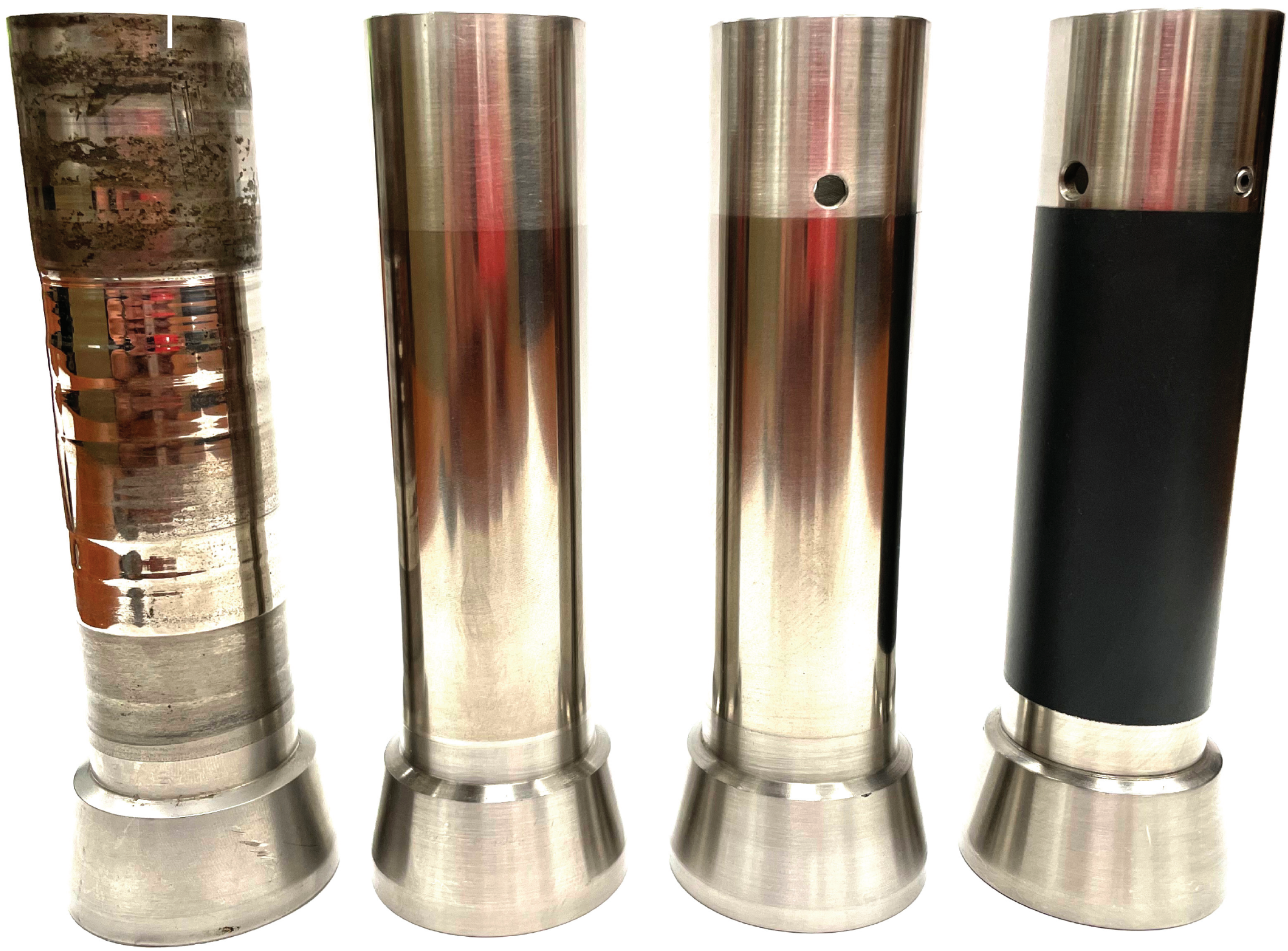
THIRD QUARTER 2023 | VOLUME 30

SPRAYTIME

American Welding Society
International Thermal Spray Association



Thermal Spray Repair

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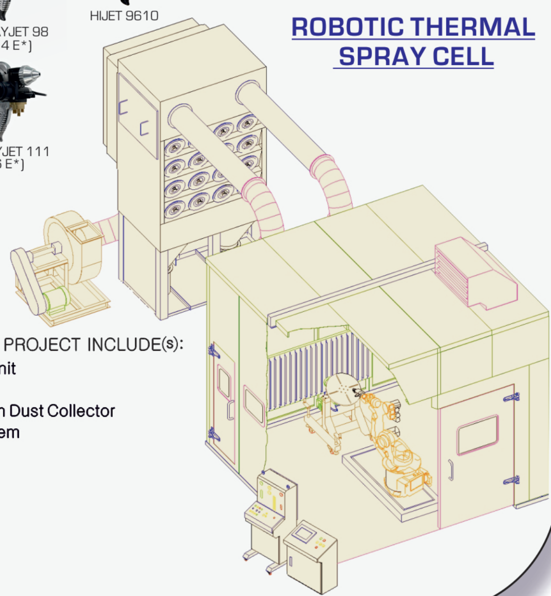

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On the cover: Pump sleeves in various conditions. Left to right: as used, coated with stainless steel and ground, coated with tungsten carbide cobalt and ground, and coated with chrome oxide and ground. (Photo courtesy of Hayden Corp.)

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

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Mollie Blasingame
Chair

Thank you to everyone who attended the 2023 ITSA Annual Meeting on August 9 in Buffalo, N.Y. We enjoyed a great turnout of member companies.

For the event, ITSA partnered with EWI, giving attendees the opportunity to tour EWI's Cold Spray Center of Excellence at Buffalo Manufacturing Works. Dr. Victor Champagne, Samuel Bedard, and Bradley Richards gave insightful presentations on the state of the cold spray industry, recent advancements, and future applications.

While in Buffalo, our membership also discussed the direction and focus of the ITSA organization going forward to ensure that it continues to create value for its members.

Another point of discussion included two specific initiatives by the ITSA Executive Committee:

1) Performing a formal review of the ITSA Bylaws; and

2) Locking in the dates and program details for a 2024 ITSA event, which will take place in Miami, Fla.

