In The News

New Literature

The Science and Engineering of Thermal Spray Coatings

L. Pawlowski, Nozay, France; 400 pp., 1994, £75.00 / $120.00; Available from John Wiley & Sons Ltd, Baffins Lane, Chichester, West Sussex, PO19 1UD, UK, Fax: +44 (0)243 531712.

Lech Pawlowski gives a complete and concise description of the technology of thermal spraying, starting with a discussion of powder manufacturing and testing, followed by the techniques involved during pre-spray treatment. Currently applied methods of spraying, together with post-spraying techniques are also outlined. The book correlates coatings properties with their microstructure and processing parameters. A strong emphasis is put on practical advice (both current and future) concerning coating characterization techniques.

The broad coverage of this work will enhance its value amongst researchers and professionals using thermal spray technology in academia and industry. Students specializing in the field will also find it of great use.

CONTENTS: Introduction; Materials Used for Spraying; Pre-Spray Treatment; Thermal Spraying Techniques; Post-Spray Treatment; Physics of Thermal Spraying; Coatings Build-up; Methods of Coatings Characterization; Properties of Coatings; Applications of Coatings; Organization Spray Shop; References and Index.

Conferences

SMT-10 - The Tenth International Conference on Surface Modification Technologies

Singapore, 2 - 4 September 1996

Topics: Coating materials and techniques for tribological applications; Wear behaviour (influence of interfacial properties, effects of environment, etc); Advanced surface analysis techniques (Auger spectroscopy, Scanning tunneling microscopy, atomic force microscopy, XPS, EPMA, etc.); Testing of surface coatings; Prediction of coating failure; Laser beam processing (laser cladding, laser glazing, laser synthesis, etc.); Surface hardening processes (nitriding, carburising and boriding); Physical and chemical vapour coating; Thermal sprayed coatings (Plasma spray, HVOF, electric arc, etc.); High temperature coatings; Biomedical coatings; Application of advanced coatings in electronics, aerospace, automobile and marine industries; Ceramic, polymer or metal matrix composite coatings; Metallography of surface coatings; Sample preparation techniques for surface coatings; and Numerical/computer modelling of coating processes.

Abstracts: Prospective authors should send a short abstract (150 - 200 words) on A4 size paper (inclusive of diagram) to the Secretariat. The deadline for receiving abstracts is 15 DECEMBER 1995. Authors will be notified of the acceptance of their papers by 30 JANUARY 1996. The abstract should state the main points of the paper and describe clearly new and significant results obtained. Abstracts must be prepared on a single side, double space typewritten form and must include author's address, affiliation, telephone, telex and fax numbers, if any. Details of the manuscript format will be sent together with the notification of acceptance.

Proceedings: Full length papers will be requested by 15 April 1996, and refereed papers presented at the conference will be published in a proceedings volume by January 1997.

Language: The language for abstracts and manuscripts, as well as for oral and poster sessions of the conference will be English.

Exhibition: An exhibition of related products and services will complement the technical programme. Please specify if your company or organisation intends to participate. Full details will be mailed to you.

For further information contact: The Secretariat, SMT-10 1996, Centre for Continuing Education (CCE), Nanyang Technological University, Nanyang Avenue, Singapore 2263, SINGAPORE, Tel: (65) 799 5243, Fax: (65) 791 6178,

"TS96" 1996 Thermal Spraying Conference

Essen, Germany, 6th-8th March 1996

In 1996 the TS 96 Conference will once again represent Germany's leading event in the field of thermal spraying. Organized by the German Welding Society (DVS), TS 96 will provide an insight into the latest applications and developments in thermal spraying. The official languages of the conference will be German and English. A simultaneous interpreting service will be provided.

Under the slogan Future - Surface TS 96 will cover the following issues: Applications and case studies; Pre- and post-position-treatment and finishing; Equipment and processing technology; Consumables; Quality control, quality assurance and quality management; Economic aspects; Design; Health and safety at work and environmental protection; Training and qualification of personnel; and Plasma Transferred Arc Surfacing (PTA).

For further information contact: TS 96, DVS, Aachener Strasse 172, 40223 Dusseldorf, Germany, Tel: (0211) 1591-0, Fax: (0211) 1591-200. Contact Mrs. S. Asshauer or Mrs. R. Bogdon for general information.

Recent Conference Agendas

NASA/DOE/NIST Thermal Barrier Coatings Workshop

Westlake, Ohio, March 27-29, 1995

Introduction

Welcome: S.J. Grisaffe, Director of Aerospace Technology, NASA Lewis Research Center

Opening Remarks: W.J. Brindley, NASA Lewis Research Center

Keynote Speaker: A Design Perspective on Thermal Barrier Coatings; F.O. Soechting, Pratt & Whitney

Overviews

Thermal Barrier Coatings for Aircraft Engines - History and Directions; R. A. Miller, NASA-Lewis Research Center

Thermal Barrier Coatings Issues in Advanced Land-Based Gas Turbines; W.P. Parks, Office of Industrial Technologies, DOE, W.Y. Lee and I.G. Wright, Oak Ridge National Laboratory

Measurement Methods and Standards for Processing and Application of Thermal Barrier Coatings; S.J. Dapkunas, National Institute of Standards and Technology

Thermal Barrier Coatings for Diesel Engines; J.W. Fairbanks, DOE

Engine Experience with TBCs

Thermal Barrier Coating Experience in the Gas Turbine Engine; S. Bose and J. DeMasi-Marcin, Pratt & Whitney

PVD TBC experience on GE Aircraft Engines; A. Bartz, A. Maricocchi and D. Wortman, GE Aircraft Engines

TBC Experience in Land Based Gas Turbines; W. A. Nelson and R.M. Orenstein, GE Power Generation

Perspective on Thermal Barrier Coatings for Industrial Gas Turbine Applications; Z.Z. Mutasim, L.L. Hsu and W.D. Brentnall, Solar Turbines Inc.

Overview of Thermal Barrier Coatings in Diesel Engines; T.M. Yonushonis, Cummins Engine Co.

Materials / Processing

Thermal Spray Processing; H. Herman and C.C. Berndt, State University of New York at Stony Brook

PVD TBC Applications and Process Development for Aircraft Engines, D.V. Rigney, R.Viguie and D.J. Wortman, GE Aircraft Engines

Jet Engine Applications for Materials with Nanometer-scale Dimensions; J.W. Appleby, Pratt & Whitney

Thermal/Mechanical/Chemical/ Physical Properties

Process, Properties and Environmental Response of Plasma Sprayed Thermal Barrier Coatings; R.C. Novak, Pratt & Whitney Talon, Inc.

Thermal Conductivity of Zirconia Thermal Barrier Coatings; R. B. Dinwiddie and S.C. Beecher, Oak Ridge National Laboratory; B.A. Nagaraj and C.S. Moore, GE Aircraft Engines

Mechanical Properties Testing and Results for Thermal Barrier Coatings; T. A. Cruse and B.P. Johnsen, Vanderbilt University

Properties of Plasma Sprayed Bond Coats; W.J. Brindley, NASA Lewis Research Center

Thick Thermal Barrier Coatings for Diesel Engines; M.B. Beardsley, Caterpillar, Inc.

Some Aspects of the Hot Corrosion of Thermal Barrier Coatings; R.L. Jones, Naval Reseach Laboratory

Modeling

Thermal Fracture Mechanisms in Ceramic Thermal Barrier Coatings; K. Kokini, B.D. Choules and Y.R. Takeuchi, Purdue University

A Software Tool Design Thermal Barrier Coatings; G. Petrus and B.L. Ferguson, Deformation Control Technology, Inc.

Thermal Barrier Coating Life Modeling In Aircraft Gas Turbine Engines; D.M. Nissley, Pratt & Whitney

MC95 International Metallography Conference

Colmar, France, 10 - 12 May, 1995

Ten papers of the Colmar meeting were of direct relevance to thermal spray technology. These are listed below.

