

SPRAYTIME®

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Commercially Viable Nanostructured MCrAlY Bond Coats

by George Kim

INTRODUCTION

In 2001, George Kim of Perpetual Technologies Inc. and Virgil Provenzano of the National Institute of Standards and Technology (NIST) conceived of the idea to develop and study nanostructured MCrAlY bond coats for high temperature applications. After approaching Dr. Lawrence T. Kabacoff (a Program Officer at the United States Office of Naval Research-ONR) with this idea, a program was initiated to carry out the study. Julie Schoenung at the University of California, Davis (UCD) was introduced to the program to complete the collaborative team.

The objective was to cryomill conventional MCrAlY powder to form the necessary nanostructured powder and to deposit this transformed feedstock powder using conventional thermal spray processes. NiCrAlY was the first alloy studied in detail within this program.

A parallel development effort to evaluate the possibility of processing nanostructured metal powder without the use of cryogenic conditions was partially funded by ONR. The goal

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The Overlooked Manipulator

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Take a look at a typical coating specification. You'll find extensive details about the powder chemistry, morphology, porosity, thickness, gun configuration, gas flows, currents, etc. However, you will usually find little, if anything, regarding the manipulation of the part and gun during the coating process. Where should the coating start? What path should be followed? Should the coating be sprayed as a single layer or multiple layers? On cylindrical objects, should the coating be achieved in axial or radial paths?

The manipulator often is not given its needed consideration. This is probably because coatings were initially hand applied and path decisions were left to the discretion of the thermal spray operator. However, with the advent of automated manipulation of the gun and workpiece, it is possible for the engineer to take charge of the manipulator; to give it adequate attention.

Plasma Powders and Systems, in conjunction with *SPRAYTIME*, has prepared a series of articles on manipulators; (and other motion devices such as turntables, gantries, robots, etc). These articles are primarily oriented

continued on page 2

Thermal Spray Pavilion Planned for 2007 Fabtech International and AWS Welding Show

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In collaboration with the American Welding Society (AWS), the Society of Manufacturing Engineers (SME), and the Fabricators and Manufacturers Association (FMA), The International Thermal Spray Association is proud to announce a **Thermal Spray Pavilion** at the **Fabtech International & AWS Welding Show November 11-14, 2007** at the McCormick Place in Chicago with an estimated attendance of 17,000.

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towards management, to highlight issues that need to be considered. The information should also be of value to the thermal spray operator or technician along with the manipulator programmer when considering options for setting up and operating a manipulator. (Editor's Note: See the end of the article for some definitions.)

For this first article, we are considering why. Why make the application process automatic? The first objective is usually cost reduction but there are other issues that may be involved. Let's consider cost along with a few others.

COST. A large production run, where the same coating is applied to parts on a production line, is certainly a candidate for automatic manipulation. For example, the spinel coating on hot-gas oxygen sensors is an ideal candidate for automation. This is a production-line process, only simple gun motions are needed and one operator can monitor multiple guns. The control program can be basic and can use hard-wired logic (limit switches, cam drives, etc.) since program changes are infrequent.

HUMAN LIMITS. Some coating processes, such as HVOF, require high-speed motion between the gun and the workpiece. In the case of cylindrical objects, this is often achieved by high speed rotation of the part, which allows the gun to be manually controlled. However, when the part cannot be rotated or moved rapidly, man's limits dictate the use of a high-speed manipulator. Such was the case when a tungsten-carbide coating had to be applied to large hydro-turbines destined for use with river water with high silt

content. The coating specifications require a gun speed that could not be sustained by a man. Therefore, a robot was selected for gun manipulation.

ENVIRONMENT. Sometimes, it is necessary to apply coatings in areas where a man cannot work. For example, coatings on repair weld areas in the hot section of a nuclear reactor. In this case, a tracked robot provided remote positioning and control of the thermal spray gun.

QUALITY CONTROL. Even though a man may be able to apply the coating manually, it may be preferable to have the coating applied under the automatic control of a manipulator with full documentation of the process. Medical implants are often coated with hydroxyapatite. Quality control of each part is significantly improved by using an automated manipulator with automatic verification of the motions and paths along with other spray parameters.

It is obvious that many factors need to be considered when evaluating manipulation systems for maintaining a competitive edge in thermal spray operations.

Next time, "Interviewing a Manipulator".

Editor's Note: Selected definitions from "Thermal Spray Terminology and Company Origins", ASM International, 2001:


Manipulator: a mechanical device for moving and orientating a spray gun or part during coating application.

Manual spraying: spraying wherein the thermal spray device is hand held by the operator who also inputs its operating parameters

Robotic spraying: the use of a computerized, articulated or multi-axis manipulation mechanism to traverse the spray gun and/or target during coating

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was to establish an alternate processing route (to cryomilling) that is more commercially viable with respect to cost and production rate. This work was carried out by Perpetual Technologies Inc. and n-WERKZ Inc.

THE TECHNOLOGY

Nanostructured NiCrAlY powders were produced via cryomilling and sprayed using both the HVOF and the LPPS processes. All YPSZ coatings were sprayed using APS. For both HVOF and LPPS applied bond coats, samples with the nanostructured bond coat showed favourable results against static oxidation and thermal cycling. Delayed formation of mixed oxide thermally grown oxide (TGO) was clearly evident on the nanostructured NiCrAlY bond coat samples. As well, dramatic improvements in thermal cycling performance were realized for thermal sprayed TBCs with nanostructured NiCrAlY bond coats, as compared to their conventional counterparts [1-3]. However, the high processing costs associated with the need for liquid nitrogen as an integral part of cryomilling were an obstacle to commercial viability.

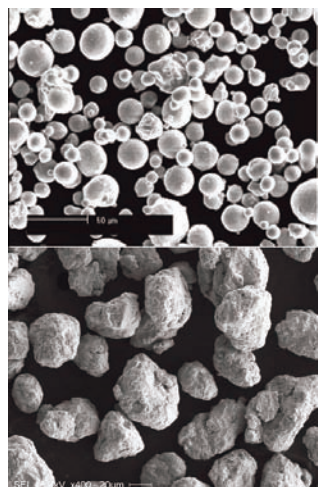


Figure 1: As-received (top) and non-cryogenically milled (bottom) NiCrAlY powder.

After more than three years of effort, n-WERKZ Inc. developed a new powder processing approach that does not use liquid nitrogen to form equi-axed nanostructured metal powders (Figure 1). The avoidance of liquid nitrogen, which has until now been an essential ingredient in processing similar nanostructured metal powders, is crucial, since the high cost of liquid nitrogen is generally cost-prohibitive for most commercial applications. In addition, the new approach offers the advantage of reduced processing time as compared to cryomilling.

For the preliminary testing of the non-cryogenically milled NiCrAlY powder, all bond coats were sprayed using HVOF and all YPSZ top coats using APS. The coatings did not undergo vacuum heat treatment prior to testing. The preliminary results from static oxidation and thermal cycling tests look very promising. As per the coatings derived from cryomilled

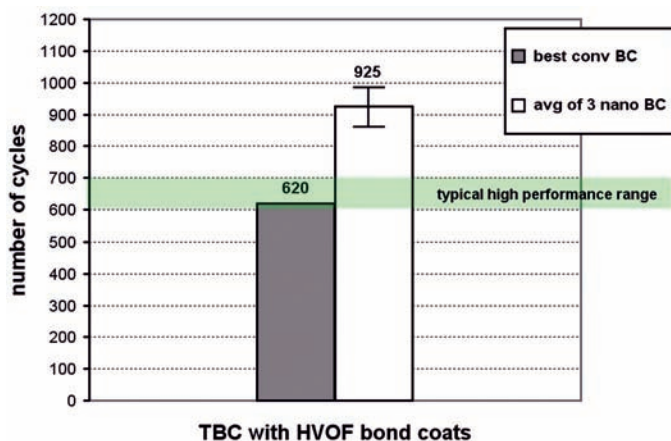


Figure 2: Thermal cycling results for TBCs with conventional and nanostructured NiCrAlY bond coats.

powder, compared to thermal spray coatings using conventional NiCrAlY bond coats, the nanostructured bond coat samples showed delayed formation of mixed oxide thermally grown oxide (TGO) [4] and the TBC samples showed 50% improvement in thermal cycles to failure (Figure 2). Characterization and analysis of the failed thermal cycle coupons will be performed by the United States Naval Academy in the near future.