Stay tuned for more information about these initiatives and the launch of a brand-new version of the *thermalspray.org* website.

ITSA MISSION STATEMENT

The International Thermal Spray Association (ITSA), 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

Mollie Blasingame, chair, Superior Shot Peening & Coatings

Kirk Fick, vice chair, Cincinnati Thermal Spray Inc.

EXECUTIVE COMMITTEE (above officers plus the following)

Ana Duminie, North American Höganäs
Jim Ryan, TechMet Alloys
David A. Lee, David Lee Consulting LLC
Bill Mosier, Polymet Corp.
Peter Ruggiero, Curtiss-Wright Surface Technologies

ITSA SCHOLARSHIP OPPORTUNITIES

ITSA 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. Visit *thermalspray.org* for criteria information and a printable application form.

ITSA *SPRAYTIME*

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

JOIN 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 listing in *SPRAYTIME*, exposure on the ITSA website, and recognition at industry trade shows.

Plus, ITSA Membership comes with an AWS Supporting Company Membership and up to five AWS Individual Memberships to give to your best employees, colleagues, or customers.

Visit *aws.org/membership/supportingcompany* for a complete listing of additional AWS benefits. For more information, contact Adrian Bustillo at (786) 937-9595 or *itsa@thermalspray.org*.

For an ITSA Membership application, visit the membership section at *thermalspray.org*.

ITSA and AWS C2 Committee Members Gather in Buffalo

More than 25 ITSA members and guests gathered in Buffalo, N.Y., on August 9 for the ITSA Annual Business Meeting. The gathering marked the first in-person meeting for the association since 2019.

The meeting was called to order by ITSA Chair Mollie Blasingame. After calling on the membership to approve previous meeting minutes, Blasingame introduced American Welding Society (AWS) C2 Committee on Thermal Spraying Chair Daniel C. Hayden. Hayden provided a recap of the committee meeting that occurred on August 8 in Buffalo.

"It was a great idea to have the AWS C2 Committee on Thermal Spraying hold their meeting at the same time as the ITSA meeting. Dan Hayden's presentation on the C2 Committee highlighted the crossover appeal. ITSA members are all either end users, applicators, OEMs, or consultants, and C2 Committee documents are the go-to standards for the thermal spray market. I hope it generated some interest in more ITSA members attending the next C2 event," said Blasingame.

Blasingame then led meeting attendees into discussions on ITSA's mission, membership, scholarships, and future meetings. She also presented a plaque of appreciation to Past Chair Ana Duminie.

Also, during the meeting, Past ITSA Chair David Lee discussed the final investigative report on the fatal 2020 propylene explosion at the Watson Grinding facility in Houston, Tex. Lee served as a consultant and provided feedback on the investigation.

Following the meeting and lunch, members toured the Cold Spray Center of Excellence at Buffalo Manufacturing Works operated by EWI. The tour kicked off with a presentation on the historic rise and fall of manufacturing in the city of Buffalo and how EWI's facility is currently revitalizing the region's industry. Attendees also had the opportunity to tour and learn about different areas of the facility including the automation workshop, cold spray system stations, and data science department.

ITSA Chair Mollie Blasingame (left) presented a plaque of appreciation to Past Chair Ana Duminie.

Following the tour, presentations were given by Victor Champagne, team lead, U.S. Army Combat Capabilities Development Command (CCDC) Army Research Laboratory; Bradley Richards, cofounder and CEO, Powders on Demand; and Samuel Bedard, applications engineer, EWI.

ITSA's planning committee will now begin discussing plans for the 2024 meeting. — *Cindy Weihl, editor*

ITSA meeting participants are seen at EWI's Cold Spray Center of Excellence at Buffalo Manufacturing Works.

AWS Mourns the Passing of 2023 President Dennis K. Eck

AWS and the welding community mourn the sudden passing of 2023 AWS President Dennis K. Eck.

Dennis K. Eck, a distinguished AWS member for more than 30 years, most recently served as AWS president.

Eck was a distinguished AWS member for more than 30 years, working within the AWS Houston Section and taking on increasingly significant roles within the Society. He was the AWS Houston Section chair from 1989–2021, AWS director-at-large from 2016–2018, AWS vice president from 2019–2022, and was inducted as the 2023 AWS president earlier this year. He received several AWS honors and awards throughout his three decades of involvement with the Society.

Eck was an enthusiastic advocate for mentoring and leading our youth toward a bright future within the industry. His focus as AWS president was on generational differences and preserving institutional knowledge by connecting the generations in new and unique ways. He was actively involved with SkillsUSA, AG Mechanics San Antonio and Houston, and the Craft Training Center in Corpus Christi, Tex. He and his wife Robin also established the Dennis K. & Robin Eck – Houston Section Scholarship through the AWS Foundation, which provides $5,250 in scholarships each year.

CSB Releases Final Report

The U.S. Chemical Safety and Hazard Investigation Board (CSB), Washington, D.C., released its final investigation report on the 2020 propylene release and explosion at the Watson Grinding facility in Houston, Tex., that fatally injured two workers and a nearby resident and damaged hundreds of neighboring homes. The CSB's final report highlights two key safety issues: the lack of a comprehensive process safety management program at the Watson Grinding facility to manage the risks of its thermal spray coating operations and an ineffective emergency response plan.

CSB Chair Steve Owens said, "Our investigation found that Watson Grinding did not have an effective program in place to assess potential hazards in its propylene process and did not have a mechanical integrity program or written operating procedures. This tragic incident was made even worse due to the lack of emergency response training for employees at the facility."

The incident occurred shortly before 4:30 a.m. on January 24, 2020, when an accidental release of propylene accumulated and exploded inside the building at Watson Grinding. The CSB found that prior to the incident, a hose disconnected from its fitting inside a coating booth and released propylene, a flammable hydrocarbon vapor, which accumulated inside the coating building at Watson Grinding. By the time employees arrived at the facility early on the morning of January 24, an explosive concentration of propylene had formed inside the building. When one of the employees entered the building and turned on the lights, the flammable vapor ignited, triggering the explosion.

