In The News

New Literature

10th International Symposium on Ceramics in Medicine

Edited by L. Sedel and C. Rey, Oct 1997, ISBN: 0-08-0426921-1. NLG 468.00/US $289.00.

The International Symposium on Ceramics in Medicine provides a unique forum for clinicians, academics, engineers, and researchers to exchange their knowledge and experience, and now access to these wide-ranging proceedings of the latest Symposium is available with *Bioceramics 10.* Bioceramics in medicine has become one of the most important fields of biomaterials. The clinical applications of bioceramics are numerous, particularly in areas such as orthopedic surgery, dentistry, and plastic surgery, but also E.N.T., percutaneous devices, and embolization materials. In addition to the many clinical applications, *Bioceramics 10* deals with a range of fundamental subjects in depth. *Bioceramics 10* contains 140 papers, many high-quality photographs, and both author and keyword indexes for fast access. This book is an essential reference tool for anyone interested in the use of ceramics in medicine.

Contact: Elsevier Science, P.O. Box 882, New York, NY 10159-0882; tel: 212/633-3730; toll free in the U.S. and Canada: 1-888-437-4636; fax: 212/633-3680; e-mail: usinfo-f@elsevier.com. For customers in other locations contact: Elsevier Science, Direct Marketing Department, P.O. Box 880, 1000 AW Amsterdam, The Netherlands; tel: 31-20-485-3757; fax: 31-20-485-3432; e-mail: nlinfo-f@elsevier.nl.

The CRC Practical Handbook of Materials Selection

Edited by James F. Shackelford, William Alexander, and Jun S. Park, Catalog No. 3709, 1995, $79.95. 640 pages. ISBN: 0-8493-3709-7.

The CRC Practical Handbook of Materials Selection uses an easy-to-follow organization based on materials properties and includes many data sets to compare materials by property value.

Contact: CRC Press, 2000 Corporate Blvd., N.W., Boca Raton, FL 33431-9868; tel: 561/994-0555; fax: 800/374-3401; e-mail: orders@crcpress.com.

COR·SUR and COR·SUR 2 for Windows

Item No. 38101 (COR·SUR), $230. Item No. 38102 (COR·SUR 2) $200. Item No. 38103 (Combination Package) $375.

Based on the well-known *Corrosion Data Survey* books (Metals and Nonmetals versions), COR·SUR and COR·SUR 2 allow evaluation of a material's performance in a specified corrosive environment by viewing data retrieved in the form of a table or graph.

Contact: NACE International, P.O. Box 218340, Houston, TX 77218-8340; tel: 713/492-0535; fax: 713/492-8254.

REFIN·COR 3.0 for Windows

Item No. 26106, $379. Upgrade (must own REFIN·COR) $189.

The new edition of REFIN·COR, a database of experiences, problems, and solutions encountered by refining industry corrosion engineers includes minutes of meetings of NACE Committee T-8 on Refining Industry Corrosion from 1957 through 1996. The CD-ROM provides easy access to the technical information exchange that takes place twice a year at the T-8 committee meetings—this is information that can't be found anywhere else.

Contact: NACE International, P.O. Box 218340, Houston, TX 77218-8340; tel: 713/492-0535; fax: 713/492-8254.

Profile Materials Information Service: Materials Databases II

There has been, in just a few years, an immense increase in the number of the metals, alloys, ceramics, polymers, and composites, which are described collectively as engineering materials. It is now impossible for materials scientists to be experts across the entire field, so they need help outside their own specialist area. Also, many companies, for economic or other reasons, do not employ their own materials specialists, tending to rely on accumulated experience, suppliers, or consultants for this expertise. For all of these people the range of materials is too big, and changing too rapidly, to fully comprehend without a constantly updated reference source. A database, or a range of databases, provide such sources.

Databases therefore should become an essential everyday tool for anyone responsible for the selection and specification of engineering materials. Readers will probably already appreciate that there a number of database types. This Profile explains how they can be used to provide information and aid decision making at every stage of material selection and specification in the design process.

The sister Profile, *Materials Databases I,* introduces the concept, history, and structure of databases, in particular those related to polymeric engineering materials.

Today, time scales in the design process are shorter and more intense than they have ever been. Many companies, who formerly produced and supplied components to a customer's drawings, now find themselves responsible for design, materials selection and specification, testing, costing, quality, and manufacture of subassemblies rather than components and in shorter times and possibly unfamiliar materials. They may, quite reasonably, lack the confidence or expertise to make the most technically sound and cost-effective selection of materials and process. This is an excellent reason for using databases.