This new processing method is also capable of producing nanostructured aluminum alloy (5083) powder. Perpetual Technologies and n-WERKZ will be evaluating the non-cryogenic processing of other metals, including CoNiCrAlY, in the not-too-distant future.

SUMMARY

A new commercially viable means of processing nanostructured MCrAlY powder has been developed and tested. The preliminary results are very promising.

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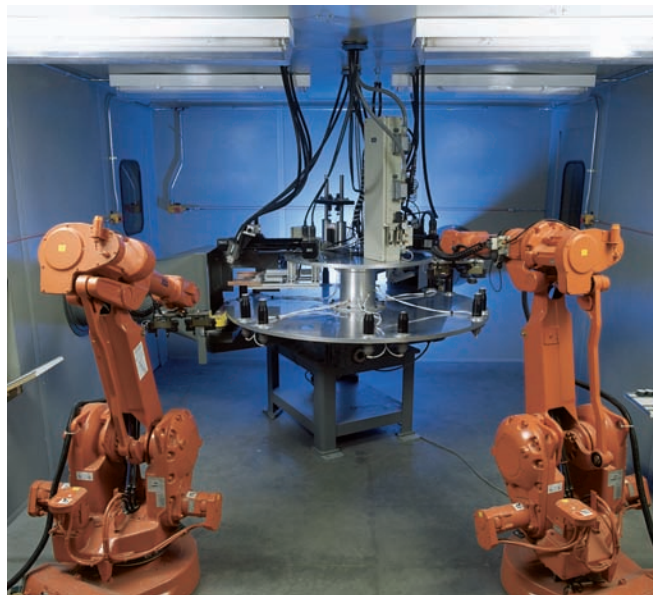
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Praxair Surface Technologies Offers Robotic Programming Classes

TAFI Incorporated, a Praxair Surface Technologies company, located in Concord, NH is now offering robotic programming classes on ABB Robots for the thermal spray industry.

The robotic programming session will include both classroom and hands-on training. Students will be taught the new ANSI standards and how they apply to the workplace; how to incorporate safety and emergency stops to protect workers and equipment; and how to further programming knowledge to create more efficient programs that cut programming time and increase overall production time.

Classes will be held in Concord, NH and run for one week. Classes are limited to six students on a first-come, first-served basis.



For further information and participation fees contact: Frank Accornero at (603) 223-2184, or e-mail Frank_Accornero@praxair.com.

Praxair, parent company of Praxair Surface Technologies, is the largest industrial gases company in North and South America, and one of the largest worldwide, with 2006 sales of \$8.3 billion. The company produces, sells and distributes atmospheric and process gases, and high-performance surface coatings. Praxair products, services and technologies bring productivity and environmental benefits to a wide variety of industries, including aerospace, chemicals, food and beverage, electronics, energy, healthcare, manufacturing, metal and others. **More information on Praxair** is available on the Internet at www.praxair.com or praxair.com/thermalspray.

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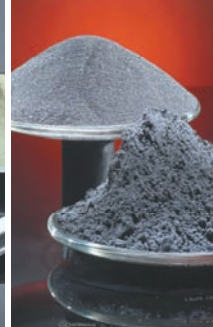
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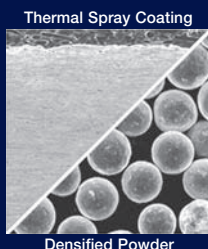
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Nanocrystalline Composite Coatings for Cylinder Bores

(Research Project underway at the Surface Engineering Institute, Aachen, DE)

The aim of the research project is the replacement of the cast iron cylinder liners in aluminum alloy engine blocks with a coating of a new type of amorphous material with embedded nanocrystallites. The revolutionary idea of the project lies in the creation of an extremely hard, minimal friction bearing surface through the thermal spraying of a nanocrystalline composite coating. Due to the nanocrystallites in the coating the sprayed surface will possess a combination of abrasive wear resistance and low friction coefficient that has remained unknown until now.

In order to implement a coating under mass-production conditions, a stable and robust coating process is necessary that in turn leads to lower production and quality related costs. For that purpose, the Surface Engineering Institute employs the wire-based Plasma Transferred Wire Arc internal surface coating system. In addition, the process must produce a coating with high dependability and long-life in later usage, despite increased engine stresses. Thus, complete and innovative production systems for the manufacturing of engine blocks with the nanocrystalline cylinder wall coating must be developed. This includes the pretreatment of the surfaces to be sprayed, the application of the nanocrystalline functional coating and finishing by means of honing.

Another aim is the further development of calculation tools for the prediction of running-in behavior and wear at the highly stressed frictional contacts between piston rings and the cylinder bore surface. Running-in and wear act decisively on lubrication performance and thus on the friction and consumption as well as oil emissions and life of engines. Tools of this type are desperately needed in order to have predictions at an early developmental stage of engines in regard to potential solutions approaches and their impact on consumption, life, and oil emissions and to thereby avoiding costly trials.

For this purpose, an improved quantitative understanding of the mechanisms of material alterations and transport occurring during the contact of individual roughness peaks should be established. This should range from the removal and carryover of the smallest amounts (clusters) to the smallest scales (nanometers) within the surfaces in friction systems. Modeling and calculation of wear mechanisms with a loss of individual roughness contacts is necessary because, with today's dependable engines, metal removal due to wear at friction points only occurs in the range of less than nm/h.

The overall goal of the research project is to work out all

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necessary requirements in order to efficiently manufacture and implement coated light metal engines. This comprises the entire process chain. At the end of the project, all of the expertise needed for an industrial application of the nanocrystalline coating as well as the production of high-performance and low-emission engines should be available.

The research is part of the joint project "Nano-crystalline composite coatings for cylinder bores with a nano-structured surface and wear forecast for highly loaded gasoline and diesel engines -NaCoLab" funded by the German Federal Ministry of Education and Research within the framework program "Nano-Mobil". Besides the Surface Engineering Institute 12 other partners - car manufacturers, OEMs and Universities - work on this project.

The Surface Engineering Institute is a part of the faculty of mechanical engineering of RWTH Aachen University. The Institute originally traces back to the Institute of Materials Technology B (IWK B) and respectively the Chair of Materials Technology B, which was led by Professor Otto Knotek since 1970. In February 1980 Prof. Dr. tech. Erich Lugscheider founded the Department of Materials Science, better known as the Materials Science Institute. In April 2005 Prof. Lugscheider handed over the Institute's leadership to Prof. Dr.-Ing. Kirsten Bobzin. At the same time the name was changed to the Surface Engineering Institute (Institut für Oberflächentechnik - IOT).