The CSB determined that the cause of the accidental release of propylene was a degraded and poorly crimped rubber welding hose that disconnected from its fitting inside a coating booth combined with: 1) not closing the manual shutoff valve at the propylene storage tank at the conclusion of production operations the previous workday, and 2) the inoperative automated gas detection alarm, exhaust fan startup, and gas shutoff system.

Investigator-in-Charge Benjamin Schrader said, "As highlighted in our safety issues, Watson Grinding did not effectively train its workers on the hazards of propylene, and on the morning of the incident, these workers were not warned to evacuate, instructed to prevent others from entering the area, or informed to contact emergency responders when the propylene release was suspected."

As a result of its findings, the CSB is issuing recommendations to encourage the companies and standard-setting bodies to share information from the CSB's report in addition to existing industry guidelines that emphasize the need for an effective process safety management system. The report can be accessed at *csb.gov/assets/1/6/watson_final_report_2023-06-29.pdf.*

Boeing Begins Construction on New Coatings Facility

Boeing has begun construction on a new facility in St. Louis, Mo., that will house postassembly phases of future military aircraft production.

The new Advanced Coatings Center will be a secure facility operated by Phantom Works, which is Boeing Defense, Space & Security's proprietary research, development, and prototyping division. The construction phase of the 47,500-sq-ft facility is underway, and the center is expected to be operational in 2025.

The Boeing Phantom Works Advanced Coatings Center in St. Louis will house postassembly phases of future military aircraft production (Boeing artist's concept).

"As we pivot toward future programs, Boeing's defense business is in the midst of one of the most significant investments in new facilities in our history," said Steve Nordlund, Air Dominance vice president and general manager and St. Louis senior site executive. "This investment is not only to win new future franchise programs but, more importantly, to enable the United States to outpace increasingly capable and aggressive adversaries. We are revolutionizing how aircraft are designed, built, and delivered because the threats demand it."

The Advanced Coatings Center is the third new facility revealed as part of Phantom Works' multibillion-dollar Production System of the Future effort, enabling Boeing to scale a platform-agnostic, modular, and flexible digital production system across future defense programs. Additional new factories supporting various phases of production are planned for the coming years.

Curtiss-Wright's Keronite Business Secures Nadcap Approval Certification

Curtiss-Wright Surface Technologies Division, Paramus, N.J., announced that its Keronite business, a provider of plasma electrolytic oxidation applications, has successfully secured National Aerospace and Defense Contractors Accreditation Program (Nadcap) accreditation for chemical processing at its Greenwood, Ind., facility.

Nadcap is the aerospace industry's global accreditation program designed to recognize special processors that integrate and maintain stringent quality system and process control standards. Pursuit of Nadcap accreditation demonstrates an organization's desire to mitigate customer risk and promote product safety. Keronite joins more than 45 other Curtiss-Wright Surface Technologies business units that are Nadcap-accredited.

"Curtiss-Wright is committed to delivering the best possible technologies and breakthrough applications while providing our customers an opportunity to utilize unique surface treatment applications offering corrosion protection, wear resistance, and other properties, such as thermal and electrical insulation. This recognition underscores the quality of our processes within the industry while also creating more opportunities to expand our footprint in the aerospace sector," said David Rivellini, senior vice president and general manager, Curtiss-Wright Surface Technologies Division.

Phase3D to Develop Cold Spray 3D Printing Quality Inspection System

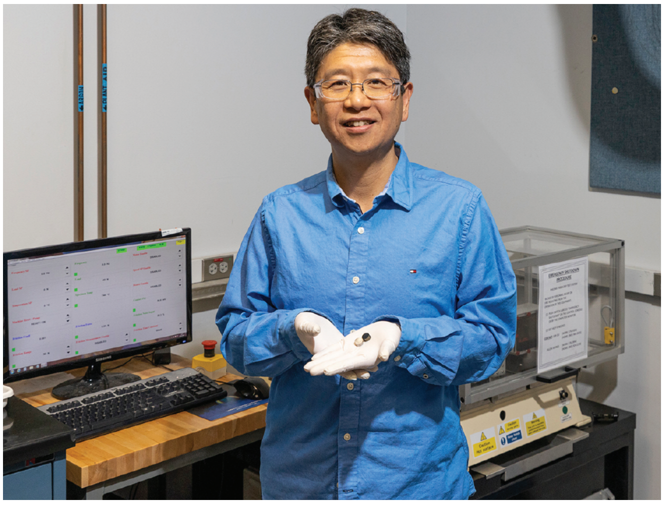
Phase3D, Chicago, Ill., has been awarded a two-year, $1.25 million contract from the Air Force Research Laboratory to develop a quality inspection system for cold spray additive manufacturing.

The company, a start-up focused on in-situ inspection for powder-based additive manufacturing, will install the cold spray 3D printing inspection technology at Ellsworth Air Force Base in South Dakota. Its goal is to validate a working concept of structured light measurements on cold spray additive manufacturing and demonstrate the full solution for real-time quality monitoring to support recladding, repair, and reinforcement.

The company has also been tasked with providing high-quality, objective data on the process. It will do this by adapting its flagship Fringe in-situ inspection system to monitor cold spray additive manufacturing deposits and produce high-quality quantitative height maps for the metal powder deposited onto the substrate. It will also use the project to provide a basis for the creation of specifications and printing guidelines for cold spray additive manufacturing.

ORNL Coating Could Reduce Friction and Wear

Scientists at the Department of Energy's (DOE's) Oak Ridge National Laboratory (ORNL), Oak Ridge, Tenn., have invented a coating that could reduce friction in common load-bearing systems with moving parts, from vehicle drive trains to wind and hydroelectric turbines. The coating reduces by at least a hundredfold the friction of steel rubbing on steel. The novel coating could help enhance a U.S. economy that each year loses more than $1 trillion to friction and wear — equivalent to 5% of the gross national product.



Jun Qu of ORNL shows stainless steel disks before (silver) and after (black) coating with carbon nanotubes that provide superlubricity. (Photo courtesy of Carlos Jones/ORNL, U.S. Department of Energy.)

"When components are sliding past each other, there's friction and wear," said Jun Qu, leader of ORNL's Surface Engineering and Tribology group. Tribology, from the Greek word for rubbing, is the science and technology of interacting surfaces, such as gears and bearings, in relative motion. "If we reduce friction, we can reduce energy consumption. If we reduce wear, we can elongate the life span of the system for better durability and reliability."