Specific databases are available either on-line or in a form that can be loaded onto and accessed from a PC. Many are sufficiently large to be best stored on CD-ROM and loaded onto the PC only when in use.

Specific databases tend to be produced by organizations with strong technical and commercial involvement in particular fields. With the continuous growth in available information, they tend to be regularly updated and reissued. Where they are produced by an individual company or interest group they may well only include that organization's products. In such cases it may well be prudent to cross check for similar materials from other producers before finalizing the specification.

Some of these databases are essentially tables of properties with text, and are called "numerical generic." Reference to one of these will enable informed choices to be made, for example, as to the best grade of nylon, most suitable aluminum alloy, optimal surface treatment, or whatever for the application being examined.

Also, recognizing that the users are not necessarily expert in the materials concerned, databases are being developed that are very user-friendly, knowledge-based, or expert systems. Some PC-loadable databases are supplied free of charge, others have a small cost, while others are fully commercial products.

There is a second type of database that can be consulted at this stage known as "bibliographical." These are indexed, annotated abstracts of the published literature that can be searched using key words. These are very useful to discover what may have been tried in the past and either worked well or failed abysmally—no point in reinventing the wheel or repeating the same mistake.

Equally they are useful in checking for any potential problems that might arise from usual service conditions, for example, any tendency to stress-corrosion cracking in the alloy or what atmospheric or environmental contaminants induce stress cracking in a polymer.

Most of these are available on-line or on disk/CD-ROM for PC use and are usually commercial products as they require costly continuous updating by skilled monitoring of the literature and abstract writing.

Of course, in addition to the ready-made databases, individuals and companies develop their own systems either from scratch or by buying a system that allows the user to reconfigure and add to it. If a user follows this route, or employs a standard database that allows them to make their own entries, it is important that they record their failures and the causes as well as triumphs.

It is worth remembering that the Internet or World Wide Web is increasingly used by companies and organizations to promote themselves and their products. A number of databases are already available on the Internet and more will surely follow in due course.

Databases can be used in the ways described to facilitate the selection of the most technically sound and cost-effective materials for an application. They enable the designer to make the best informed decisions and to consider alternative methods and materials, but it must be emphasized "the designer makes the best informed decision."

Contact: For advice relating to particular materials problems, contact The Materials Information Service, The Institute of Materials, 1 Carlton House Terrace, London SW1Y 5DB; tel: 44-171-839-4071; fax: 44-171-839-5513; e-mail: mis@materials.org.uk.

Conference Proceedings of the World Aviation Gas Turbine Engine Overhaul and Repair '97

The conference proceedings of World Aviation Gas Turbine Engine Overhaul and Repair '97 are now available. Each set contains hard copies of all papers presented during the general sessions of the conference. In addition a list of all registered participants at the conference including address, company affiliation, telephone, and fax numbers is included with purchase. The proceedings contain data and analyses from more than 20 presentations including: General Electric's strategies for customer solutions in the 21st century, Pratt & Whitney Canada's development of repair processes, U.S. Airways' perspective on engine management, Rolls Royce Aero Engine's approach to joint ventures, Paine Webber's view of the financial outlook for the turbine aftermarket, the FAA's analysis of cumulative engine risk, and more.

Contact: Gorham Advanced Materials, Inc., P.O. Box 250, Gorham, ME 04038; tel: 207/892-5445; fax: 207/892-2210; e-mail: gorham@goradv.com.

Conference Information

50th Pacific Coast Regional and Basic Science Division Meeting of The American Ceramic Society

The symposia of Recent Advances in Processing and Characterization of Thermal Barrier Coatings is being held 21-24 October 1998 at the Hyatt Regency in Irvine, California.

Organizers: Mattison K. Ferber, Oak Ridge National Lab; tel: 615/576-0818; e-mail: ferbermk@ornl.gov; and Rajendra K. Bordia, University of Washington; tel: 206/685-8158, bordia@u.washington.edu.