For further information, contact Dipl.-Ing. Jochen Zwick via email: zwick@iot.rwth-aachen.de

FREE Thermal Spray Patent Copy

A copy of the original Schoop thermal spray patent - suitable for framing - is available from the International Thermal Spray Association. This is a photograph copy of the original February 19, 1914 "Apparatus for Spraying Molten Metal and Other Fusible Substances" by M.U. Schoop from the United States Patent Office. Send an email request to itsa@thermalspray.org

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Kermetico Begins Operations in Bay Area

Dr. Andrew Verstak announces the startup of Kermetico Inc., a new thermal spray company located in the Bay Area of Northern California.

Kermetico Inc. is a privately owned company, incorporated in 2006. The company operates thermal spray facilities in Benicia Industrial Park in the heart of Northern California refineries. Several new-design AcuKote HVOF systems are installed in these facilities, along with a 32 ft-long spray booth, equipped with a removable roof, 50 in. diameter and 12 ft centers manipulator, 7,000 lb overhead crane, Motoman robot, 12,000 cfm Torrit dust collector, 100 hp

compressor. A stone- and belt-grinding setup allows turning parts up to 48 in. diameter and 20 ft-long. Kermetico Inc. serves local refineries and steel mills applying tungsten carbide, hard-metal and superalloy coatings.



Kermetico Inc. also started manufacturing and sale of AcuKote HVOF systems, designed for deposition of high-quality coatings of metallic alloys, cemented carbides and other composite powders. The main feature of this system is its ability to accurately regulate spray particle temperature below or above its melting point to achieve the desired coating quality and efficiency of the process.

For more information, contact Andrew Verstak, Kermetico Inc., 3900 Oregon Street, Ste 2, Benicia, CA 94510, phone (707) 745-3862, e-mail: averstak@kermetico.com, or visit company website: www.kermetico.com

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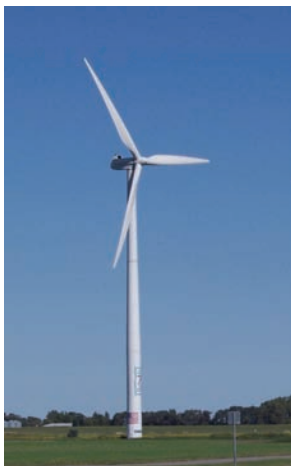
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Metallisation Equipment Protects Wind Turbines

Metallisation's Spanish distributor, Descon Quimica, has recently supplied an electric arc spray system for wind turbine components to Granallados Molinero S.L. Molinero approached Descon because of its expertise in supplying automated metal spraying equipment and specific industry expertise in wind turbines. Molinero is new to the industry of thermal spraying wind turbine components and wanted to utilize the benefits of automating the process. This is in contrast to a lot of wind turbine thermal spraying which is carried out manually.



Programming the spray gun.

The problem of atmospheric corrosion in wind turbines is significant, particularly considering that many turbines are placed in coastal or saltwater environments. It is for this reason that many manufacturers of wind turbines specify thermal sprayed zinc or zinc/aluminium alloys as a method of corrosion protection to all or part of the steel wind turbine structure. Thermal sprayed coatings offer a very resilient finish, which is less susceptible to damage than many paint coatings. It is for this reason that the joint areas of the columns and the components being assembled are thermal sprayed to offer corrosion resistance in areas where paints may be damaged during assembly of these large items.

Descon Quimica has been supplying metal spraying equipment and materials for the protection of wind turbine parts throughout Spain, as well as other anticorrosion and engineering applications, for many years. Descon provides anticorrosion protection for diverse industries

including, liquid gas bottles, tube manufacturers, beer tanks, silos, parts of railroad bridges and aqueducts. This level of experience, combined with the global knowledge of Metallisation Ltd., made Descon Quimica and Metallisation the natural choice to supply Molinero with their automated spraying cell.

The spray equipment is being used by Molinero to spray components within the assembly that support the turbine blades. The actual coating with pure zinc is only one part of the process. To ensure optimum adhesion of the coating, the surface of the turbine part is first grit blasted to a profile of around 3 mils (75 microns) and a cleanliness of SA3. A robot mounted arc spray system then applies an even 5 mils (120 microns) of zinc at a spray rate of up to 79 lb/hr (36 kg/hr). A final coating of epoxy paint is then applied. This is an excellent way to protect wind turbines from corrosion and offers up to 20 years protection.

As a new user of metal spraying, Molinero is delighted with the support and service provided by Descon. The adaptability, flexibility and ease of use of the Metallisation Arc 140 equipment, has made the transition into metal spraying much easier for Molinero. One of the main reasons for selecting the Metallisation Arc 140 is that it is easily integrated with the robot cell, which then controls the spray gun to start and stop the spraying. The 66 ft (20m push/pull) supplies package also allows the power source, wire and wire dispensing system to be located outside the dusty spray booth, giving the system greater reliability.

There are many advantages of automating the spraying process. Obviously, these generally apply when there are batches of identical parts to process, as is the case at Molinero. Automatic spraying will enable a very uniform coating thickness. Not only is this beneficial to the coating quality but also has a commercial value. Typically, if components are manually sprayed and the specification calls for a minimum coating thickness of 5 mils (120 microns), it is very difficult to maintain a consistent coating depth. Even



an experienced operator would usually coat to a minimum of 5 mils (120 microns) and in places, up to 7-8 mils (180-200 microns) or more. Through automation, an even 5 mils (120 micron) coating is achievable, offering on average, material savings in the region of 40%. The spraying environment is also noisy and dusty. Through automation, the operator can remain outside the spray booth area.

Ignacio Sanchiz, Director of Descon Quimica, says: "We are really proud to have worked on this contract with Molinero. The demand for wind turbines across Spain and the rest of Europe means Molinero will have a vast market to supply metal spraying

protection to. The ability of the Metallisation Arc 140 system to be so easily integrated with Molinero's robotic equipment, provides a perfect solution for all concerned."



In the electric arc process, the raw material, a pair of metal wires, is melted by an electric arc. The molten material is atomised by a cone of compressed air and propelled towards the work piece. This spray solidifies when it hits the surface of the work piece to form a dense coating, which protects against

corrosion or reclaims/repairs components. Sprayed coatings may also be used to provide wear resistance, electrical and thermal conductivity, or for freestanding shapes.

Major advantages of the process are that the coatings are available for almost immediate use, with no drying or curing times; there is no risk of damaging the component; the deposits possess a higher degree of bond strength than most other thermally sprayed deposits; the use of only



compressed air and electricity mean more economic coatings.

For more information on surface coatings or the Metallisation equipment and processes, please contact Stuart Milton phone: +44 (0) 1384 252 464 or visit www.metallisation.com

Photos courtesy of DMI Canada.

ASM TSS Email Discussion Group

Over 600 subscribers from 40 countries use this lively discussion forum. Sharing information and networking with colleagues is a key goal of the ASM Thermal Spray Society. All thermal spray related communication is welcome. The forum has seen ideas on applications for thermal spray, coating properties, equipment for sale, positions wanted and job openings, calls for papers, and other news of interest to the thermal spray community.

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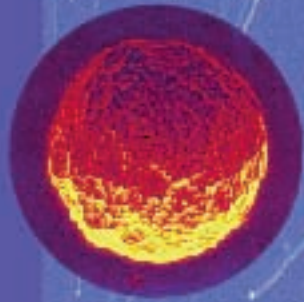
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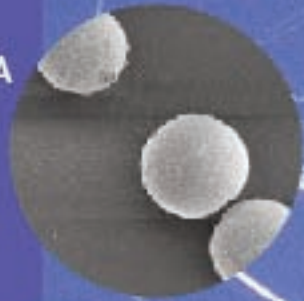
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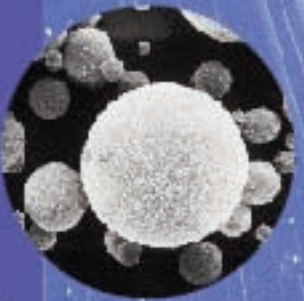


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Powdermet Celebrates 10 Years

Powdermet, Inc. celebrated 10 years of business with the grand opening of their newly renovated Nanomaterials Research and Manufacturing Center on June 1, 2007.