With ORNL colleagues Chanaka Kumara and Michael Lance, Qu led a study published in *Materials Today Nano* about a coating composed of carbon nanotubes that imparts superlubricity to sliding parts. Superlubricity is the property of showing virtually no resistance to sliding; its hallmark is a coefficient of friction less than 0.01. The ORNL coating reduced the coefficient of friction far below the cutoff for superlubricity, to as low as 0.001.

The work described in the paper, titled "Macroscale Superlubricity by a Sacrificial Carbon Nanotube Coating," was a finalist for an R&D 100 award in 2020. The researchers have applied for a patent of their novel superlubricity coating.

"Next, we hope to partner with industry to write a joint proposal to DOE to test, mature, and license the technology," Qu said. "In a decade, we'd like to see improved high-performance vehicles and power plants with less energy lost to friction and wear."

WPI Researchers Improve Lithium-Ion Battery Electrode Production

A research team at Worcester Polytechnic Institute (WPI), Worcester, Mass., has developed a solvent-free process to manufacture lithium-ion battery electrodes that are greener, cheaper, and charge faster than electrodes currently on the market, an advance that could improve the manufacturing of batteries for electric vehicles.

"Current lithium-ion batteries charge too slowly, and manufacturers typically use flammable, toxic, and expensive solvents that increase the time and cost of production," said Yan Wang, the research team leader and WPI William B. Smith dean's professor in the department of Mechanical and Materials Engineering. "Our solvent-free manufacturing process addresses those disadvantages by producing electrodes that charge to 78% of capacity in 20 minutes, all without the need for solvents, slurries, and long production times."

WPI researcher Yan Wang led a team in developing a new manufacturing method to addresses a challenge facing the electric vehicle industry.

The researchers' process, reported in the journal *Joule*, involved mixing dry powders that were electrically charged so they adhered when sprayed onto a metal substrate. The dry-coated electrodes were then heated and compressed with rollers. Skipping the conventional drying and solvent-recovery process cut battery manufacturing energy use by an estimated 47%, the researchers reported.

WPI has filed a patent application on the manufacturing technology developed by the research team.

Fisher Barton Expands Turning Center of Excellence

Fisher Barton, Watertown, Wis., has selected MSI General Corp., Oconomowoc, Wis., for the design and construction of its new industrial building and site development for the Accurate Specialties Inc. (ASI) Turning Center of Excellence, Waukesha, Wis. ASI, a division of Fisher Barton, is a manufacturer of bronze gear blanks for power transmission and agricultural applications.

Scott Hoffman, CEO of Fisher Barton, stated, "We are expanding our capacity with this high-speed, fully automated, 56,000-sq-ft facility adjacent to our Accurate Specialties division to offer our customers additional manufacturing capabilities for close tolerance components, shafts, and bearings that compliment Fisher Barton's already robust offering."

An artist rendering of what the ASI Turning Center of Excellence could look like after expansion.

BY DANIEL C. HAYDEN

THERMAL SPRAY REPAIR:

The Fountain of Youth

Fig. 1 (top): Metco 12E flame wire application of molybdenum to lathe ways. (Photo courtesy of Hayden Corp. archives.)

Fig. 2 (above): Metco 12E flame wire application on-site. (Photo courtesy of Hayden Corp. archives.)

There is a certain sinking feeling that settles in when an essential piece of equipment goes offline unexpectedly. A machine that is fundamental, the beating heart of a manufacturing operation, suddenly ceases to beat, and a clock begins ticking. Each minute the unit is down, product is not being made, people are idle, and costs continue to add up without revenue to maintain the delicate balance of efficiency. I hate to even talk about it for fear that it might jinx us, but, until machines can be made of indestructible stuff, wear, outage, and downtime will continue to be a part of our lives.

This truth was fundamental to the early development of thermal spraying. A process that could quickly replace worn metal with new metal, without distortion or compromise, became an instant solution for problems that had plagued machines since the dawn of the Industrial Age. Before materials scientists began looking to spraying as a way of enhancing surfaces, technicians and entrepreneurs were out on the streets lugging wire spray guns and cylinders of oxygen and acetylene into factories, mills, and utilities to get failed machinery back online quickly — Figs. 1 and 2.

Why Choose Thermal Spray for Restoration?

Thermal spraying is chosen for restoration for a number of reasons, but some of the most common scenarios are the following:

- Parts for the failed machine are no longer manufactured or available.
- The cost of complete replacement or spares might be entirely prohibitive for the business.
- The lead time for fabrication of a replacement item might be longer than the business can afford to be down.
- An existing essential wear protection coating has begun to deteriorate, putting the life of the component at risk.
- A machining error was made, too much stock was removed, and now the piece is nonconformant.

In each of these cases, thermal spraying can typically restore the item to like-new condition or better, and can do so in a matter of days or weeks, rather than months, and often for a fraction of the cost of replacement.

Such is the case for a few items on our shop floor at Hayden Corp., West Springfield, Mass. In three case studies (see sidebar on pages 14 and 15), we'll look at components in harsh service environments that have been given new life through thermal spraying. One item is the badly pitted hydraulic ram from an earth mover. In the second, leaking pump sleeves are restored to better-than-new condition through the use of more durable materials. And, in the third, we'll see a rotating element that is given virtually unlimited life through a regular maintenance practice involving thermal sprayed ceramics.

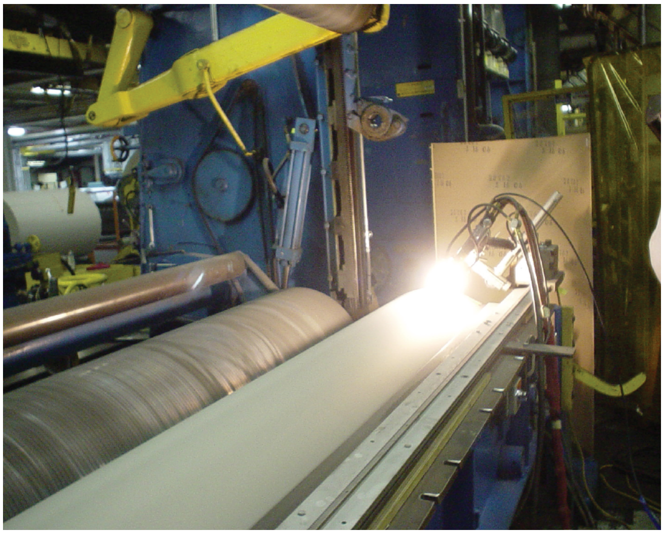


Fig. 3 — Metco 6P on-site flame powder application. (Photo courtesy Hayden Corp.)