Examination of Layered Coatings by SEM, TEM and STM/AFM; D.G. Rickerby; Institute of Advanced Materials, Italy

Comparison of Different Techniques for Porosity Measurements of Thermally Sprayed Coatings; J. Skogsmo; IVF, Sweden

Microstructure Investigation on Metal/Ceramic Interface; S. Matera; Centro Sviluppo Materiali, Italy

Microstructure Properties of Hydroxyapatite Coatings on TiNi Shape Memory Alloys; P. Filip, K. Mazanec; Technical University of Ostrava, Czech Republic

Structure Fluctuations in Thermal Sprayed Coatings and their Influence on the Properties; L.I. Markashova, V.V. Statsenko; Electric Welding Institute, Ukraine

Observation and Characterization of Individual Splat Morphologies in the Thermal Spraying Process in View of Assesing Coatings; G. Montavon, C. Coddet; LERMPS, France

Powder Characterization Using Images Processing Techniques; A.M. Nazar, F. A. Silva, J.J. Ammann; UNICAMP, Brazil

Dependence of Plasma Coating Properties on Powder-Making Process; V.M. Beletsky, G.A. Krivov; Ukrainian Research Institute of Aviation Technology, Ukraine

Microscopy of Thermal Sprayed Coatings with Amorphous and Nanocrystalline Structure; T. Shmureva, A. Mukhin, L. Mukhina; State Metallurgical Academy of Ukraine, Ukraine

In Situ Checking of Porous Coating Quality; J. Tehver, V. Temkina; Institute of Energy Research, Estonia

4th Thermal Spray Symposium of the American Welding and Fabrication Exposition and Annual Conference

Cleveland. Ohio, April 2-6, 1995

The 7 sessions listed below were sponsored by the AWS C2 Committee on Thermal Spraying.

Session TS1
The Future of Thermal Spray

Thermal Spray: An Introduction and Update, D.E. Crawmer, Miller Thermal Inc.

Testing and Evaluation: The First Step in Coating Standardization, K. A. Evans and J.P. Sauer, Metcut Research Associates

A Multimedia-Based Approach for Advanced Education and Training in Plasma Spray, C. Cheng, E.J. Onesto, and K. Sampath, Concurrent Technologies Corporation

Nanostructured Coating Technology for the Thermal Coatings Industry, A. Rotolico and D. Parker, General Plasma

The Issues and Recommendations Regarding Air Quality Requirements for the Thermal Spray Industry, E.R. Sampson, TAFA Incorporated

Session TS2
Materials, Testing, and Mechanical Properties - Part 1

Test for Evaluating Materials Performing in High Impact Applications, L. Moskowitz, Naval Air Warfare Center

Erosion Testing and Performance of Thermal Spray Coatings, W.R. Kratochvil, E.R. Sampson, TAFA Incorporated; and G.W. Brunkhorst, Concord High School

The Development of Residual Stresses in Underwater PTA Cladding, R. A. White, B. Fusaro, and H.D. Solomon, GE Corporate Research & Development; and D. Hornbach, Lambda Research; and K. Horstman, GE Nuclear Energy

Session TS3
Materials, Testing, and Mechanical Properties - Part 2

Statistical Studies for Indentation on Thermally Sprayed Coatings, C.K. Lin, S. Sampath, H. Herman, and C.C. Berndt, State University of New York at Stony Brook

Review of Sliding Wear Performance of Thermal Spray Coatings, M. Kim, R.W. Smith, M. Mohanty, M. Bohley, and R. Weaver, Drexel University

Tension and Compression Values of Youngs Modulus and Poissons Ratio for Thermal Spray Coatings, J.R. Shadley, E.F. Rybicki, D. Greving, and Y. Xiong, University of Tulsa

Statistically Designed Experimentation for Plasma Applied Ceramic Coatings, D.J. Varacalle, Jr., Idaho National Engineering Laboratory; M.W. Poe, Mid-Atlantic Associates Ltd.; T.J. Steeper, Savannah River Laboratory; and W.L. Riggs, II, TubalCain Company

A New Approach in Investigating the Electric Arc Spraying Process, R. Mohan, M. Murugesan, and R. Kovacevic, University of Kentucky

Session TS4
Selection, Preparation, Spraying, and Finishing Thermal Spray Coatings

Development of the AWS A5U Thermal-Spray Feedstock Specification, R.A. Sulit, Sulit Engineering

Selecting Thermal Spray Materials and Processes, L.F. Grimenstein, Nation Coating Systems, Inc.

A Process Model for Optimizing Plasma Spray Parameters, V.K. Suri and K. Sampath, Concurrent Technologies Corporation

Machining and Grinding Thermal Spray Materials with Superabrasives, J.H. Dailey, GE Superabrasives

Session TS5
Applications

Thermal Spray Polymer Coatings: An Engineering Solution to Problems Wear and Corrosion, R.J. Du Mola, M. Weinstein, Eutectic Corporation; and P. A. Kammer, Castolin, S. A., Switzerland

Worldwide Applications in the Sugar and Mining Industries, E.R. Sampson, TAFA Incorporated

The Development and Application of Chromium Plating Alternatives Using the High Velocity Oxyfuel Process, M.R. Dorfman, B.A. Kushner, J.A. DeBarro, and B. Dulin, Sulzer Metco

High Velocity Oxyfuel Thermal Sprayed Titanium Coatings for Marine Corrosion Control, R.A. Hayes, R.L. McCaw, D. A. Davis, and J.L. Pugh, Naval Surface Warfare Center

Plasma Sprayed Laminates for High-Temperature Applications, R.D. Seals, R.E. Price, and M.E. Garrison, Oak Ridge National Laboratory; and E.L. Bird and C.E. Holcombe, Jr., Martin Marietta Energy Systems, Inc.

Session TS6
HVOF (High Velocity Oxygen Fuel)

Characterization and Applications of Nickel Base Alloys Applied by High Velocity Oxyfuel, G.L. Fillion, Wall Colmonoy Corp.

An Investigation of the Galvanic Corrosion Performance of Several Wear-Resistant Thermal Spray Coatings, K. Cetin and B. A. Shaw, The Pennsylvania State University; and L. Moskowitz, Naval Air Warfare Center

The Development and Application of Corrosion-Resistant, High Velocity Oxyfuel Thermal Spray Coatings, M.R. Dorfman, B.A. Kushner, and J.A. DeBarro, Sulzer Metco

Underwater High Velocity Oxyfuel Spraying of Noble-Metal-Doped Metallic Coatings, Y.C. Lau, D.M. Gray, P.L. Andresen, and Y.J. Kim, GE Research and Development Center

Session TS7
Automotive

The Role of Thermal Spray Technology in Automobile Manufacturing, R.C. McCune, Ford Motor Company

Implementation of Thermal Spray Coatings onto Aluminum Engine Blocks, M. Kramer and L. Bynes, General Motors Powertrain Division

Materials-Finishes Applicable to Improved Cylinder Kit Components, H.E. McCormick, C-K Engineering

An Evaluation of Three Arc Spray Systems and Their Relationship to Final Automotive Paint Finish Results, E.R. Sampson, W.R. Kratochvil, and E.L. Peets, TAFA Incorporated

Companies listed as exhibiting in the area of Thermal Spray included: AGA Gas; All-State Welding; American Torch Tip; ASB Industries; BTU Contracts; Bug-O Systems; High Purity Gas; Hobart Brothers; Miller Thermal; Southwest Aeroservice; Stellite Coatings; Sulzer Metco; Thermadyne Industries; Thermadyne International; Thyssen Welding; and UTP Welding Technology.

ITSC95 in Kobe, Japan is a Success!

With over 200 technical papers and some 600 participants, there is no doubt that the International Thermal Spray Conference in Kobe, Japan was a resounding success. The effects of the recent earthquake (see the following feature) were quite apparent in the city of Kobe (~ 2 miles from the conference site on the mainland). But all aspects of the ITSC proceeded quite smoothly with virtually no inconvenience to the participants. A future report in JTST will report on this major and important conference.

Modern Buildings Fared Well in Kobe Quake[1]

Most modern buildings—and structures retrofitted with modern engineering techniques—fared well in the Kobe quake, the 6.8 January 17 earthquake. Much of the damage occurred in traditionally built older homes and in areas near the coast where liquefaction of the soil caused instability in structures.