The development of reliable thermal barrier coatings (TBCs) for industrial gas turbines has been identified as an effective approach for obtaining higher operating temperatures and thus higher turbine efficiencies. A number of TBC systems have been successfully applied to aircraft engine applicants with the expressed goal of life extension. Due to the conservative nature of operating conditions, coating failure in these applications can be tolerated without loss of function of the underlying metallic component. In the case of land-based gas turbines, the need for increased turbine inlet temperatures and the long operating lifetimes will necessitate highly reliable TBC systems. To realize this objective, issues related to process control of the coating deposition method, characterization of thermal and mechanical induced damaged, and life modeling must first be examined. Papers for this symposium are requested on, but not limited to, industrial overview and experience, process optimization for PVD and plasma sprayed coatings, novel processing methods, advanced characterization techniques, and modeling of thermal and physical behavior.

Contact: Program Chairs: Reinhold H. Dauskardt (Basic Science Division Co-Chair), Stanford University; tel: 650/725-0679; fax: 650/725-4034; e-mail: dauskardt@forsythe.stanford.edu; Martha L. Mecartney (PCRM Program Chair), University of California, Irvine; tel: 714/824-2919; fax: 714/824-2541; e-mail: martham@uci.edu; Gregory S. Rohrer (Basic Science Division Co-Chair), Carnegie Mellon University; tel: 412/268-2696; fax: 412/268-7596; e-mail: gr20@andrew.cmu.edu.

AUSTCERAM '98

AUSTCERAM '98, the 18th Biennial International Conference of the Australian Ceramics Society, will be hosted by the Victorian Branch of the Society, 28-30 Sept 1998 at Monash University, Australia's International University. The conference will be organized in collaboration with the Department of Materials Engineering at Monash University through the Department's National Key Centre for Advanced Materials Technology.

Following a series of successful, high-profile international AUSTCERAM conferences in recent years, the AUSTCERAM '98 conference will seek to preserve the international tradition while providing a major forum, principally for those in the Australasian region, for discussion of recent developments in industrial ceramics and craft-based ceramics, as well as research in engineering ceramics. Paper and poster presentations are strongly encouraged in the fields of both traditional and advanced ceramics.

AUSTCERAM '98 will utilize the facilities within the Faculty of Engineering at Monash University to permit a reduced registration fee and allow for the greatest possible participation, particularly by students. The University is located 30 min from the city center to the east of Melbourne. It affords a relaxed, attractive campus setting. Participants will be offered the choice of city-based hotel accommodation, a range of motel-style accommodations surrounding the Monash campus, or low-cost, serviced rooms and apartments at Monash Halls of Residence within easy walking distance of the conference venue.

Symposium topics of interest will include, but are not restricted to:

- Refractories
- Advanced technical ceramics and composites
- Cement and concrete
- Glass and glass-ceramics
- Industrial heavy clay
- Solid oxide fuel cells and electrical ceramics
- Traditional ceramics and whiteware
- Wear corrosion and erosion-resistant ceramics
- Ceramic processing and processing equipment
- Ceramic art
- Environmental and energy issues

Contact: AUSTCERAM '98, Centre for Advanced Materials Technology, Monash University, Clayton, Victoria 3168, Australia; tel: 61-3-9905-4941; fax: 61-3-9905-4998; e-mail: austceram98@eng.monash.edu.au; http://www.monash.edu.au/mateng/AUSTCERAM98.htm.

Bioceramics 11

Bioceramics 11, the 11th International Symposium on Ceramics in Medicine, will be held 6-8 Nov 1998 in New York City, New York, at the New York University College of Dentistry. It will also mark the first year of the establishment of the International Society for Ceramics in Medicine (ISCM).

The Scientific Sessions will focus on "Bioceramics: Present and Future" and will be attended by international researchers of multidisciplinary backgrounds (cellular and molecular biologists; materials scientists, physicists, chemists, and engineers; clinicians, physicians orthopedists, and dentists); manufacturers of bone-grit materials, implants; and researchers from the National Institute of Health.

Lead papers will be presented by respected scientists. Contributed papers and posters will be selected from submitted abstracts. Topics will include materials for bone repair and regeneration (alumina, bioglass, calcium phosphate materials, cements, ceramic/polymer composites, and coatings on dental and orthopedic implants), in vitro or in vivo material evaluation, growth factor carriers, tissue-engineered or biomimetics-based biomaterials, cells/materials interaction, bone/material interfaces, clinical applications (in orthopedics, dentistry, maxillofacial surgery, plastic surgery, ENT, and drug delivery), and biological events in bone healing.

To allow maximum participation, no parallel sessions are planned.