The new nanomaterials research center contains materials research facilities including thermal analysis, mechanical testing, and a coating wear and performance lab, as well as housing materials pilot manufacturing equipment; including tape casting, vacuum sintering, injection molding; and wet chemistry laboratories. The main nanomaterials production facility was opened in November 2003, and includes 23 powder production reactors, large sintering furnaces, and powder pressing and molding equipment, as well as a materials quality control laboratory containing scanning electron microscopy, AAS and ICP analysis, laser particle size analysis, and BET surface area analyzers used for R&D and QC activities.



Ribbon cutting ceremony: (left to right) Powdermet CEO Andrew Sherman, Congresswoman Stephanie Tubbs Jones, and City of Euclid Mayor Bill Cervenik.

Powdermet started in a Los Angeles warehouse in 1997, with the grand idea of building the revolutionary performance of nanomaterials into a usable, low-cost particle "building block" that could be converted into useful articles using current manufacturing processes. Since 1997, Powdermet has been developing and manufacturing metallic nanocomposite particles, including our DiaBond™ engineered superabrasive products and ToolMet™ nanoengineered tungsten carbide products. In 2003, Powdermet relocated and expanded to Ohio, opening our Stage I nanoengineered powder production facility. In 2005, we licensed our R&D 100 award winning RFFB (Recirculating Fast Fluidized Bed)

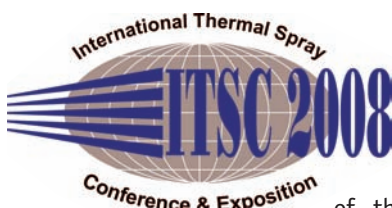
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nanomaterials production process and ToolMet™ product line to a regional fortune 500 company, and refocused on developing next-generation breakthrough products incorporating nanostructured metals. Powdermet is now commercializing 4 new nanomaterial product lines including our PComP™ nanocomposite coatings which are a low cost, environmentally-friendly substitute for hard chrome plating; our SComP™ syntactic composites which are used in armor, energy adsorbing lightweight structures, and as high temperature structural insulation, our MComP™ metallic nanocomposites, including nanocomposite aluminum, titanium, and magnesium products that offer revolutionary advances in strength-weight compared to traditional wrought and cast materials; and finally our NComP™ energetic nanocomposites used for energy storage applications in batteries, capacitors, and fuel cell applications.

According to company CEO Andrew Sherman "The opening of our new Nanomaterials Research and Manufacturing Center represents a major milestone in company history. I believe the economic conditions, quality and availability of workers, state and local commitment to manufacturing and reasonable cost of living in northern Ohio provides the perfect condition for the emerging nanomaterials industry. I look forward to our next decade and contributing to the growth of the nanomanufacturing economy here in northern Ohio."

For more information, visit www.powdermetinc.com or contact Andrew Sherman, tel: 216.404.0053, email: ajsherman@powdermetinc.com



Thermal Spray Crossing Borders Maastricht, The Netherlands June 2 - 4, 2008 Call For Papers

ITSC 2008, the worldwide leading conference of thermal spray, returns to Europe. ITSC is an opportunity for the global thermal spray community to meet, exchange information and conduct business.

This outstanding annual event in the world of thermal spray technology is jointly organized by the German Welding Society (DVS), the ASM Thermal Spray Society (ASM TSS), and the International Institute of Welding (IIW).

ITSC 2008 follows the successful path of the previous events in Basel (2005), Seattle (2006) and Beijing (2007). It presents the latest status of application, research and development in the field of thermal spray.

Maastricht is a bustling town of some 180,000 inhabitants. Its twice-weekly market and busy shops attract customers from Belgium and Germany and it draws numerous tourists and businessmen. Current policies emphasize Maastricht's central location in Europe and its European image. In 1981 and 1991 the city hosted the summit meeting of the European Community heads of state. The creation of the "Euregio" area, centered on the cities of Aachen, Liege and Maastricht, is a sign that Maastricht is returning to the central European location it occupied during the reign of Charlemagne.

ITSC 2008 will take place at the MECC Maastricht Congress Centre. MECC Maastricht is a state-of-the-art conference and exhibition center constructed according to the "fourth-generation" concept. Visitors can attend ITSC 2008, dine, and also sleep there. Everything is under one roof.

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All paper/poster manuscripts must be written in English and submitted electronically.

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International Thermal Spray Association Welcomes New Members

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For more information, contact ITSA company representative Cliff Lessnau, lessnau@actionsuper.com, tel: 800.544.5461, web: www.actionsuper.com

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For more information, contact ITSA company representative Jim Tomczyk, tel: 800.345.8462, email: jim.tomczyk@parker.com, web: www.domnickhunter.com

For a free copy of the "What Is Thermal Spray?" publication, send an email request to itsa@thermalspray.org

Nanomaterials-Health and Safety Concerns

by Paul Kammer, Kammer Associates, Inc.

As we all know, there are many efforts underway to develop, understand, and utilize nanomaterials on an industrial scale. The results of some of these efforts are already in commercial use. The thermal spray industry is no exception to this involvement with nanomaterials.

In parallel with these research and commercial efforts, many organizations and individuals have expressed concern about "unknowns" for these materials in the areas of health and safety. Some experts believe that due to their size, nanomaterials in particulate forms may pose greater risks than the same material in conventional particle sizes. Thermal spray processes can utilize nanosize materials as feedstocks; but in addition, the spray process itself may produce nanosize particulates from more conventional feedstocks.

In order to stimulate more research on these safety and health concerns, the National Nanotechnology Initiative (NNI) developed a document, "Environmental, Health and Safety Research Needs for Engineered Nanoscaled Materials". Others have also spoken out about the need for more Information and potential action. For example see "Thinking Big About Things Small: Creating an Effective Oversight System for Nanotechnology" authored by Mark Greenwood, former director of EPA's Office of Pollution Prevention and Toxics.

The EPA has awarded grants totaling over \$30 million to investigate potential health and environmental effects of

nanomaterials and applications and/or implications of manufactured materials. NNI has also funded similar studies.

In the interim, thermal spray researchers and commercial users of nanomaterials should have in place a good environmental health and safety program that takes into account the presence of nanosized materials in the workplace. One company's (Altairnano) efforts in this regard were reported on at a recent conference and were described in the Occupational Hazards e-journal.

(See www.occupationalhazards.com/News/Article/43536/Nanotech_Conference_Advice_for_StartUps.aspx)

For more information, contact Paul Kammer, email: pakammer@suddenlink.net

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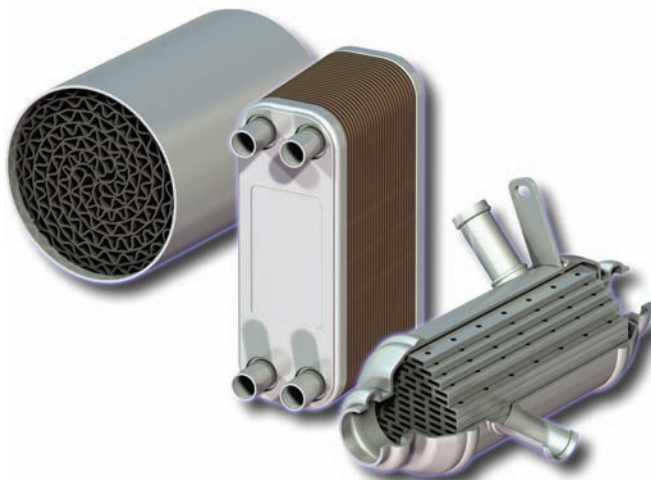
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New high chromium boron-free braze filler metals developed by Sulzer Metco, a Swiss based surface solutions company, were introduced early this year providing a uniquely cost effective and more reliable manufacturing material to automotive component manufacturers.