At the time of the earthquake, a team of scientists were in Osaka, 30 km east of Kobe, for a National Science Foundation funded US Japan Workshop on Urban Earthquake Hazard Reduction, co-sponsored by the Earthquake Engineering Research Institute and the Japan Institute of Social Safety Science. The workshop participants immediately undertook preliminary post-earthquake reconnaissance efforts funded by the National Science Foundation (NSF).

The team recently issued a preliminary report describing their findings. "After a damaging earthquake, it is important to get researchers into the field to collect information and make observations as soon as possible because much of the data is perishable and will disappear when the recovery process commences," said William Anderson, head of the earthquake hazard mitigation program at NSF. "Because the US group, comprised of researchers from such disciplines as earthquake engineering, seismology and the social sciences, was already in Osaka at the time of the earthquake, they were able to undertake the earliest possible investigation of that event and collect information that would later be unavailable to other investigators."

The earthquake killed more than 5,000 people and caused more than $200 billion in damage. More than 56,200 buildings were destroyed in the quake and subsequent fires. Preliminary assessment indicated the single most significant cause of damage is the proximity of affected cities to the fault rupture. In areas of heavy damage, the pattern indicates that a strong horizontal pulse, rather than the repeated shaking, caused the majority of the destruction. The most extensively and severely damaged structures were smaller commercial buildings (often with residences upstairs) constructed with limited engineering design and traditional homes. The smaller commercial and mixed occupancy buildings are typically framed with wood or light steel and have walls of stucco over wood slats. Many of these buildings have a large shop window in the front and lack interior walls, factors which weaken the first floor.

Traditional homes, typically those built before the 1970s, have heavy tile roofs with tiles set in a thick clay and mud mortar, few partitions, and are not waterproofed which causes widespread dry rot and water damage. Little nailing is used; wood joinery is more common. Many casualties were found in damaged and collapsed traditional homes. The heavy tile roofs stressed the walls, which cracked, crumbled and often collapsed, triggering fires from broken gas pipes. The Kobe earthquake exposed more modern and engineered buildings to stronger forces than any previous earthquake.

The failure of transportation structures produced dramatic and frightening images flashed across the world following the quake. Perhaps the most memorable image was a bridge on the Hanshin expressway which "rolled over." Most of the damage to bridges occurred to older structures designed before modern earthquake engineering. The damage was typically column shear and structures that broke instead of bending. Other more modern structures suffered extensive damage due to liquefiable soils along the bay. The Akashi Suspension Bridge bore the brunt of the earthquake with essentially no damage—an example of how engineering can prevent damage during earthquakes. Rail facilities were hard hit—and more casualties and fatalities would have resulted if the quake had occurred during commute times. Railway structures failed because of shear failures in support structures, inadequate restraint between spans at critical joints, and large ground movements causing spans to fall off supports; also many cars rolled because of the ground movement.

The Port of Kobe suffered extensive damage, mainly due to liquefaction. Modern design criteria are more stringent and liquefiable soils can now be identified and the effects mitigated. Electric power and telecommunications systems performed remarkably well during the earthquake, with little or no disruption to service. Water pipelines sustained severe damage, causing a general lack of service in Kobe, Ashiya, and Nishinomiya. Some residents were informed to expect no water service for two months. The lack of water also inhibited fire fighting efforts. It is expected that the sewer system suffered similar damage. The gas system sustained numerous breaks, which will interrupt service to residents for several months.

The formal emergency response confirms the oft-repeated warning that citizens should be prepared to be on their own for 72 hours following a disaster. It takes time for response agencies to identify and locate problems and organize resources. The failure of transportation structures inhibited emergency response. Also of note: access to damaged buildings was not prohibited—and people returned to cracked, crumbling and dangerous homes to seek shelter and to gather belongings, putting themselves again at risk.

1 Extracted from a preliminary report issued by the National Science Foundation

Japan's Basic Plans for Promoting R&D

The National Science Foundation's offices in Tokyo and in Paris periodically report on developments abroad that are related to the Foundation's mission. These documents present facts for the use of NSF program managers and policy makers; they are not statements of NSF policy.

On December 12, 1994, the Council for Science and Technology (CST), Japan's highest S&T policy-making body in the government, presented a report to the Prime Minister with recommendations on "Basic Plans for Promoting R&D on Advanced Fundamental Science and Technology." The CST report was prepared in response to a June 1993 "Inquiry" (Inquiry #21) from the Prime Minister. In September 1993, the CST established a Committee on Advanced Fundamental S&T and three sub-committees, each with members drawn from academia, industry, and government. The Committee and sub-committees met several times and their findings and recommendations served as the basis for the CST's report to the Prime Minister.

The report identifies more than 180 specific "advanced fundamental technologies" that need to be developed over the next 10 years to help advance the frontier of scientific and technological R&D efforts in Japan. These advanced fundamental technologies are divided into two categories: (a) technologies for use as advanced laboratory tools for R&D, and (b) integrated multi-disciplinary technologies needed to resolve complex and diversified problems for the advancement of S&T and for achieving harmony of S&T with nature and mankind. The report has been referred to the S&T-oriented ministries and agencies in the government for their consideration and implementation.

The original report contains an appendix with details on each advanced technology recommended for development, including descriptions of the technology's present state-of-the-art, goals in terms of technical parameters to be achieved, and examples of potential spin-off applications. Inquiries may be addressed to: Secretariat for the Council for Science and Technology, c/o Planning Division Science and Technology Planning Bureau Science and Technology Agency 2-2-1, Kasumigaseki, Chiyoda-ku, Tokyo 100, Japan.

Industrial News and Views

Plasma Arc Production of Nano-Sized and Metal Particles

Japanese companies are now synthesizing nano-sized ceramic and metallic particles through the technology of thermal plasma. Thus, the International Submicron Industry, ISI Ltd. of Saitama, Japan, is using such techniques for the production of nano-crystalline TiO_2 for the cosmetics industry and for surface coatings applications. To inhibit the decomposition of these particles in UV light, ISI either impregnate them with iron or provide alumina skins for the particles, which are then calcined at 400 - 600C. Thanks to the plasma-aided desensitizing process, the use of phosphite or phosphate surfactants is eliminated. ISI also see potential use of ultrafine TiO_2 in the areas of photochromic materials, organic films, fibers and textiles. Moreover, the company suggests that the use of ultrafine SiO_2 in contact lenses of plastic composition could improve the necessary O_2 permeability of these items.

Elsewhere, Hosokawa Micron B.V. (Doetinchem, Netherlands) has developed a plasma reactor that produces superfine metal powders (d nm). For further information see Chemical Engineer, August (1994) p.39. (Information extracted from Plasma Info - the Newsletter of the CRTP Plasma Technology Research Centre - University of Sherbrooke, Canada. Tel: (819) 821-7168; Fax: (819) 821-7955.)

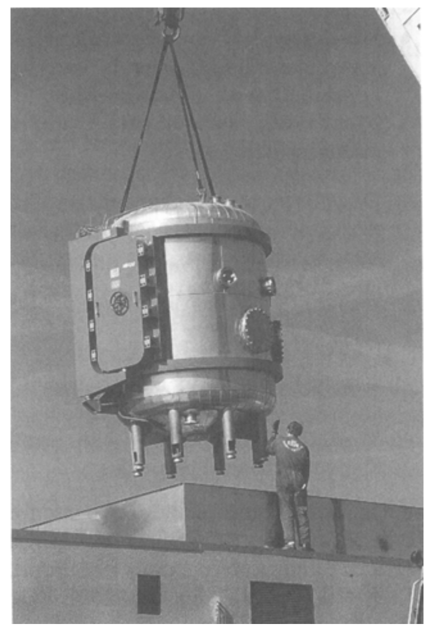
Graded Coating of Bone Implants Strengthens Bonds

A combination of sol-gel and ion implantation has been developed at Los Alamos, NM-USA, that reportedly enables the coatings on titanium bone replacements to bond well with both titanium and bone. The goal of the research is to develop a graded coating of hydroxylapatite that changes from a porous layer on the outside, which bonds to the bone, to a solid, dense crystalline layer next to metal, which forms a strong bond with titanium. Hydroxylapatite (HA) is a common mineral that makes up 75% of bone.