Contact: Bioceramics 11; fax: 212/995-4244.

"Planning, Production, & Productivity" WTIA 46th Annual Conference

Welding Technology Institute of Australia (WTIA), in conjunction with the CRC for Materials Welding & Joining and supported by numerous other organizations, will hold the WTIA 1998 Conference in Perth from 15-20 Nov 1998.

This year the Conference is designated for both delegates and their partners or families to see Perth and take a short break while in Western Australia. Airfare for local delegates will be reduced by at least 50% if they stay a Saturday night. Discounted airfares with QANTAS and discounted accommodation rates at various hotels have also been negotiated.

The actual conference, which runs from 16-18 Nov, will include the following:

- Monday, 16 Nov: Plenary Session "The Role of Welding in Resource Based Industries"
- Tuesday, 17 Nov: Four sessions: Developments in Fabrication, Construction, and Maintenance; Aluminum Fabrication and Shipbuilding Colloquium; Oil and Gas Colloquium; Mining & Mineral Processes Colloquium
- Wednesday 18 Nov: Plenary Session "The Way Ahead" and Industry Tours

Contact: Nicole Patterson or C. Smallbone, WTIA, Unit 3, Suite 2, 9 Parramatta Road, Lidcombe NSW 2141, Australia; tel: 61-(0)2-9748-4443; fax: 61-(0)2-9748-2858; e-mail: info@wtia.com.au; http://www.wtia.com.au.

High-Temperature Coatings III

1998 TMS Annual Meeting 28 Feb-4 March 1999, San Diego, CA. Sponsored by TMS Surface Modification and Coatings Technology Committee (SMACT) and Materials Design and Manufacturing Division (MDMD).

This symposium will focus on the processing and characterization of high-temperature coatings with regard to engineering, physical, and chemical properties. Established methods along with novel and innovative techniques of producing coatings and their applications in a variety of environments will be addressed. Symposium coverage encompasses thermal barrier coatings and associated oxidation-related areas. The symposium will bring together researchers, engineers, and technologists from industry, research laboratories, and academia who have specialized in different aspects of high-temperature coatings science and technology. Both invited and contributed papers will be included.

The key areas to be explored include:

- Thermal barrier coatings
- Oxidation-resistant coatings
- High-temperature ceramic coatings
- Ultrahard coatings
- High-temperature composite coatings
- High-temperature metallic coatings
- Tribological coatings
- Characterization techniques for coatings
- Coatings for optical applications
- Advances in coatings techniques
- Repair and removal of coatings
- High-temperature intermetallic coatings

Abstracts of approximately 150 to 200 words in length should be sent before 15 July 1998 to either of the organizers or submitted electronically (http://www.tms.org/). If more information is needed on the planned topics, please contact an organizer.

All invited and contributed papers at the symposium will be published in a bound proceedings volume. Camera-ready manuscript packets will be provided to the authors. Contributing authors should plan ahead to ensure that the first draft of their paper arrives in organizer's office by 15 Sept 1998 for review purposes. Camera-ready manuscripts must be submitted to organizer by 1 Nov 1998, for publication of concurrent proceedings.

Contact: Organizers: Dr. Janet Hampikian, School of Materials Science and Engineering, Georgia Institute of Technology, Atlanta, GA 30332-0245; tel: 404/894-2845; fax: 404/894-9140; e-mail: janet.hampikian@mse.gatechedu; Dr. Narendra B. Dahotre, Center for Applications, MS 24, University of Tennessee Space Institute, Tullahoma, TN 37388-8897; tel: 931/393-7495; fax: 931/454-2271; e-mail: ndahotre@sparc2000.utsi.edu.

News from the DVS

UTSC '99

The United Thermal Spray Conference '99 will be the second conference in the sector of thermal spraying jointly organized by ASM/TSS and the DVS. It will be accompanied by a company exposition. It will be the outstanding event in its specialty field anywhere in the world. Like its successful predecessor event in Indianapolis in 1997, UTSC '99 will present the latest status of application, research, and development in thermal spraying. The conference languages will be German and English with simultaneous interpreting.