Giving New Life to Old Parts

When thermal spray is considered for a repair or restoration, it is typically best to assess the nature of the original failure, as this will likely steer the repair approach. In most cases, the metal that has been lost can be replaced with something similar, but thermal spraying, because it is not a welding process, has the advantage of being able to apply something dissimilar and even longer wearing. If the damage was caused by galling (metal-on-metal wear usually characterized by adhesive transfer of metal from one surface to another), it may be a good idea to restore the worn surface(s) with dissimilar materials to reduce the likelihood of metal transfer. Abrasive wear and erosion, caused by cutting or grinding of one material by another, are typically improved by replacing the lost material with something considerably harder, such as a chromium or tungsten carbide, or a ceramic, such as chromium oxide or alumina.

Analyzing the Cost of Replacement vs. Repair

The economic case for a thermal spray repair is often straightforward. When damage occurs, the cost for complete replacement of the damaged part is added to the opportunity cost of the downtime during the manufacturing lead time for the new component (or the cost for an on-hand spare), and the cost for disassembly and removal as well as installation and reassembly when the replacement part arrives. By contrast, the cost of a thermal spray repair is typically the cost of preparatory machining to remove the damage, the cost to coat the repair zone, and the cost of finish machining after coating. Disassembly and reassembly costs still apply, but some thermal spray repairs can be done in situ, eliminating the expense and time of assembly and shipping — Fig. 3. The total work scope is considerably less than full replacement because most of the

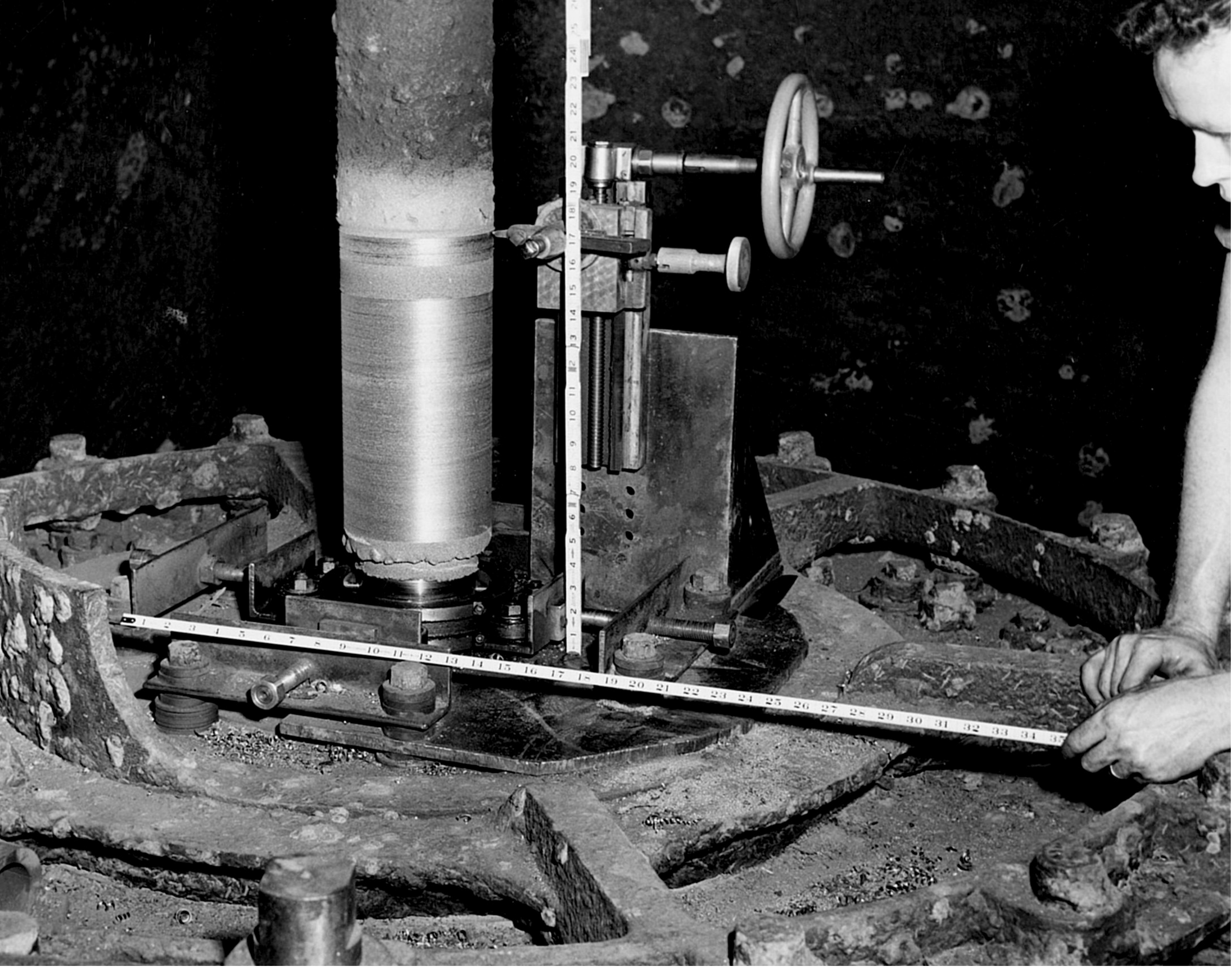


Fig. 4 — Martindale portable lathe for on-site machining. (Photo courtesy of Hayden Corp. archives.)

original component is still functional and correct, and only the damaged zone must be addressed. As a result, a thermal spray repair is typically far less expensive and the lead time far lower, and that sinking feeling we talked about at the beginning of this article will dissipate more quickly.