The sol-gel method involves a liquid preparation that forms a sol, a colloidal solution of ceramic particles. In conventional sol-gel techniques, the substrate is dipped into the sol-gel and then heated to harden the gel into a coating. Instead of heat, the Los Alamos team will use a line-of-sight beam that causes the ceramic particles to mix with titanium surface layers. Ideally the implant material could be dipped repeatedly into the HA sol-gel to form as many as 100 layers. The first layer would be ion-implanted, and each successive layer would simply be heated. By lowering the temperature for each layer, the successive coatings become less dense. The last layer would be very porous to facilitate bonding with the bone. Contact: Mike Nastasi, Los Alamos National Laboratory, Los Alamos, NM 87545, Tel: (505) 667-7000. (Information extracted from *Advanced Materials & Processes*, 3/95).

A New Plasma Spraying Center in France Called "C2P"

The P.M. Fourt Materials Research Center of the "Ecole des Mines de Paris" has just merged its plasma spraying facilities; i.e. a recently received a Sulzer Metco CAPS ("Controlled Atmosphere Plasma Spraying") system, with some of those of the French Atomic Energy Agency, "Commissariat a l'Energie Atomique" (C.E. A.), and with research teams in the field of surface science at the University of Evry Val d'Essonne. This has resulted in the creation of a joint Center devoted to plasma spraying and related activities. This so-called C2P ("Centre de Competence Projection Plasma"; i.e. Center for Plasma Processing) was created (i) to serve industry (including medium and small-sized companies) and (ii) for educational training.



Installation of the CAPS system through the roof of the C2P building in France.

The creation of C2P was supported by the French Government, French Ministry of Defense (through its Research and Technology Agency (DRET)), "Ile-de-France" region, and E.D.F. ("Electricite de France"). In addition, for operating (from June 1995), the C2P will also benefit from the support of a "Club" of various industrial partners.

Advanced equipment is available close to Paris at Evry and Bruyeres le Chatel. Spraying capabilities in Evry are Controlled Atmosphere Plasma Spray; including Air Plasma Spraying (APS), Inert Gas Plasma Spraying (IPS), Vacuum Plasma Spray (VPS), Reactive Plasma Spray (RPS), and High Pressure Plasma Spray (HPPS) equipped with additional cryogenic cooling (i.e., the ATC system patented by C.E. A.), and a 6-axis robot in an 18 m^3 chamber.

Spraying capabilities in Bruyeres le Chatel include APS, VPS, IPS and ATC (3 chambers up to 35 m^3 in volume) with a robot and 5 laboratory-scaled chambers for R&D. Also available are 2 Inductively-Coupled Plasma (ICP) processing installations (the only ones in Europe) for spraying, synthesis and treating of powders.

The main topics for work to be carried out at C2P are :

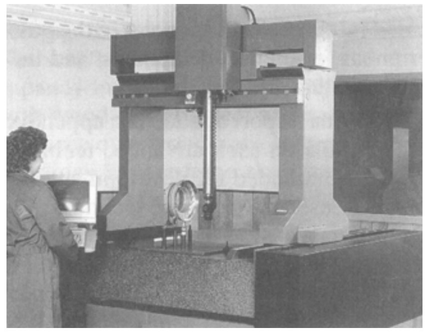
- Development of new processes such as spraying under high pressure, spraying combined with thermomechanical processing, inductively-coupled plasma spraying etc..
- Development of advanced sprayed materials such as coated organic materials, metal-matrix composites etc.
- Morphological analysis of sprayed surfaces.
- Wear behavior of sprayed coatings.
- Modeling of physical and thermomechanical properties.

Contact: Dr. Michel Jeandin, Center for Plasma Processing (C2P), Ecole des Mines de Paris / Centre des Materiaux P.M. Fourt, BP87, 91003 Evry Cedex, FRANCE. Tel.: (33) 1-60 76 30 33, Fax : (33) 1-60 76 31 50, e-mail: jeandin@mat.ensmp.fr

Turbine Overhaul Facility Enhances QA Program

A Brown & Sharpe Coordinate Measuring Machine (CMM) has been installed at Wall Colmonoys turbine engine overhaul facility in San Antonio, Texas. The new CMM will enhance Wall Colmonoys quality assurance program by allowing for completely programmable precision measurement of dimensions, diameters and true positions within turbine components. The system has an X-Y-Z measuring range up to 36 inches.

Wall Colmonoy overhauls hot section turbine components from Pratt & Whitney PT6, PW100, JT15D, and PW901 series; Allison 250; and Garrett TPE331 and TFE series engines. Wall Colmonoy also provides turbine overhaul services



WCC-1010: New CMM at Wall Colmonoy runs through a program for final inspection of a PT6A-50 series stator.

for land and marine use; contract furnace brazing and heat treating; and specialized prototype and OEM development.

For more information, contact John Kasavich, Wall Colmonoy Corporation, San Antonio, Texas. Tel: (210) 924-5061, Fax: (210) 924-0129.

Unique Process Improves Mold-Making Technology

A major improvement in mold-making technology that can reduce cycle time and improve product quality has been developed as part of an agreement between Metallamics, Inc., a Michigan company, and the Oak Ridge Centers for Manufacturing Technology (ORCMT) at the Department of Energy's (DOE's) Oak Ridge Y-12 Plant.

The technique reduces the cycle time - the time it takes to make a mold or to make the part - by as much as 25 percent and reduces the manufacturing costs by as much as 50 percent. "These improvements would apply to all blow mold, foam mold and some sheet molding applications," according to Dr. William Jones, engineering director for Metallamics, where the technology is being prototyped under contract to a major producer of injection molded automotive seating, plastic bottles, bath tubs, truck boxes and a wide range of other molded products.

For best quality and efficiency, molds need to be maintained at a constant temperature and achieve even heat distribution. The new manufacturing technique uses a variety of thermal plasma techniques to coat the surface of specially designed molds with a layer of specific metals. This improves the heat transfer efficiency of the mold, thereby reducing temperature variation in the mold, which improves both molded product economy and quality.

Current mold technology does not permit uniform temperature or heat transfer. These variations cause less than optimum cycle time and finished product quality flaws caused by variations in heat distribution from the mold have commonly shown up as flaws in finished products. There are hundreds of thousands of molds made in manufacturing each year. This new technology for mold manufacturing could modify the entire market. This term is tossed around quite a bit but we believe this technique will truly be a paradigm shift for mold making technology," Jones said.

Metallamics was one of the first small companies to enter into a user agreement with ORCMT. User facility agreements are reimbursable partnerships with provisions for subsidization for small business and educational partnerships. Today there are 28 user agreements, seven of those with small business, 16 with educational institutions and four with large businesses.

Martin Marietta Energy Systems, a Lockheed Martin company, manages the Oak Ridge Y-12 Plant, the Oak Ridge National Laboratory and the Oak Ridge K-25 Site for the DOE. Major technology transfer activities for the Oak Ridge Complex are carried out in the Centers for Manufacturing Technology. Contact Bill Wilburn of Y-12 Public Affairs for further information. Tel: (615) 241-4937.

Awards Announced from NACE and AWS

F. Peter Ford

The W.R. Whitney Award recognizes individuals who have made national or international contributions leading to a better understanding of corrosion science through education or work. It is named for the man who was the author of the pioneering paper on the electrochemical theory of corrosion. F. Peter Ford (General Electric Corp., Schenectady, New York) is the 1995 recipient of this award.

A NACE member since 1977, Ford's unique contribution is his quantified development of the slip dissolution mechanism of environment sensitive cracking and in a form that allows its application for predictive purposes to the solution of engineering problems. He has not only made an outstanding contribution to the underlying corrosion science of the environment sensitive cracking of metals, but has applied that knowledge to the solution of corrosion-related engineering problems in the electric power industry, although his work is applicable beyond the confines of that industry. In more recent times, this mechanisms-based knowledge has been used for life-prediction of light-water reactor components and for laying the technical basis for life-extension decisions. His wider range interests relate to other material/environment interactions including, for instance, cladding for nuclear fuel, resolution of corrosion problems in chemical plants and the development of specialty coating for nuclear reactors and gas or steam turbines subject to environmental or thermal degradation, etc.

