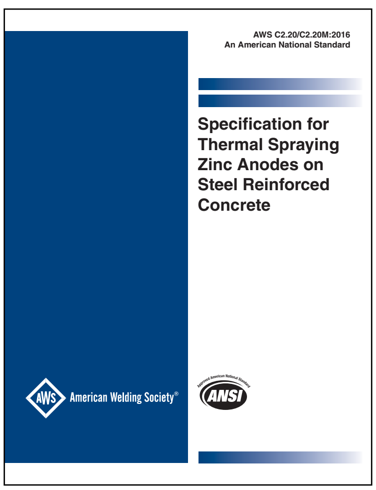

Fig. 1 — This AWS specification for the application of thermally sprayed zinc anodes on concrete was recently updated.

The concept of making the protected metal a cathode is known as cathodic protection, a well-proven method for mitigating corrosion. Cathodic protection can be implemented as an impressed current (ICCP) system or as a galvanic (also known as sacrificial) system. The difference between the two systems is that the ICCP requires an external source of electricity to force a protective current onto the surface of the metal, while the galvanic system uses a metal higher in the electromotive chart (galvanic series) to generate the current. However, in reinforced concrete, both systems establish an electrical circuit similar to that of a corrosion cell to provide the protective current — Fig. 2. In this case, the concrete itself serves as the electrolyte on which the current moves from the anode to the cathode.

Zinc and zinc alloys are the thermal sprayed anodes commonly used for cathodic protection of the reinforcing steel in concrete. The zinc or zinc alloy anode comes in a wire form that can be melted and applied by the thermal spray process. Either the flame spray or arc spray method can be used to apply the anode. However, arc spray is preferred and most commonly used because of its safer and faster application. As the name implies, the flame spray system uses a gas-produced combustion flame to heat the zinc wire to a molten state that is then propelled onto the concrete by means of compressed air. The arc spray system uses a DC current

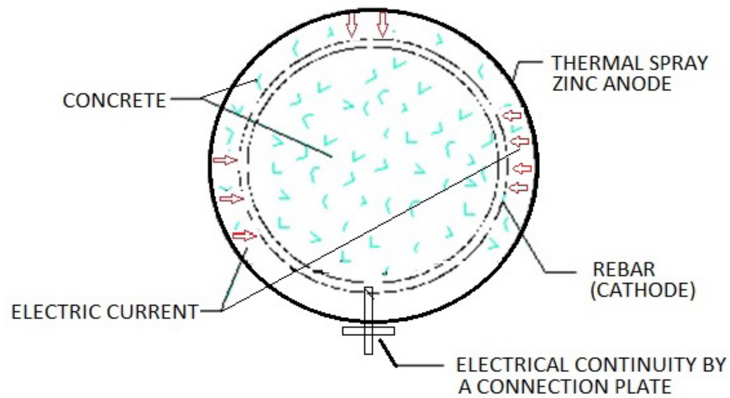

Fig. 2 — Schematic of the cathodic protection circuit for sprayed zinc anodes on concrete.

to simultaneously melt two zinc wires, and then compressed air is again used to propel the molten product onto the concrete. Because the heating current can be adjusted, the arc-spray system has the added advantage of being able to melt wires of different types and diameters (sizes), and the temperature for that purpose can be adjusted as needed.

To properly develop an effective thermally applied zinc cathodic protection system, it is essential to determine the electrical resistance of the concrete to which the zinc will be applied. Since a galvanic cathodic protection system can only use the natural electrical potential of the zinc to force the current through the concrete and onto the reinforcement, concretes with high electrical resistance will impede current flow. This high resistance condition is common on noncontaminated and dry concretes. For those situations, the thermally sprayed anodes are set as impressed current systems such that an external power supply can augment the current flow. In both cases, wire connections are provided to the zinc and to the reinforcement such that an electrical circuit can be established. For galvanic systems, the two wires are directly connected to each other, while for an impressed current system, the wires are connected to the external power source.

The best and more common application for a galvanic thermally applied zinc anode cathodic protection system is for structure components that are in proximity to water and contaminated with chlorides such as those in or near marine environments (Fig. 3), but it is also common for concretes contaminated by deicing salts. Concretes in these environments typically exhibit a low electrical resistance that allows the current to flow onto the reinforcement with no assistance from external power sources. In addition, the high humidity of such environments does not permit the zinc anode to

Fig. 3 — Application of sprayed zinc anode on concrete on a structure in a marine environment.

passivate, which is a tendency of the zinc when dry for prolonged periods. Thermally applied zinc anode systems are many times preferred over ICCP systems because of their low maintenance requirement since no external components are needed.