After determining that thermal spraying is a viable option for a project, the next challenge is to determine exactly how the repair is to be executed. What is the dimensional requirement, and what is acceptable? If original drawings of the component are available, the answer is clear. However, in many cases, drawings are not available. Another excellent but uncommon resource is an undamaged spare part. The next best guide for determining the target buildup is the form, fit, and function of the part with those that mate to it. If a bearing rides on the worn surface (which is often the case), the bearing manufacturer will have size and tolerance data for the fit. As a last resort, there are often undamaged surfaces immediately adjacent to the wear zone that can provide a usable dimension, if the undamaged area appears to be of the same surface as the material lost. In some cases, such as the worm gear case study that follows, 3D scanning can provide worthwhile reference information.

Set the Strategy

Once the repair strategy is set, the work of executing the repair can begin. Most used machine parts will arrive covered in oil, grease, dirt, or worse. All of this is hazardous to the performance of a sprayed coating and must be removed thoroughly, by solvent or aqueous parts washer, for instance. With the part cleaned and the damage area clearly visible, final plans for the repair design can be set. It is best to ensure that the final coating thickness is uniform, greater than 0.003 in. to ensure integrity, and less than the maximum recommended thickness for the material being applied. Some sprayed materials can be applied to virtually unlimited thickness, but most hard materials will be prone to cracking if the thickness is too great. If the thickness of the repair is greater than the maximum thickness recommended for the coating, a bond coat of nickel chromium or nickel aluminide beneath the hard surface can usually make up the difference. Usually, the damage zone should be machined to clean up any unevenness. Such an undercut should also extend slightly beyond the damage zone so that final machining can ensure a clean, flush match with the remaining adjacent surfaces, and the edges of the undercut should be chamfered. A 45 deg is typical.

Material Matters

The material selected will guide the particular thermal spray process to be used. Most metals can be sprayed by arc wire, plasma, or high velocity oxygen fuel (HVOF). Carbides are best handled by plasma and HVOF. Ceramics are typically applied by plasma. Other process selection factors include the surface finish required (HVOF coatings have lower porosity and can generally be ground to a finer finish) and cost (arc wire coatings are least expensive while HVOF coatings are generally the most expensive). If the repaired surface must be machined extensively after coating, such as by threading or milling, a laser clad overlay is likely to be more durable and effective than a thermal spray repair.

Coating operations tend to be simple because the nature of the repair will usually be determined by people familiar with thermal spray's capabilities and limitations, and the repair plan will likely have been developed with best practices in mind. Some useful general guidance includes erring on the side of extra thickness, when possible, to avoid additional rework; ensuring the coated area has a generous overlap beyond the repair undercut pocket so that final machining creates a seamless blend at the edges; and taking extra care during demasking and deburring to avoid accidental chipping into the repair zone.

In nearly all cases for repair, the coating will need to be machined or ground to final dimension and finish. Tooling and grinding thermal spray coatings present challenges all their own, due to the brittleness of hard coatings and the comparatively weak bond between the coating and substrate (compared to wrought material). The scope of machining techniques for finishing thermal spray coatings is beyond this article (the September 2011 issue of *Welding Journal* includes a good, comprehensive guide). In general, low surface speeds, sharp inserts, and light cuts are recommended for tooling, and, whenever possible, grinding is preferable, with removal rates of 0.0005 to 0.0015 in. per pass. When the coated zone must mate with a concentric part, it is often best to err on the high side of the dimensional tolerance and polish the surface in to fit. From time to time, a repair made on-site must be machined in place, and specialized equipment can be brought in to turn or mill features with the repaired component still in place or partially disassembled — Fig. 4. Softer metallic coatings can often be brought to size and finish with emery tape or other hand polishing methods.

Executing the Repair

In an ideal case, a repair would begin with an engineering assessment of the damage and its associated effects. One or more repair approach alternatives would be considered, including the costs and durability of each option. From there, one option would be down-selected, and planning can begin for an outage. The repair plan would include a schedule of operations, including a timeline, with adequate accommodation for contingencies, and actual project milestones would be benchmarked against the plan to ensure that the outage was proceeding as planned. Following the job completion, a postmortem meeting would assess planning effectiveness and identify logistical or technical problems for consideration in the next repair.

In reality, many repairs follow a much more condensed timeline. A component failure causes a machine outage, and the clock is ticking to come up with a solution that will get operations back online quickly. This is where thermal spray's advantages truly shine. The low thermal impact of applying a thermal spray coating (when compared to welding, for instance) means that lost material can be replaced quickly, with very little risk of distortion, and finished in place. It is often as easy to apply a superior material as it would be to apply material identical to that which was lost, and so a higher-integrity repair is often the result. And, most thermal spraying for repair can be done using equipment that is field portable, making it easy to set up in a facility's maintenance or machine shop or do the work directly on the installed component.

Conclusion

Thermal spraying is often an alternative repair method with substantial advantages. Leveraging low cost, simplicity, and portability, it can be the fastest way to return mission-critical equipment to service. In making the selection for a repair strategy (thermal spray or otherwise), it is important to weigh all of the costs (direct and opportunity) into each alternative. In this regard, thermal spraying can often be the fastest and least costly repair method available. Contingencies (utility issues, potential machining issues, etc.) are a critical part of the plan when the repair timeline is constrained. It is important, too, to recognize there are potential risks that may arise. A coating may fail to bond adequately, unexpected heat or pressure may create a delamination in service, or machining limitations may make it impossible to achieve the desired surface finish. Nonetheless, once all factors are considered, thermal spraying may be the ideal choice to get essential equipment back in service, on time and under budget, and eliminate that sinking feeling.

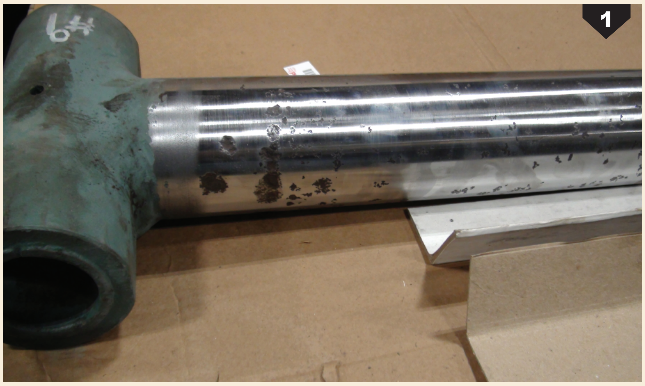
Disclaimer: The historical photos used in this article were taken in 1965 and are not in accordance with the safety practices used today.