The innovative braze alloys marketed under the AMDRY® brand - AMDRY®105, AMDRY®108 and AMDRY® 805 - are exclusive filler metals designed for greater corrosion resistance and strength. These new products deliver superior performance in joining applications for heat exchangers, catalytic converters and EGR coolers, at an equal or lower cost than traditional materials.


AMDRY®105, AMDRY®108 and AMDRY® 805 each have higher chromium content compared to most other nickel-based braze alloys in the market. A minimum of 23% chromium by weight produces strong, corrosion resistant braze joints for steel, stainless steel and superalloy components.



The anti corrosion characteristics of these braze materials have been proven to deliver positive results. Corrosion and high temperature oxidation tests on braze samples of AMDRY®105, AMDRY®108 and AMDRY® 805 indicate superior corrosion resistance compared to BNi-2 and BNi-5 test samples.

According to Dr. S. Rangaswamy, Product Line Manager and Head of Development Metals and Alloys at Sulzer Metco, the "metallographic examinations did not reveal any corrosive attack on the AMDRY®105, AMDRY®108 and AMDRY® 805 braze joint samples that were put under rigorous aqueous solutions test parameters for the duration of 150 hours". He also affirms that, "When tested for 24 hours at 1500 °F (810 °C) under air-atmosphere furnace, results clearly indicate there was no significant weight changes compared to the pre-oxidation weight of the test samples."

AMDRY®105, AMDRY®108 and AMDRY® 805 braze in the same temperature range as the



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alloys currently used in heat exchangers, catalytic converters and EGR coolers. Phosphorous in these filler metals act as a boron-free alternative to reduce the braze temperature range and improve ductility for improved burst strength in heat exchangers. In AMDRY®108 and AMDRY® 805 iron replaces some or most of the nickel content, reducing the cost and the impact from increasing nickel prices.

The diverse forms in which these products are available to the market offer efficient and economical benefits. AMDRY®105, AMDRY®108 and AMDRY® 805 can be purchased as powder, paste, custom-sized tape, and customized performs for ease of application and improved in-process reproducibility that reduces production costs.

For more information and to take control of your surface engineering challenges, contact your Sulzer Metco sales office, visit our website at www.sulzermetco.com or email us at info@sulzermetco.com

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WHERE IS YOUR ARTICLE?

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CALENDAR OF EVENTS AUGUST 2007

6-9 Fort Lauderdale, FL USA 40th Intl Metallographic Society IMS Convention - contact ASM International, tel: 800.336.5152 or 440.338.5151 x5900, fax: 440.338.4634; em: cust-srv@asminternational.org, web: www.asminternational.org

6-9 Fort Lauderdale, FL USA Microscopy & Microanalysis 2007 - contact Phillip Ridley email pridley@bostrom.com, web: <http://microscopy.org/MMMeetings/MM07>

SEPTEMBER 2007

3-7 Islamabad, Pakistan 10th International Symposium on Advanced Materials (ISAM-2007) - contact Rawalpindi tel: 95.51.9268140, email: isampk@comstats.net.pk

4-6 Thailand, Bangkok POWER-GEN Asia - contact PennWell Corporation www.powergenasia.com

9-13 Sunriver, OR USA 2007 Corrosion Solutions Conference - contact Sheryl Renzoni, ATI Wah Chang, email sheryl.renzoni@wahchang.com, web: www.corrosionsolutions.com

10-13 Nürnberg, Germany Euromat 2007 European congress & Exhibition on Advanced Materials & Processes - contact tel: +49.69.75306.747, email: euromat@fems.org, web: www.euromat2007.fems.org, www.mse-expo.com

16-20 Detroit, MI USA Materials Science & Tech. Conf & Expo (MS&T'07) - organized by ASM, ACerS, AIST, AWS, and TMS, and held in conjunction with *ASM Heat Treating Society Conf & Expo*, contact ASM Int'l, tel: 440.338.5151

x5900, em: cust-srv@asminternational.org, www.asminternational.org

17-20 Detroit, MI USA 24th ASM Heat Treating Society Conf & Expo - held in conjunction with MS&T'07 - contact ASM Int'l, tel: 800.336.5152 or 440/338-5151 ext. 6, fax: 440.338.4634, web: www.asminternational.org, email: customerservice@asminternational.org

OCTOBER 2007

2-4 Charlotte, NC USA South-Tec Machine Tool and Metalworking Expo - contact SME Society of Manufacturing Engineers tel: 800.733.3976, web: www.sme.org/southtec

8-9 Akron, OH USA Cold Spray 2007 Conference with table top exhibits and an industrial visit to ASB Industries - contact ASM Int'l, tel: 800.336.5152 or 440/338-5151 ext. 6, web: www.asminternational.org/events, email: customerservice@asminternational.org

14-19 Seattle, WA USA AVS 54th International Symposium & Exhibition - contact AVS, New York tel: 212.248.0200, email: avsnyc@avs.org, web: www.avs.org

15-19 Toulouse, France International Powder Metallurgy Congress & Exhibition (EURO PM2007) - contact tel: 44.1743.248899, email: info@epma.com, web: www.epma.com/pm2007

31 OCT - 2 NOV Kiev, Ukraine Kiev Technical Trade Show 7th Welding Ukraine 2007, Surface Engineering 2007, Sheet Metal Working 2007, Wire Steel Ropes 2007, Cabling Wiring 2007 - contact Olga Krasko, tel.: 00.380.44.526.91 .84, email olga@welding.kiev.ua, web www.weldexpo.com.ua

NOVEMBER 2007

4-8 San Jose, CA USA 33rd Int'l Symposium for Testing & Failure Analysis (ISTFA2007) contact ASM Int'l, tel: 440/338-5151 ext. 6, web: www.asminternational.org, em: customerservice@asminternational.org

6-8 Genoa, Italy Eurocoat 2007 Trade Show & Congress - contact Eurocoat Exhibition, France tel: 33.1.41984025, web: www.eurocoat-expo.com

11-14 Chicago, IL USA FABTECH Int'l & AWS Welding Show - with a Thermal Spray Pavilion - organized by American Welding Society, web: www.aws.org, Fabricators & Mfrs Assoc, web: www.fmafabtech.com, Society of Manufacturing Engineers, web: sme.org/fabtech

12-13 Carefree, AZ USA Intellectual Property Forum - sponsored by ASM International tel: 440.338.5151, email customerservice@asminternational.org, web: www.asminternational.org

12-16 Las Vegas, NV USA ASNT Fall conference & Quality Testing Show 2007 - contact tel: 614.274.6003, web: www.asnt.org

26-30 Boston, MA USA 2007 MRS Fall Meeting & Exhibition - contact tel: 724.779.3003, email: info@mrs.org, web: www.mrs.org

DECEMBER 2007

2-7 Tokyo, Japan Interantional Gas Turbine Congress - email: web:www.soc.nii.ac.jp/gtsj/igtc/IGTC07/index_e.html, igtc@rainbow.dti.ne.jp,