Alan V. Levy

The 1995 Plenary Lecture for the NACE 1995 annual meeting in Orlando was presented by Alan V. Levy, of Lawrence Berkeley Laboratory, University of California (Berkeley, California). His lecture was titled "Combined Erosion-Corrosion of Materials at Elevated Temperatures".

Levy received degrees in physical metallurgy from the University of California at Berkeley. He was materials engineer and manager in the aerospace industry supporting the development and production of ramjet engines and solid and liquid rockets for 20 years. Levy became a staff scientist and principal investigator at Lawrence Berkeley Laboratory (LBL) of the University of California in 1975, carrying out studies on the basic mechanisms of erosion and erosion-corrosion of materials for use in energy generation and conversion systems. He has recently retired.

AWS Foundation Awards 1994 - 1995 Graduate Fellowships

The AWS Foundation announced the six recipients of its 1994-1995 graduate fellowships. Students awarded the fellowships receive $20,000 toward the completion of their post-graduate work with a matching amount supplied by the applicable university. Students must also be pursuing a welding science or welding engineering program. The 1994-1995 recipients are:

Matthew Q. Johnson, attending the Colorado School of Mines, thesis: "Science and Engineering of Shielded Metal Arc Welding Consumables," received a Navy Joining Fellowship.

Scott A. Martin, attending Clarkston University, thesis: "Weldability of Materials in Microgravity Environment," received the Glenn J. Gibson Fellowship.

Heather E. Beardsley, attending University of Kentucky, thesis: "Three Dimensional Measurement of the Weld Pool Geometry for Adaptive Control of Weld Penetration in GTAW," received the Miller Electric Fellowship.

Thomas J. Lienert, attending The Ohio State University, thesis: "A Fundamental Study of the Joining of High-Temperature Discontinuously Reinforced Al-Fe-Si-A Alloys," received a Navy Joining Fellowship.

Guijin Jiao, attending Renssalaer Polytechnic Institute, thesis: "Development of a Graphite Fiber-Reinforced Copper-Alloy Composite Electrode for Resistance Spot Welding," received an AWS Fellowship.

Robert A. Santarossa, attending the University of Alberta, thesis: "The Mechanism and Mitigation of Ductility-Dip Cracking," received an AWS Fellowship.

AWS Named Fellowships are sponsored or endowed by organizations or individuals who wish to support the cause of welding research. Although all AWS Fellowship candidates are chosen by the AWS Research and Development Committee with the cooperation of the Welding Research Council (WRC), the sponsoring party is offered a list of those selected from which they can choose the student to receive their Named Fellowship. Contact the AWS Tel: (800) 443-9353; Fax: (305) 443-7559 for further information.

News from NASA

More About Plasma-Spraying Ceramics onto Smooth Metals

A short paper presents additional information on the fabrication process described in "Plasma-Spraying Ceramics Onto Smooth Metallic Substrates" (LEW-15164), NASA Tech Briefs, Vol. 17, No. 4 (April 1993), page 56. To recapitulate, the process involves optional preoxidation of the substrate surface followed by low pressure plasma spraying of a thin layer of a thermal barrier ceramic (zirconia/yttria) onto the substrate, followed by atmospheric pressure plasma spraying of a second layer of the ceramic onto the first layer. The new paper provides additional information on specific substrate materials that could be advantageously coated in the two-stage plasma spraying process. The paper describes an application of the process to coating specimen substrates of NiAl + 0.1 at.% Zr. Specimen substrates coated in this process survived as many as 294 thermal cycles between ambient temperature and 1200 °C in a burner rig.

This work was done by Robert A. Miller and Joseph Doychak of Lewis Research Center. This invention has been patented by NASA (US Patent No. 5,302,465). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Lewis Research Center. Contact Walter Kim, Tel: (216) 433-3742, E-mail: wskim@lims01.lerc.nasa.gov Refer to LEW-15535.

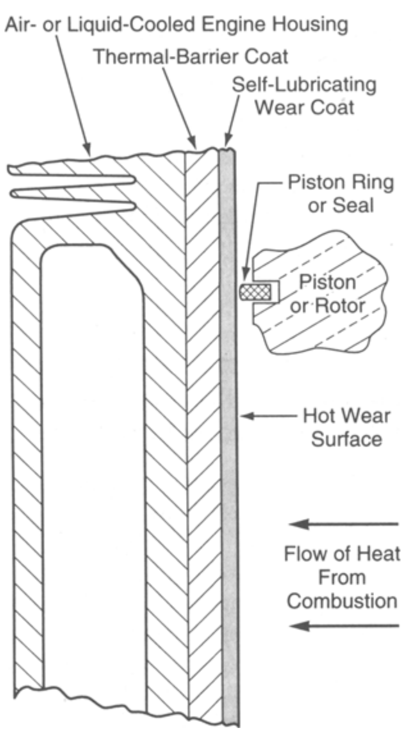
Reprinted with permission from *NASA Tech Briefs*, 19[4], April 1995, p. 84.

Combination Thermal Barrier and Wear Coating for Engines

Thermal barrier layers coated with wear-resistant self-lubricating surface layers are being developed for use as liners subject to sliding contact in advanced high-temperature engines (see figure). The thermal barrier layers are needed to reduce cooling loads and enable operation at the high temperatures that are needed for high efficiency. For example, the power densities of air-cooled rotary engines are limited by the ability to maintain acceptable temperatures in their housings, which are typically made of aluminum. The wear-resistant, self-lubricating surface layers are needed because thermal barrier materials are not sufficiently resistant to wear in sliding contact, and oil-based lubricants cannot survive the high temperatures.

In the development efforts undertaken thus far, zirconia has been shown to be effective as a thermal barrier material, but it resists wear very poorly. The resistance to wear can be increased greatly by coating zirconia with PS-200, a self-lubricating material developed by NASA for use in turbine bearings and Stirling engines, where traditional lubrication with oils and greases is impossible. PS-200 consists of 80 percent silicon carbide [430 NS (Sulzer Metco Powder), or equivalent] 10 percent silver, and 10 percent calcium fluoride/barium fluoride eutectic. The silicon carbides serves as a hard matrix. The silver is soft and compliant and provides low friction. The eutectic mixture provides lubricity at high temperature.

Both the zirconia and the PS-200 coatings can be applied by plasma arc spraying to substrates made of conventional engine materials like aluminum and iron. They adhere well to the substrates and to each other. Other combinations of thermal barrier and self-lubricating, wear-resistant coating materials could be used as long as the two materials adhere to each other, can be applied by use of similar or compatible processes, have similar coefficients of thermal expansion, are sufficiently strong at high temperatures [generally, 600 °F (about 320 °C)], and are affordable.



A zirconia thermal barrier coat is applied to the surface of a combustion chamber in an engine by plasma arc spraying. Then the PS-200 self-lubricating coat is plasma-arc sprayed onto the zirconia. The self-lubricating coat prevents sliding contact between the thermal barrier and the piston ring, effectively preventing both wear and the production of additional heat via friction.

This work was done by Mark Weingart and Paul Moller International for Lewis Research Center. For further information contact Walter Kim, Tel: (216) 433-3742, e-mail: wskim@lims01.lerc.nasa.gov. Refer to LEW-15356.

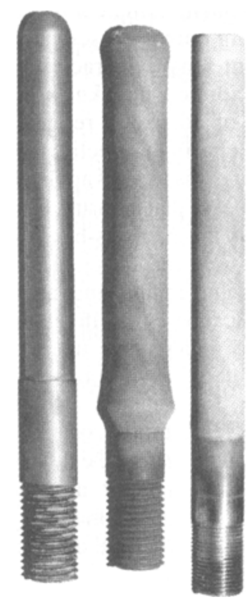
Reprinted with permission from *NASA Tech Briefs*, 19[5], May 1995, p. 62.