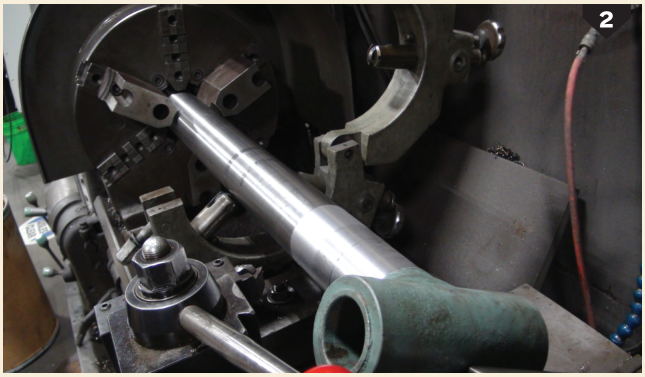
DANIEL C. HAYDEN (*daniel.hayden@haydencorp.com*) is presdent of Hayden Corp., West Springfield, Mass.

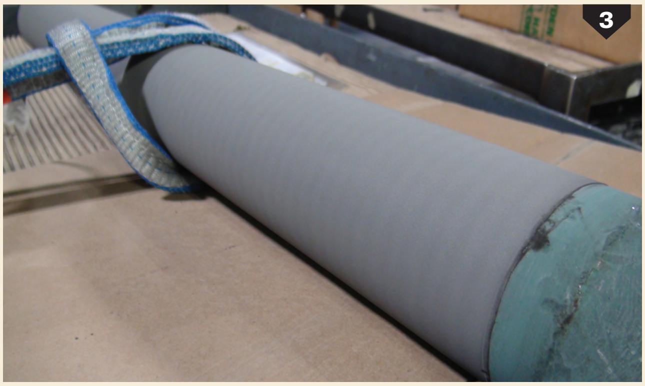
Case studies for this article continue in the sidebar on pages 14 and 15.

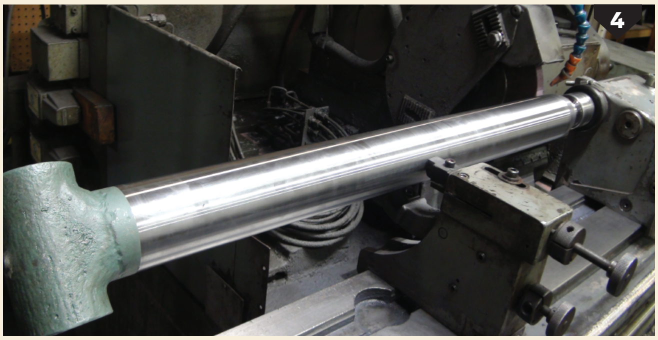
CASE STUDY 1: Hydraulic Rams

Hydraulic rams often see tremendous abuse because they are placed in service in challenging and dirty environments. Those that see limited actuation or whose stroke doesn't permit full retraction often suffer from pitting and corrosion on the portion of the cylinder that is always left exposed. In image 1, the ram had heavy pitting near the knuckle and abrasion and scoring along the actuation length. A lathe operation turned the ram to remove the heavy pitting and take a skim cut along the full actuation length — image 2. The heavily undercut areas were built up with nickel chromium bond coat, and then the whole length was finished with an HVOF hard coat of chromium carbide — image 3. After finish grinding, the ram was as good as new — image 4.









1. Hydraulic ram, incoming condition with pitting.
2. Hydraulic ram, lathe turning to remove damage.
3. Hydraulic ram, as coated, HVOF chrome carbide nichrome.
4. Hydraulic ram, cylindrical grinding.

CASE STUDY 2: Pump Sleeves

HVOF-applied chromium carbide was selected for the following application because it is hard, wear resistant, dense, and easily ground to a fine finish that will not deteriorate the cylinder's seals. It was also chosen because the chromium carbide/nickel chromium composite is exceptionally corrosion resistant. The result was a hard surface considerably thicker than the original chromium plating that may even tolerate a few regrinds over the course of its service life.

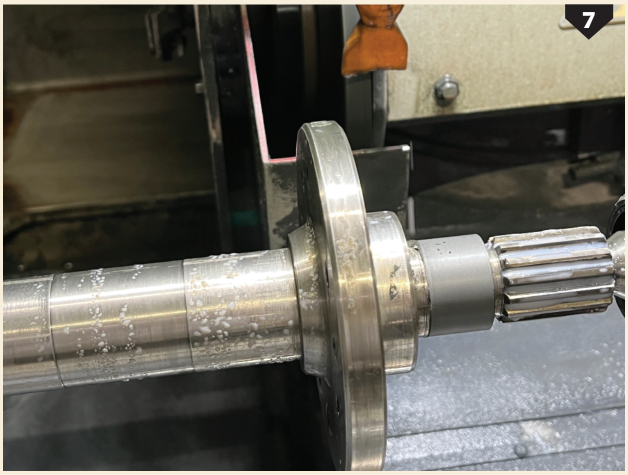
Pump sleeves are the rotating elements that pass through a gland from the wet interior of a pump to the dry exterior. Due to the need to control leakage at this zone, packing materials are compressed against the sleeve to form a seal as it rotates. This combination of active loading and constant rotation

5. Pump sleeves in various conditions. Left to right: as used, coated with stainless steel and ground, coated with tungsten carbide cobalt and ground, and coated with chrome oxide and ground.

leads quickly to circumferential wear and leakage. As seen in image 5, worn pump sleeves (left) can be fully restored with stainless steel (second from left) or can be enhanced by repairing with HVOF tungsten carbide (second from right) or chromium oxide ceramic (right), both of which are far harder than stainless and will last considerably longer. The ceramic option has the added benefit of being chemically nonreactive.

CASE STUDY 3: Splined Drive Shafts

The splined drive shafts in image 6 are among the more expensive parts to manufacture of the machine in which they are used. In service, however, the only surfaces that wear are the sealing areas at each end. The end user maintains a rotating stock of spares that are regularly sent for strip grinding, coating, and finishing of the seal zones using plasma sprayed chromium oxide ceramic. The repair cost is minimal since only the seal areas must be machined, coated, and ground. And, as there are spares in rotation, their machine downtime is reduced to the hours needed for replacement.