11-13 New Orleans, LA USA ASME Gas Turbine Users Symposium 2007 co-located with Power-Gen International - Contact Lisa Gasaway, tel: +1-918-832-9245, email: pgievent@pennwell.com



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JANUARY 2008

27-30 Los Angeles, CA USA *PACE 2008, The Power of Paint + Coatings* - contact www.pace2008.com

27JAN-1FEB Daytona Beach, FL USA *32nd International Cocoa Beach Conference & Expo on Advanced Ceramics & Composites* - contact Megan Mahan, tel: 614.794.5894, email: mmahan@ceramics.org, web: www.ceramics.org/acc

29-31 Mexico City, Mexico *Weldmex Show* - contact Joe Krall, email: JoeKrall@aol.com, tel: 1-800-443-9353 ext 297

FEBRUARY 2008

14 - 16 Hawaii, HI USA *International Thermal Spray Association Membership Meeting and Technical Program* - contact Kathy Dusa tel: 440.357.5400, email: kathydusa@thermalspray.org

14-16 New Delhi India - *International Trade Fair Joining, Cutting, Surfacing* - contact christina.kleinpass@messe-essen.de, tel: +49(0)201.7244.227, www.messe-essen.de

MARCH 2008

16-20 New Orleans, LA USA *NACE Corrosion 2008 Conference & Expo* - visit www.nace.org

24-28 San Francisco, CA USA *2008 MRS Spring Meeting & Exhibit* - contact tel: 724.779.3003, email: info@mrs.org, web: www.mrs.org

APRIL 2008

14-17 Detroit, MI USA *SAE World Congress and Expo* - visit www.sae.org

MAY 2008

26-28 Buenos Aires, Argentina *International Conference on New Developments in Metallurgy & Applications of High Strength Steels* - visit www.steelconfbsas08.com

JUNE 2008

2-4 Maastricht, the Netherlands *International Thermal Spray Conference/Expo (ITSC 2008)* - visit web www.dvs-ev.de/itsc2008 or contact ASM Int'l tel: 440.338.5151, email: customerservice@asminternational.org, web: www.asminternational.org

8-12 Washington, DC USA *World Congress on Powder Metallurgy & Particulate Materials* - email: info@mpif.org, web www.mpif.org

9-12 Chongqing, China *MRS International Materials Research Conference* - contact tel: 724.779.3003, web: www.mrs.org

9-13 Berlin, Germany *ASME Turbo Expo 2008* - visit www.turboexpo.org

AUGUST 2008

18-21 Louisville, KY USA *MegaRust 2008 Marine Coatings & Corrosion Conference* - visit www.nstcenter.com

SEPTEMBER 2008

14-18 Champion, PA USA *11th International Symposium on Superalloys (Superalloys 2008)* - contact TMS tel: 724.776.9000 x 243, email: mtgserv@tms.org, web: www.tms.org

OCTOBER 2008

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Welding Society, web: www.aws.org, Fabricators & Mfgs Assoc, web: www.fmafabtech.com, Society of Manufacturing Engineers, web: sme.org/fabtech

6-9 Pittsburgh, PA USA *Materials Science & Technology 2008 Conference & Exhibition (MS&T'08)* - organized by ASM, ACerS, AIST, and TMS tel: 440.338.5151 ext.0 email: customerservice@asminternational.org, web: www.asminternational.org

SEPTEMBER 2009

14-19 Essen, Germany *International Trade Fair - Joining, Cutting, and Surfacing* - visit web: www.messe-essen.de, contact email: christina.kleinpass@messe-essen.de

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Montreal Plant Receives Goodrich Approval



The Deloro Stellite Surface Technologies facility in Montreal has achieved its first major customer approval. Goodrich Landing Gear has granted the approval for application, finishing and stripping of HVOF coatings on landing gear components. This approval allows our facility to begin processing production parts for a number of projects associated with Goodrich including Airbus A-380 and Gulf Stream G5 components. This approval will also open doors to additional approvals by other OEMs and manufacturers in the near future.

In addition to the HVOF approval, the Montreal plant also received approval for the grinding of hard chromium plating on landing gear components. Our strategic alliance partner, Tecnickrome, currently sends all of the parts that are plated with hard chrome to outside vendors for grinding. This approval will allow Deloro Stellite to become their primary grinding house for small components. Because of the integration of our scheduling and manufacturing systems, we will be able to improve service and lead times to the customer.

The facility is also working toward a number of other approvals and certifications including Messier-Dowty, Heroux Devtek, Boeing, AS-9100 and NADCAP.

For more information, visit www.stellite.com

Air Products Reaches Microbulk Solutions Milestone with 10,000th Installation

Air Products achieved a milestone in May with the 10,000th customer installation of its innovative Microbulk Solutions for small volume industrial gas customers. The installation of Microbulk Solutions at a customer manufacturing facility located in Georgia marked the achievement of the global product offering first introduced in the United States in 2005, and offered in Europe prior to



1990. Microbulk Solutions is a novel gas supply and services option that provides the most technically-advanced and cost-effective alternative to traditional cylinder gas packaging in the marketplace.

"Microbulk delivery service and on-site storage and blending systems are very popular and have reached the 10,000th installation because the offering brings the advantages of bulk supply to operations with less than traditional bulk delivery volumes. At the 10,000th installation, Microbulk was the answer for our customer's argon needs for vacuum furnaces. Whether it is argon or nitrogen for heat-treating furnace atmospheres, nitrogen or oxygen for laser-assist gases, or argon and argon blends for weld shielding, Microbulk supply can mean efficient, economical and reliable supply for small-volume users," said John Tapley, Microbulk business development manager at Air Products.

Air Products' Microbulk Solutions has had an impact for several markets including metals processing, biotechnology, foods, electronics and healthcare industries, and for applications with relatively small volume gas requirements. The service appeals to small-volume customers by virtually eliminating cylinder handling and reducing the number of product deliveries.

Microbulk tank trucks provide fast fills into storage tanks that are designed to offer customers a range of flexible supply options. They feature automatic fill shut-off devices; computer telemetry that remotely monitors tank levels, or programmable digital liquid level gauges to help customers monitor their inventory; and tanks with enhanced thermal qualities to limit product loss during periods of little or no use. Microbulk Solutions provide a much simplified supply chain option over the former gas supply practice of many industries' processing operations that historically relied on high-pressure cylinders and dewars - a labor-intensive approach often resulting in wasted residual gas and the potential for interrupted supply, cross-contamination and safety issues.

Air Products serves customers in industrial, energy, technology and healthcare markets worldwide with a unique portfolio of atmospheric gases, process and specialty gases, performance materials, and equipment and services. Founded in 1940, Air Products has built leading positions in key growth markets such as semiconductor materials, refinery hydrogen, home healthcare services, natural gas liquefaction, and advanced coatings and adhesives.

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Journal of Thermal Spray Technology®

A publication of the **ASM Thermal Spray Society**
Enhancement of Service Life of Steam Generating Tubes
in Oil-Fired Boiler for Power Generation Employing
Plasma Spray Technology

Kazumi Tani and Yoshio Harada

The effects of Ni-50 mass% Cr alloy coating, that is plasma-sprayed onto the fire-side of steam generating tubes in a heavy oil-fired boiler, on the high temperature corrosion resistance were examined. One of the severe environments in the industrail manufacturing facilities, where thermal sprayed coatings are employed, is the high temperature corrosion such as the oxidation, sulfidation, and low melting fuel ash corrosion in the fire-side of boiler tubes. In the fossil fuel-fired steam generating boiler facilities, the degradation of failure of steam generating tubes that were derived from the contaminants in a lower grade fuel have often occurred. The situation of degradation of the water evaporator and superheater tubes and corrosion-preventing effects of plasma sprayed coating are described. The enhanced effects of plasma sprayed Ni-50 mass% Cr alloy coating for the suppression of hot corrosion failure of the steam generating tubes of boiler are summarized.