Removable Mandrels for Vacuum-Plasma-Spray Forming

Improved mandrels have been developed for use in vacuum-plasma-spray (VPS) forming of refractory metal and ceramic furnace catridge tubes. The mandrels are designed so that after the tubes have been formed on them by VPS, the mandrels shrink away from the tubes upon cooling back to room temperature.

To maximize shrinkage, a madrel of this type is made of a material that has a coefficient of thermal expansion (CTE) significantly greater than the CTE of the material to be deposited on it. On cooling, the mandrel shrinks more than does the deposited tube, so that the mandrel can simply be slipped out of the tube.

Typically, a mandrel of this type is made of stainless steel or high-CTE graphite. In addition to shrinking more than the deposited materials do, these mandrel materials can withstand the harsh, high-temperature vacuum plasma environment. The outer surface of a mandrel is machined to the desired shape of the inner surface of the tube to be formed on it, and preferably with a slight taper to facilitate removal after deposition. The tube to be formed could have a closed end with a shape (e.g., a hemispherical or flat end) that is easily machined onto the narrower end of the mandrel (see figure). Such features as a flange can also be machined onto the mandrel at its wider end.



Refractory material tubes of various shapes are formed by VPS on mandrels that have the desired shape. The mandrels are designed for ease of separation from the tubes upon cool down after the VPS process.

This work was done by Phillip D. Krotz, William M. Davis, Christopher A. Power, William H. Woodford, Douglas M. Todd, Yoon K. Liaw, Richard R. Holmes, Frank R. Zimmerman, and Timothy N. McKechnie of Rockwell International Corp. for Marshall Space Flight Center. For further information contact Harry Craft, Tel: (800) USA-NASA, e-mail: harry.craft@msfc.nasa.gov. Refer to MFS-30005.

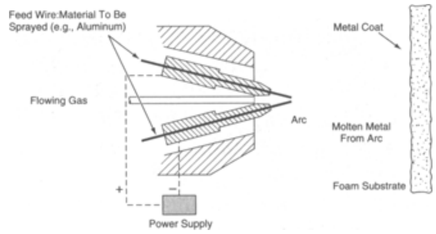
Reprinted with permission from *NASA Tech Briefs*, 19[5], May 1995, p. 82.

Wire-Arc Spraying of Metal Onto Insulating Foam

Wire-arc spraying can now be used to deposit protective metallic coats on thermally insulating foams. Heretofore, it has been common practice to deposit such coats by electroplating. Wire-arc spraying costs less than electroplating does. Wire-arc spraying is also faster and, unlike electroplating, does not involve toxic and polluting chemicals. Moreover, unlike other thermal spray metal-deposition processes, wire-arc spraying does not degrade of burn the foam.

Metal coats on insulating foams provide several benefits: they protect the foams against damage during handling and provide reflectivity that may be needed for optical and/or thermal-radiation purposes. On foams used to insulate cryogenic hardware, metallic coats help to prevent undesired cryo pumping by sealing the foams against leakage of air from the environment to the cold surface of the hardware.

Traditionally, wire-arc spraying has been used to deposit corrosion-inhibiting zinc coats on metal structures and aluminum coats on computer components to suppress electromagnetic interference. Recent advancements in wire-arc spraying have made it possible to use this process to deposit metal on foam without harming the foam. The figure illustrates the basic concept of wire-arc spraying. An electric arc is drawn between the tips of two wires of the metal to be deposited, melting the wires. A high-pressure flow of gas (for example, argon, a mixture of argon and hydrogen, or air) accelerates the molten



The arc melts the tips of the wires and the flow of gas sweeps the molten metal toward the substrate.

metal toward the foam or other substrate to be coated.

During wire-arc spraying, the sprayed surface of the foam or other substrate is exposed to temperatures in the range of about 100 to 300 °F (about 38 to 149 °C). Other thermal spray processes produce greater temperatures, which would degrade insulating foam. In one case in which the density of the foam was so low that wire-arc-sprayed metal particles impinging at high speeds penetrated the surface of the foam, a hard epoxy surface coat was used to stop the penetration.

This work was done by James W. Bonds, Jr., Ronald L. Daniel, Jr., Phillip D. Krotz, Timothy N. McKechnie, and Heather L. Sanders of Rockwell International Corp. for Marshall Space Flight Center. For further information contact Harry Craft, Tel: (800) USA-NASA, E-mail: harry.craft@msfc.nasa.gov Refer to MFS-30013.

Reprinted with permission from *NASA Tech Briefs*, 19[5], May 1995, p. 84.

Thermal Spray for Infractructure

NCSU Tests Robotic Blasting System

Introduction

A working prototype of a robotic blasting system may help the industry develop commercial robotic systems for removing lead-based paint on bridges. North Carolina State University (NCSU) developed the prototype to eliminate worker exposure to lead on bridge maintenance jobs. The Federal Highway Administration (FHWA) funded the project in August 1993, says Dr. Leonhard Bernold, associate professor of civil engineering and director of the project. The same month, Bernold's team began to construct a robotic system that could be tested in the field. The North Carolina Department of Transportation (NC DOT) became a strong partner in this effort.

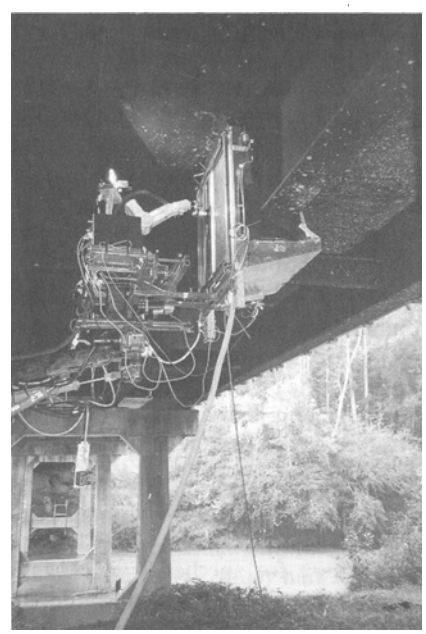
Initial Research and Testing

Bernold explains that the robotic system is based on the modification of a peeper crane, which typically inspects structural steel under bridge decks. A truck positioned on a bridge deck operates the crane arm. A bucket at the end of the crane arm provides access to the underside of the bridge. Bernold and his team modified this configuration, replacing the third boom element with a robotic arm on an actuated platform, 2 movable tables, a camera, sonar sensors, and an inflatable enclosure to contain dust and debris.

Video-equipped robotic platform moves toward corroded area during field test (Photos courtesty of North Carolina State University)

When the system is set up for operation, the crane arm is lowered and positioned under the bridge using the remote camera together with the sonar distance sensors to locate and orient the robotic arm and its movable enclosure. It can bend itself automatically, says Bernold, so that it can adjust its distance and orientation relative to a beam. When the arm and tip reach the desired position, a containment chamber encloses a designated area using inflatables that seal off the work area to prevent dust emissions. A vacuum system is located either on the truck bearing the system or on another truck and is attached to the containment chamber by hoses. The endifactor on the arm performs blasting. According to Bernold, any type of abrasive can be used.

In June 1994, Bernold held a field test of the robotic system on a bridge in Raleigh, NC, attended by repre-



Robotic attachment and containment chamber ready to spot clean

sentatives of the NC DOT, the FHWA, and equipment manufacturers. The robotic system was set up to blast a beam on the bridge using silica sand. The bridge is coated with a red lead primer / epoxy top coat system, says Bill Medford, chemical testing engineer with NC DOT. The coating was deteriorated, says Medford, and the epoxy top coat was delaminating.

During the first prototype's demonstration, the system blasted an area 5 in.

(125 mm) in diameter, says Bernold. Further blasting would have been performed; however, the demonstration was hampered by rain. Bernold judges the project to have been successful because the blasting system removed the existing coatings from the steel. He adds that no particular degree of cleanliness was specified - the basis of the project was to determine if the machine would simply operate as designed.

Bernold states, however, that not all aspects of the test went smoothly. For example, the night before the test, the computer that controls the arm of the system malfunctioned. As a result, the joystick that would normally be used to position the arm was inoperable, and the team had to use a backup switch control instead.