6. Splined shaft, as coated with chromium oxide.
7. Splined shaft, cylindrical grinding.
8. Splined shaft, finished condition.

The repair method was to plunge grind the worn areas, leaving the undercut just shy of the planned depth. Any remaining coating was removed by grit blasting. In image 6, the wear zones were then plasma sprayed with chromium oxide, selected because of its hardness and density. Grinding brought the coated zone and adjacent shoulders to size and finish — images 7 and 8. Note that the repair process will typically leave a little residual coating on the shoulders adjacent to the coated zone; in this application, provided the outside diameter was correct, the overspray was not an issue.

All photos courtesy of Hayden Corp.

Industry 4.0 Digital Platform Transforms Thermal Spray Equipment

The Metco IIoT digital platform enables connectivity of thermal spray systems within an Industry 4.0 platform for a smart thermal spray factory. The digital solution helps users understand the production process through data analysis and monitoring in real time as well as improve it based on this information. This enables simpler, faster, and more efficient operation of machines and production systems, thus reducing scrap rate and increasing throughput. The digital platform also consolidates process-related machine data from one or more systems on a central platform. Therefore, raw data for further analysis (e.g., in the case of quality problems) are available at any time without having to physically access one or more machines. The real-time status is displayed regardless of the number of spray systems/locations or geographic location, allowing users to quickly identify errors, optimize systems and processes, and achieve reliable repeatable results. Its data analysis capabilities make it possible to detect downtime; compare machines, even locations; track quality-related indicators; and more. Depending on customer requirements, data can be stored locally or in the platform's Cloud Service for historical analysis and quality control. The product is currently available for the MultiCoat™, MultiCoat Pro, and UniCoatPro™ thermal spray controllers, with plans for expansion to other systems.

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Plasma Nozzle Treats Components or Surfaces at High-Process Speeds

The PFW100 open-air-plasma nozzle treats flat components or surfaces at high-process speeds and, at the same time, over a large width. It is particularly suitable for the pretreatment of heat-sensitive materials, such as thin plastic films, or textile products, such as synthetic nonwovens. It can also be used for the surface cleaning of glass or metal. The nozzle performs uniform pretreatment over a width of 100 mm (3.937 in.) per plasma nozzle at relative speeds of up to 200 m/min (7.874 in./min). The treatment width can be flexibly varied via the modular arrangement of several nozzles.

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Thermal Spray Coatings Market Slated to Be Worth $14.3 Billion by 2028

According to *Thermal Spray Coatings Market by Materials (Ceramics and Metals & Alloys), Process (Combustion Flame and Electrical), End-Use Industry (Aerospace, Automotive, Healthcare, Agriculture, Energy & Power and Electronics) and Region — Global Forecast to 2028*, the thermal spray coatings market is projected to grow from $10.4 to $14.3 billion at a compound annual growth rate of 6.5% from 2023 to 2028. The increasing industrialization across various sectors, such as automotive, aerospace, energy, and healthcare, is a significant driver for the market. The report states North America is the largest region in the market due to the increasing use of thermal spray coatings in various countries, which are driving the need for thermal spray coatings in the region. The region also has multiple service providers, which hold significant market share in the industry. For example, the area is home to prominent aerospace manufacturers, and thermal spray coatings are extensively used in aircraft engines, turbine components, aerospace structures, and other critical parts. Additionally, the demand for lightweight, corrosion-resistant, and high-performance coatings in this industry fuels the growth of the thermal spray coatings market.

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Bob Unger | *runger@polymet.us*
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ASSOCIATE MEMBER ORGANIZATIONS

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(954) 249-0127 | *airglide.expert*

David Lee Consulting
Ligonier, IN
David Lee | *dlee@daltsc.com*
(574) 849-3636

Florida Institute of Technology
Melbourne, FL
Frank Accornero | *faccornero@fit.edu*
(386) 506-6900 | *fit.edu*

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Arvind Agarwal | *agarwala@fiu.edu*
(305) 348-1701 | *mme.fiu.edu*

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Richard P. Mason
rmason@masonglobalmanagementllc.com
(724) 554-9439
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The Mozolic Group
Londonderry, NH
Jean Mozolic | *jean.mozolic@comcast.net*
(508) 254-4375

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Stony Brook, NY
Sanjay Sampath
ssampath@ms.cc.sunysb.edu
(631) 632-8480 | *ctsr-sunysb.org*

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werner.kroemmer@gts-ev.de
+49 89 31001 5203 | *gts-ev.de*

Institute of Materials Malaysia (IMM)
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(603) 5882-3584 | *iomm.org.my*

Japan Thermal Spray Society (JTSS)
Nick Yumiba | *jtss@mb8.seikyou.ne.jp*
+81 6 6722 0096 | *jtss.or.jp*

Metal Powder Industries Federation (MPIF)
James R. Dale | *jdale@mpif.org*
(609) 452-7700 | *mpif.org*

Surface Engineering for Advanced Materials (SEAM)
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Thermal Spraying Committee of China Surface Engineering Association (TSCC)
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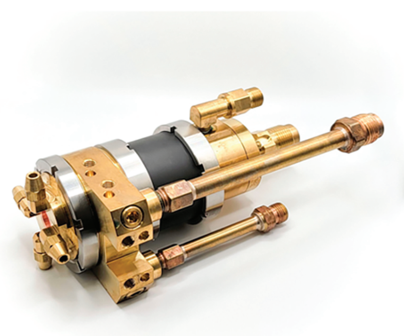

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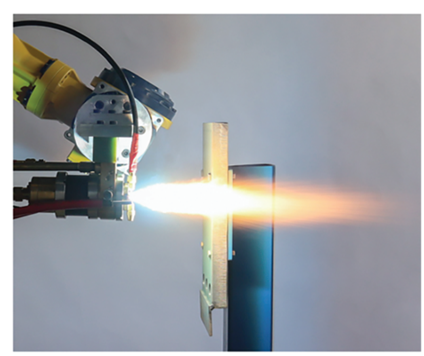

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