Read the entire article in the March 2007 Journal of Thermal Spray Technology. For more information visit www.asminternational.org/tss

Editor: Christian Moreau • **Associate Editors:** Jan Ilavsky, Seiji Kuroda, Lech Pawlowski, and Armelle Vardelle

Sermatech Receives Approval From Goodrich

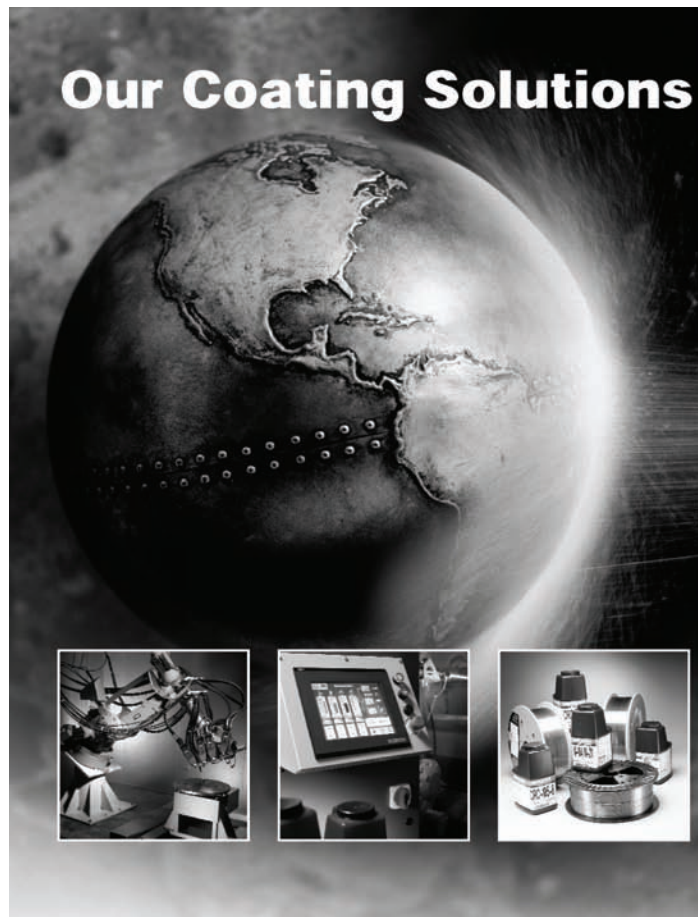
Sermatech Canada has received process approval from Goodrich Landing Gear to apply LGPS 1301 HVOF thermal spray coatings at their Dorval, Quebec facility. This approval covers the application of tungsten-carbide-cobalt-chromium coatings on various landing gear components and is effectively replacing chrome plating on all new designs. The coatings will be applied at Sermatech's state-of-the-art facility which includes a fully automated robotic system to ensure repeatability and excellent coating characteristics.

Sermatech International is a recognized leader in coating development, coating applications, and surface engineering technologies, serving major aerospace OEMs and their suppliers for over 40 years. Sermatech serves its customers globally leveraging facilities across the US and in Canada, UK, Germany and Korea. Additionally Sermatech holds a wide range of OEM Aerospace approvals (including AS9100, NADCAP, FAA and EASA) and uses six-sigma and lean techniques to drive continuous improvement in all its operations.

For more information about this approval, contact Jan Siedlikowski via email jsiedlikowski@sermatech.com, tel: 514-631-2240, or visit web www.sermatech.com.

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Chairman Froning

A company-member trade association, ITSA invites all interested companies to talk with our officers, committee chairs, and company representatives to better understand member benefits. A complete list of ITSA member companies and their representatives are at www.thermalspray.org

ITSA Mission Statement

The International Thermal Spray Association is a professional trade organization dedicated to expanding the use of thermal spray technologies for the benefit of industry and society.

Officers

Chairman: **Marc Froning**, BASF Catalysts LLC
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ITSA Scholarship Opportunities

The International Thermal Spray Association offers annual Graduate and Undergraduate 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 Materials Camp Student Sponsor

Commencing in 2001, the International Thermal Spray Association provides an annual \$1,500 student scholarship to the ASM International Foundation Materials Camp.

ITSA Thermal Spray Historical Collection

In April 2000, the International Thermal Spray Association announced the establishment of a Thermal Spray Historical Collection which is now on display at their headquarters office in Fairport Harbor, Ohio 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 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 Newsletter

Since 1992, the International Thermal Spray Association has been publishing the **SPRAYTIME** newsletter for the thermal spray industry. The mission is to be the flagship thermal spray industry newsletter 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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The editor reserves the right to select letters for publication, and due to space and time limitations not all letters will be published nor acknowledged. If you have any questions please contact SPRAYTIME via email spraytime@thermalspray.org, or via phone 440.357.5400.



Southwest Purchases CEEL

Southwest United Industries purchased CEEL Limited of Brampton, Ontario in February 2006. Currently CEEL provides hard chrome and sulfamate nickel plating services from its 18,000 sq ft facility to aerospace, military and general industrial customers. CEEL is NADCAP accredited and approved by Boeing, Goodrich and Messier-Dowty.

From the outset Southwest and CEEL undertook the installation of HVOF thermal spray coating and grinding as a top priority. We are now pleased to announce the installation and commissioning of two brand new spray booths. We anticipate the accreditation and approval process will take several more months, but look forward to serving the aerospace market in southern Ontario later this year.

Southwest United Industries has facilities in Tulsa and



Oklahoma City, Oklahoma. Southwest provides non-destructive testing, shot peening, thermal spray coating, plating, grinding, anodizing and painting services to the aerospace industry. It is NADCAP accredited and is certified and approved by all the major aerospace manufacturers. Southwest is also an FAA Repair Station utilizing thermal spray coating, plating, grinding and machining to repair aircraft component parts for airlines and third-party maintenance facilities.

Plasma Coating Corporation is a wholly-owned subsidiary of Southwest United Industries and is located in Gardena, California. PCC provides thermal spray coating (HVOF, plasma, electric arc, combustion powder and wire), grinding, painting, Teflon and dry film lube services to the aerospace industry. It is NADCAP accredited and is approved by many aerospace manufacturing companies as well as being an FAA Repair Station.

For more information, contact Mr. Bill Emery, Southwest United Industries, www.swunited.com, tel: 918.587.4161 or Mr. Jim Emery, Plasma Coating Corporation, tel: 310.532.3064, www.plasmacoatingcorp.com

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AWS is Headed South of the Border!

The American Welding Society, WEMCO and RWMA are proud to support the WeldMex Show, being held at the new Centro Banamex Convention Center, in Mexico City, January 29-31, 2008.

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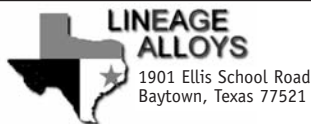


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Chris Berndt Inducted to Thermal Spray Hall of Fame



Prof. Christopher C. Berndt, Professor of Surface and Interface Engineering at James Cook University, School of Engineering, Townsville QLD, Australia, has been inducted into the Thermal Spray Hall of Fame. He was cited for outstanding contributions to the science and technology of thermal spray, and for leadership in promoting thermal spray technology. Prof. Berndt's

many innovations have led to facilitating the bridge between academia and industry affecting numerous collaborations. Also, he was among the first to use solution plasma spraying, an area which is emerging as a very promising technology.