Bernold also notes that air-borne dust escaped the inflatable containment during blasting. The vacuum used to pull air out of the containment did not create an adequate suction because it was connected to the same compressor used to supply blasting air, explains Bernold. Medford noted that the DOT provided an air sampling pump for the demonstration. Because the demonstration was cut short, however, the pump did not operate long enough to generate meaningful data on air-borne lead dust, he states.

According to Medford, the inflatable containment and robotic blasting arm are important developments. He believes that the problem of unbalanced air in the vacuum recovery system can be corrected as the system is refined.

Further Research Promises Advances

The initial success of the research project has led North Carolina DOT to fund the program for another 3 years, says Bernold, permitting research on developing the capability of the arm to change tools, automating the arm completely, and using the system to prepare more complex steel configurations, such as cross bracing and bearings.

Bernold expects to enhance the capabilities of the robotic system to include water washing and even painting. The key to these developments is redesigning the robotic arm and an endifactor capable of changing tools during operation.

Another possible aspect of research is the calibration of the robotic system to achieve specific surface cleanliness and production rates, adds Bernold.

This article originally appeared in the *Journal of Protective Coatings & Linings* (JPCL) under the title "NCSU Tests Robotic Blasting System", December 1994, pp. 41-43, and is reprinted here with permission of the publisher, Technology Publishing Co., Pittsburgh, PA. The photographs were provided by the courtesy of Catherine Carver, North Carolina State University, Department of Civil Engineering.

Metallized Sliding Gates Rust-Free Since 1986

Eighty-five thermal-sprayed and top coated sliding gates at the Decatur Sanitary District's wastewater treatment facility in Decatur, IL, have provided uninterrupted service since their installation in 1986, says Charles Williams, operations manager at the facility. The metallized carbon steel structures replaced aluminum sliding gates as part of a federally funded project to upgrade the wastewater treatment plant. Because of the build-up of corrosion by-products on the aluminum gates, some were difficult to move, and others could not be moved at all, says Williams.

When the facility began the first phase of its maintenance overhaul, the contractor was given the choice of using either stainless steel or thermal-sprayed and top coated gates, says Williams. The contractor chose the latter because, says Williams, the thermal-sprayed and top coated gates were a more economical choice.

After fabrication, the new gates were abrasive blasted to a Near White (SSPC-SP 10) finish and thermal sprayed with zinc to a thickness of 4 to 6 mils (100 to 150 microns), says Dave Niblett, product manager for the gate manufacturer. Seal areas on the metal frame were then masked, and the metallized gates were top coated with epoxy to a 14-mil (350-micron) dry film thickness. The seals ensure a tight closure when the gate is in use. Niblett explains that if the top coat is chipped, the system provides sacrificial cathodic protection to the carbon steel by the zinc.

The thermal-sprayed and epoxy-top coated gates are in service in both the primary system and the activated sludge section of the wastewater treatment plant. The harsh service environment in the primary system includes exposure to raw sewage, hydrogen sulfide, and other chemicals, says Williams. The activated sludge section offers exposure to a mixture of chemicals, but, says Williams, the environment is fairly pH neutral.

Annual visual inspections during tank shut downs have revealed that the gates are corrosion free, says Williams. In fact, he states, the performance of the gates is comparable to that of stainless steel gates installed in the last phase of the maintenance overhaul in 1987. The carbon steel gates have required no maintenance to date, says Williams, and he expects that they will continue to provide service for at least another 10 years, in accordance with the manufacturer's product warranty. If other gates require replacement in the future, the thermal-sprayed epoxy-top coated gates will be among the maintenance options considered, states Williams.

The thermal-sprayed gates were manufactured by Ashbrook Corporation (Houston, TX).

This article originally appeared in the *Journal of Protective Coatings & Linings* (JPCL) under the title "Metallized Sliding Gates Rust-Free Since 1986," December 1994, pp. 44-45, and is reprinted here with permission of the publisher, Technology Publishing Co., Pittsburgh, PA.

CALTRANS Tests Powder Coatings in Field

by Andrew Rogerson
State of California
Department of Transportation

Introduction

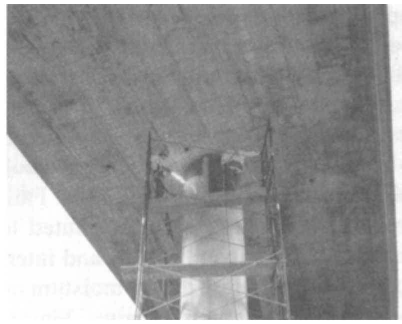
Proper application and curing of a protective coating for structural steel are critical to the coating's performance. Water-borne coatings mandated by air pollution control regulations have more restricted application and curing conditions than the solvent-borne coatings they replaced. Standard specifications for the State of California Department of Transportation (CALTRANS) contain minimum requirements for environmental conditions so that proper curing can occur. When conditions do not conform to these requirements, it is unlikely that a coating will perform as intended. Unfortunately, in many California locations, proper curing conditions rarely occur long enough to obtain optimum performance of applied coatings.

The northern California coast is one of these areas. A contract to clean and paint the Eureka Slough Bridge in 1983 exemplifies the problems with application of protective coatings in the region. There were 89 possible working days between June 7 and October 13, 1983. Weather conditions were acceptable for paint application on only 32 of those days. Work done on several days was lost and had to be redone because the contract required that the succeeding coat of paint be applied within 72 hours of the previous coat. There was an average of 2.1 consecutive workable days with an average of 3.7 days of inclement weather in between. The lowest bidding contractor, which was from southern California, was not familiar with north coast weather patterns. The high cost of maintaining an idle paint crew ultimately led to the contractor's default in 1984. A new contract was awarded in 1985 to a local painting contractor that completed the project. The firm kept its crew busy with other work on days CALTRANS would not permit painting.

Painting conditions that consistently conform to the minimum acceptable limits compromise the ultimate performance of conventional coating systems that rely on solvent evaporation or coalescence to form a protective film. Coating systems applied under marginal application conditions have a documented history of early failure.

In 1991, information was presented to CALTRANS and other groups on new, 100 percent solids plastic coating and flame spray application techniques for protecting steel. An article gave results of studies conducted using ethylene acrylic acid and ethylene methacrylic acid co-polymer-based thermoplastic powder coatings applied through spray equipment utilizing propane fuel and air.

Application of a protective coating using this type of equipment could eliminate problems associated with the curing of a protective film through solvent evaporation or film coalescence. Two companies manufacture the respective co-polymers that are then compounded into coatings by various manufacturers. Co-polymerization of the acid moiety with ethylene yields a polymer that can provide exceptional adhesion to metal along with the barrier properties associated with polyethylene.



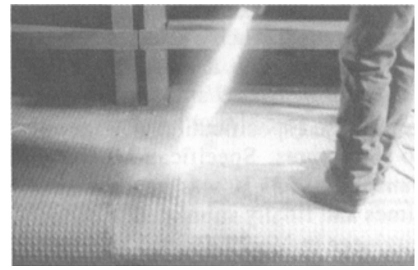
Application of powder coatings (Photos courtesy of Plastic Flamecoat® Systems and CALTRANS)

Steel and aluminum panels coated with these polymers were submitted to the Chemistry Branch of CALTRANS for evaluation. Accelerated weathering tests conducted on the panels showed that the coatings had outstanding resistance to corrosion. A project was initiated to evaluate the feasibility of using a flame sprayed thermoplastic coating under adverse conditions found along the north coast of California.

Trial Application

The Noyo Harbor Bridge in Fort Bragg was selected as a suitable location for testing the flame sprayed plastic. The environment is constantly cold and wet, and optimum conditions for painting rarely occur. Pedestrian and vehicle traffic limit access to the area. Structures Maintenance had previously requested assistance in selecting a coating system that could be used on the steel sidewalk to minimize the impact on its use. Both suppliers of the powder coating were contacted to determine if they would provide demonstration applications at the bridge. Company A provided a listing of 5 applicators of the ethylene acrylic acid co-polymer. One was located in San Diego. This California company was contacted and agreed to provide a demonstration; however, it failed to confirm the scheduled application date. Company B had an applicator of its product contact the laboratory. This applicator agreed to provide materials and spray equipment necessary to coat a section of the steel sidewalk.