Given that the cathodic protection process systematically consumes the zinc anode, it is important to apply a sufficient amount of zinc. This is monitored by measuring the thickness of the applied zinc coat. The bond between the thermally applied zinc and the concrete is also extremely important. Should a poor bond or delamination between the zinc and the concrete exist, the cathodic protection current will not be able to flow though the concrete.

THE UPDATED SPECIFICATION

Although it does not address the details of a cathodic protection system, AWS C2.20/C2.20M:2016, *Specification for Thermal Spraying Zinc Anodes on Steel Reinforced Concrete*, provides the minimum requirements for proper installation of thermally sprayed zinc anodes on concrete. This specification was updated this year and covers the application of zinc thermal spray coatings on concrete using both arc and flame spray equipment. The document introduces the work with a process flow chart for the application of zinc spray to concrete followed by the requirements regarding coating thickness, bond strength, surface preparation, and acceptance testing.

A coating thickness of 0.010 to 0.020 in. is specified along with methods to measure it, but the specification allows for other specified ranges as defined by the designer and indicated in the contract documents. The range specified is common practice, and its efficiency has been verified by research and evaluation of previously installed thermally sprayed zinc anodes. The specification also establishes a minimum bond requirement of 150 lb/in.^{2} between the zinc coating and the concrete, and addresses the use of a job reference standard(s) that is representative of all concrete conditions within the job. For thermally sprayed zinc anodes on concrete, the job reference standard is of extreme importance since the surface matrix of concrete differs based on the concrete properties, age, and pour conditions. Therefore, different concretes may require different levels of cleanliness, sandblasting (surface profiling), and/or zinc application procedures to meet the required bond strength. It is not unusual for preproduction application trials

Fig. 4 — Preparation of a job reference standard prior to commencing production work.

to be performed to determine the best application procedures — Fig. 4. For both the required thickness and adhesion strength, the document establishes methods and frequencies of measurements.

In addition, the document addresses the holding period and the feedstock material to use. The holding period, or time for application of the thermal zinc, is defined as the permissible time between the start of final blasting for surface preparation and application of the thermal sprayed coating. This period depends on factors such as moisture in the concrete, ambient temperature, and humidity. It is important since the tensile bond is reduced in the presence of these factors. The holding period should be of utmost consideration when applying thermally sprayed anodes on structures in or near marine environments.

CONCLUSION

AWS C2.20 also addresses requirements for thermal spraying equipment, inspection and quality control equipment, concrete temperature, job records, and procedures for repair of deficient thermal spray zinc coatings. To complement the specification, one mandatory annex and two nonmandatory annexes are also included. The mandatory annex includes an example of a job control record for the application of thermal spray that users can adjust to their particular jobs. The first nonmandatory annex is dedicated to general safety and the safe use of thermal spraying equipment, while the second contains AWS administrative information.

As discussed earlier, the use of thermal sprayed zinc anodes for cathodic protection of steel reinforcement in reinforced concrete is widely accepted as an effective means of providing corrosion control and extending the service life of structures. However, there are several conditions and specific requirements that need to be met for the process to be successful. Simply spraying a zinc coating over the concrete will not provide effective corrosion control. A thermally applied zinc cathodic protection system must be well bonded to the concrete for the current to flow from the zinc onto the reinforcement's surface. In addition, because the zinc consumes itself in the process of producing the cathodic protection current, special attention must be placed on the amount of zinc that is applied as the anode to ensure the system will meet its design service life. AWS C2.20 provides the tools and guidance to complete a successful installation of thermally sprayed zinc anodes on concrete. The included requirements and commentary in the document are based on research and the expertise of corrosion control practitioners who have evaluated the performance of thermally applied zinc anode systems in multiple structures treated with the system at an international scale.

ACKNOWLEDGMENTS

Figure 1 is courtesy of the American Welding Society. All other figures are courtesy of the Florida Department of Transportation.

IVAN R. LASA **(Ivan.lasa@dot.state.fl.us)** ***is State Steel Material Products Administrator, Florida Dept. of Transportation – Corrosion Research Laboratory, Gainesville, Fla. He is a member of the AWS C2 Committee on Thermal Spraying and chair of the C2C Subcommittee on Thermal Sprayed Coatings for Reinforced Concrete.***

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