The Thermal Spray Hall of Fame was established by the ASM Thermal Spray Society in 1993 to recognize significant contributions to the science, technology, practice, education, management and advancement of Thermal Spray.

Wall Colmonoy Appoints Ami Zelcer General Manager



Wall Colmonoy announces the appointment of **Ami Zelcer** to the position of General Manager, WCC Ohio Aerospace Group.

Zelcer will have responsibility for the overall administration and management of the business units in Cincinnati and Dayton.

Zelcer has more than twenty years experience in the aerospace industry; having served as general and operations manager, engineering and business-development manager, and head of quality control for suppliers of major components for the aircraft industry.

Zelcer received his Master's in engineering from Ohio State University.

To find out more about Wall Colmonoy or WCC Aerobrazing Division, visit www.wallcolmonoy.com

WHERE IS YOUR ARTICLE?

You and your company have the opportunity to help design the content of your thermal spray community newsletter. The **SPRAYTIME** Editorial Staff encourages and welcomes your contribution.

Send news and articles via email to spraytime@thermalspray.org

Technical Program Open To Public Next Program in Hawaii

The **International Thermal Spray Association** welcomes non-member participation at the Technical Program portion of their membership meetings. ITSA membership meetings are typically three-day events with a thermal spray technical program on Friday from 8:00 am through 5:00 pm.

This is in response to interest from non-member individuals wanting to take advantage of these valuable thermal spray educational opportunities.

The February 15, 2008 Technical Program will be held in Waikoloa, Hawaii. The cost for non-members to attend is \$400, which includes breakfast and lunch.

For more information, contact Kathy Dusa via email kathydusa@thermalspray.org

FREE Thermal Spray Patent Copy

A copy of the original Schoop thermal spray patent - suitable for framing - is available from the International Thermal Spray Association. This is a photograph copy of the original February 19, 1914 "Apparatus for Spraying Molten Metal and Other Fusible Substances" by M.U. Schoop from the United States Patent Office. Send an email request to itsa@thermalspray.org



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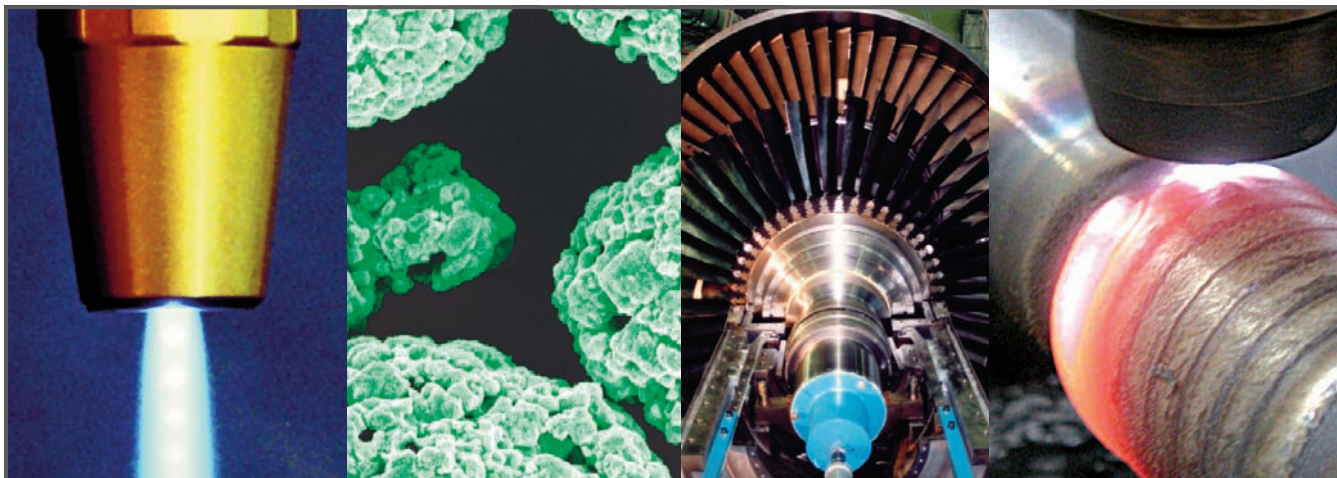
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Hermanek and Moreau Named ASM Fellows

ASM International established the Fellow of the Society honor in 1969 to provide recognition to members for their distinguished contributions to materials science and engineering and develop a broadly based forum of technical and professional leaders to serve as advisors to the Society. Following are the members recognized by their colleagues in 2006 in the Thermal Spray Field.

Frank J. Hermanek's thermal spray career spans more than 40 years and includes a number of publications, patents, and successful novel applications of the technique so close to his heart. He has guided the industrial development and application of thermal spray technology as a manager of various engineering groups at a number of companies. Frank is a life member of ASM International - having joined ASM in 1958. Frank was the chair of the ASM Thermal Spray Society (ASM TSS) Awards committee for 9 years and the originator of the Hall of Fame. He is the primary author of the of the *Thermal Spray Terminology and Company Origins* glossary publication. Frank was very active in the American Welding Society (AWS) C2 Thermal Spray Committee and authored two chapters of the AWS Thermal Spray Handbook.



His ASM International Fellow citation reads: "For long term activities in thermal spray, in particular the conceptualization and nurturing of the thermal spray glossary and the creation of the Thermal Spray Hall of Fame."

Dr. Christian Moreau, Group Leader, Surface Technologies, National Research Council Quebec Canada. Moreau has an approximately 20-year-long, distinguished career at the National Research Council of Canada and in the field of thermal spraying in general. He is author of numerous high-quality publications in respected journals and holds seven patents on optical sensing techniques for thermal spray processes. He is currently Editor-in-Chief of the ASM TSS



Journal of Thermal Spray Technology (JTST) and served also as co-editor of *Thermal Spray 2003, Proceedings of the International Thermal Spray Conference 2003*, guest editor of JTST, Vol 10 (No. 3) issue. Christian has organized or co-organized conferences, sessions, workshops, and meetings for the last 20 years. He was elected to the ASM TSS Board of Directors in 2006.

Also in 2006, Christian was the recipient of the ASM Canada Council G. MacDonald Young Award. This award was established by ASM Canada Council in 1988 to recognize

distinguished and significant contributions by an ASM member in Canada.

His ASM International Fellow citation reads: "In recognition of his invention and development of novel sensor technologies for thermal spray processes, and for strong support of ASM Thermal Spray conference activities."

Walter Wynarczuk New Salesperson at ATTC

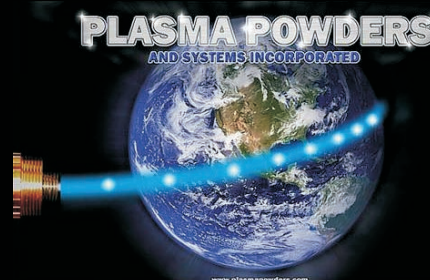
American Torch Tip recently hired Walter Wynarczuk as Thermal Spray Salesperson.

Walter brings over 35 years of industrial knowledge. His main responsibility will be to improve product breadth and grow consumable sales. He will be involved directly with ATTC's Thermal Spray Division (Thermatec) which has been expanded to include replacement consumables for most of the best known thermal spray equipment currently on the market.

For more information, contact American Torch Tip, 6212 29th Street East, Bradenton, FL 34203 USA, tel: 800.342.8477 or 941.753.7557, fax: 941.753.6917, email: walter@attcusa.com, web: www.americantorchtip.com



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