District 04 provided an air compressor and crew to abrasive blast a portion of the sidewalk, and District 01 provided a crew for lane control. For minimal impact on local traffic, the test application was scheduled for 4:00 a.m. on October 28, 1992. An electrical problem with the compressor delayed the start of abrasive blasting until 5:10 a.m. One section of



Flame spray application of powder coating to metal sidewalk (Courtesy of CALTRANS)

the sidewalk surface, approximately 3 m (10 ft) long, was prepared to between an SSPC-SP 6, Commercial Blast, and an SSPC-SP 7, Brush-Off Blast condition. Small amounts of tightly adhering vinyl paint remained on the steel. The crew finished abrasive blasting at 6:00 a.m.

The steel temperature was 12 C (54 F), and the relative humidity was 80 percent, when abrasive blasting was completed. It was necessary to preheat the steel to 77 C (171 F) before applying the plastic so that good adhesion and flow of the applied plastic could be obtained. The same propane-fueled spray gun used to apply the plastic was used as a blowtorch to preheat the steel by bathing it with a propane flame. Preheating caused the vinyl paint to char and burn where it had not been completely removed by abrasive blasting and charred the vinyl paint on adjacent sections of sidewalk. Preheating the steel took longer than actual application of the plastic.

The sidewalk had a rough, diamond-plate texture, but to minimize the potential for pedestrians to slip, the contractor added abrasive grit to the semi-molten plastic after an initial film thickness of at least 300 m (12 mils) had been applied. A thin coat of additional plastic was sprayed over the grit. Application of plastic was completed by 7:00 a.m. when the sidewalk was reopened to pedestrian traffic. Total film thickness of the plastic, measured according to SSPC-PA 2 with a fixed probe gage, ranged from 500 to 850 m (20 to 34 mils), more than twice the 200-m (8-mil) minimum film thickness required. The high total film thickness was probably caused by inclusion of abrasive grit in the film.

Results

The sidewalk section was examined in June and again in September 1993. Grit retention was excellent, and there was no visible wear or corrosion. Adhesion was excellent when evaluated by scraping the film with a knife blade at the edges of the coated area.

A proposed specification was submitted to Structures Specifications in mid-January 1993. It was revised several times and finally submitted to the office engineer in March 1993. The first full-scale implementation occurred as a contract change order in District 1, which began November 17, 1993. This was an earthquake column retrofit project on the Klamath River Overflow Bridge, No. 1-32, 01-DN-101-R3.8. The contract originally required a coating system consisting of an inorganic zinc-rich primer on all surfaces, latex finish paint on exterior surfaces, and membrane waterproofing on surfaces below grade. The contract change order eliminated primer and finish paints on exterior surfaces and membrane waterproofing below grade. The change required application of flame-sprayed plastic to a minimum 200-m (8-mil) thickness on all exterior surfaces of the steel column casings and adhesion and pinhole tests to insure that the plastic had been properly applied. This change resulted in an 11.5 percent increase in the item cost. However, the permit to work in the river channel was about to expire, and the weather prevented application of the originally specified system. The contract would have had to be suspended and new permits obtained from the California Department of Fish and Game and Federal Bureau of Reclamation if flame-sprayed plastic had not been used.

Steel temperature prior to application ranged from 4 to 7 C (39 to 45 F). Relative humidity ranged from 85 percent to 100 percent. Light to moderate rainfall occurred during application of some of the plastic; however, the bridge deck prevented rain from impinging on the freshly applied plastic. Adhesion tests conducted in accordance with ASTM D 4541 yielded an average adhesion strength greater than 14 MPa (2,030 psi). A minimum of 7 MPa (1,015 psi) was required.

Discussion

Although the CALTRANS field applications have been limited to the ethylene methacrylic acid-based plastic, the chemical properties, of ethylene acrylic acid-based plastic are similar. The ethylene portion of the polymer contributes inertness and barrier properties, while the acid portion serves to promote adhesion. The resultant film functions as a barrier to the environment similar to the barrier resulting from application of a seven-coat solvent-borne vinyl paint system that was successfully used along the California coast in the 1970s. Failures of vinyl paints were attributed to unsatisfactory solvent blends and intercoat adhesion failure due to moisture on the previously applied paint. Flame-sprayed plastic contains no solvent, and the high temperature required for application prevents moisture from condensing on the film. The applied plastic is cured as soon as the surface has cooled and can easily be repaired. Any overspray quickly cools and will not adhere to surfaces that have not been properly preheated. Overspray on the roadway surface adjacent to the sidewalk at Noyo Harbor could be swept and collected. The plastic is not considered a hazardous material.

The specification that has been developed requires the application contractor to perform specific tests on the applied film to insure it provides effective barrier protection and that thermal spray conditions did not degrade the plastic. It has been shown that excessive thermal degradation will cause decreased adhesion.

Conclusion

Field evaluation of flame-sprayed plastic has shown that it can be applied under conditions that would not permit application of more conventional coatings. Successful performance after 1 year at Noyo Harbor and accelerated test results indicate that long-term performance should be acceptable. It will be necessary to continue to monitor performance of applied flame-sprayed plastic so that a better assessment of its long-term durability can be made.

This article originally appeared in the *Journal of Protective Coatings & Linings* (JPCL) under the title "CALTRANS Tests Powder Coatings in Field", August 1994, pp. 25-32, and is reprinted here with permission of the publisher, Technology Publishing Co., Pittsburgh, PA. (Note that the original article also contained 5 photographs courtesy of CALTRANS and Plastic Flamecoat® Systems.)

The Seattle Aquarium Uses Zinc Thermal Spray

The Seattle Aquarium opened its doors to the public in 1977. Its construction is of reinforced concrete set above Puget Sound on prestressed concrete piles. Most of the large exhibit tanks are fabricated reinforced concrete as well.

One of the features of the Aquarium is that it houses the only salt water fish ladder in the US. The ladder consists of a series of pools which enable salmon to travel "up steam" to spawn. The water flow rate in these ladders range from 600 to 1000 gallons per minute. This rapid, continual water flow coupled with the close location of the Aquarium itself to salt water has lead to severe corrosion of some of the reinforcement structures within the Aquarium.

The City of Seattle Department of Parks and Recreation retained the firms of Tinnea & Associates, of Seattle WA together with Corrosion Control Specialists (CCS), Kent, WA to develop plans and specifications necessary to rehabilitate portions of the Aquarium including the ladders.

Environmental, animal safety and sensitivity considerations were issues the design team gave top priority. Zinc thermal spraying was chosen primarily because the coating is dry on contact and requires no curing time. This benefit allows the tanks to be returned to service in a timely manner and the aquarium could be open continuously to visitors. There were questions as to the affect the cathodic protection electrical current would have on the salmon's migration instinct. These concerns turned out to be unnecessary because in 1994, over 400 salmon swam up the fish ladder to spawn.

Great Western Coatings Inc. of Vancouver, WA sprayed the fish ladders with zinc and then top coated with a potable water grade epoxy polyamide coating. The top coat provided extra corrosion protection and extended the life of the cathodic protection system.

Other areas slated for repair were the stainless steel viewing window frames on an otter tank and a seal tank. After the animals were transferred to other tanks, the areas were drained and sprayed with Plattzinc 85/15 zinc aluminum. The 85/15 zinc aluminum alloy withstands salt water immersion and continues to protect the steel galvanically for years. Another area for repair was damaged and cracked concrete in one of the tanks. An epoxy resin was used to fill in the cracks, plates were fastened to connect the rebar to the surface concrete and then the entire area was sprayed with 20 mils of pure zinc for galvanic cathodic protection. This application is also called a passive system. Thermion Arc equipment was used on this project. After two years of operation, all of the thermal sprayed areas are performing well.

Reprinted with permission from "Metallinze: The Corrosion Bulletin," 11(1), Feb. 1995; available from The Platt Bros. & Co., Box 1030, Waterbury, CT 06721, Tel: (203) 753-4194. Mr. Jack Tinnea of Tinnea & Associates, 976-20th Ave., Seattle, WA Tel: (206) 328-7872, contributed to this case history.