The UTSC '99 will offer:

- Technical papers: Highly topical contributions from international specialists
- A technical and scientific poster show: Description of current research and development work
- Workshops: Exchange of experience and discussion of current problems
- Technical films and videos: Technical, economic, and scientific information
- An expert exchange: Free advice from specialists from companies and research facilities
- An interesting supporting program
- A company performance show featuring original products: Devices, equipment, materials, accessories, and services

The UTSC '99 will bring together specialists from industry and research. It will offer users and other interested parties an up-to-date overview of the state-of-the-art and of future development trends. It will give those people active in research and development the opportunity to describe and discuss the results of their work.

With the slogan "Coating in Practice," subject areas will include:

- Application technology and solutions to problems
- Pretreatment and posttreatment
- Equipment technology and process engineering
- Spraying consumables
- Quality inspection, quality assurance, and quality management
- Economic aspects
- Design
- Health and safety at work and environmental protection
- Training and qualification or personnel
- Plasma transferred arc surfacing (PTA)

UTSC '99 will thus be of great interest to all the specialists dealing with questions and problems relating to thermal coating, that is, for production engineers, research and development engineers, designers, welding engineers, and also for anyone else required to solve coating problems within the framework of their activities.

The UTSC '99 will take place in the Congress Centre South in Düsseldorf (CCD). Thanks to the spacious and modern facilities, it will be possible to hold the conference, poster show, and the company performance show in one central location.

Contact: Frau R. Bogdon, Frau B. Brommer, or Frau S. Mahlstedt, DVS, Aachener Strasse 172, D-40223 Düsseldorf, Germany; tel: 49-(0)211-1591-0; fax: 49-(0)-211-1591-200.

Advanced Thermal Spraying Short Course—held in conjunction with ITSC '98, Nice, France

22-24 May 1998

Course objectives:

- To understand thermal spray processing science, as well as applications and practice
- Learn how thermal spray processing interacts with the materials it is designed to protect
- Technoeconomic comparison of different technologies

Thermal spray coatings are receiving new attention as a method of solving corrosion, wear, and compatibility problems. Thermal spray processes of electric arc, combustion, and plasma spray coatings can apply almost any material to the surface of another. These coatings systems must be engineered and applied correctly to operate as an overlay surface. However, education is vital to understanding the coating systems and improving thermal spray coating reliability.

The course reviews the processing science for a wide range of thermal spray coating processes. The theory of operation and practice of the coatings will be presented including thermal spray control, coating application, characterization and testing. Practical coating systems for electric arc, flame, and plasma will be reviewed using case studies.

This course would be of interest to process, application, development, and design engineers, researchers, and quality control personnel. The course will also be helpful for anyone involved in specifying materials, material suppliers, sales representatives, and technical management.

The course will be held in a small town about 100 km from Nice. With Grand Prix de Monaco taking place, no rooms are available in the Nice area during this time. A bus will bring participants from Nice Airport on Friday, 22 May at 11 a.m. and bring attendees back to the conference on Sunday, 24 May.

Lecturers:

- Prof. M. Boulos, University of Sherbrooke, Quebec, Canada, has been involved for more than 25 years in rf spraying, plasma particle heat momentum, and mass transfer.
- Prof. P. Fauchais, University of Limoges, Limoges, France, has been involved in dc plasma and flame spraying, transferred arc reclamation, and coating optimization for given service properties for more than 30 years.
- Prof. J. Heberlein, University of Minnesota, Minneapolis, MN, has more than 15 years experience in dc plasma and arc spraying and spraying parameters optimization.

Overview of the course:

- Friday, 22 May: introduction, overview of thermal spraying techniques, flame spraying systems, thermal plasma properties
- Saturday, 23 May: dc plasma spraying, rf induction plasma spraying, wire arc spraying, plasma transferred arc reclamation, plasma particle interactions, process diagnostics, spraying powders
- Sunday, 24 May: surface preparation, deposit formation and coatings properties, thermal spray process control, industrial applications

Contact: Prof. P. Fauchais, ITSC '98, L.M.C.T.S.—U.E.R. des Sciences, Université de Limoges—Faculté des Sciences, 123, avenue Albert Thomas, 87060 Limoges Cedex, France; tel: 33-(0)5-55-45-7421; fax: 33-(0)5-55-45-7211; e-mail: fauchais@unilim.fr.

Nanostructured Ceramics

The Materials Science Summer Institute will offer "Intelligent Manufacturing of Nanostructured Ceramics" 20-29 Aug 1998 at Rutgers Continuing Education Conference Center, New Brunswick, NJ. This course explores the status of intelligent processing of ceramics, current use of diagnostics, and further needs for measurements and instrumentation in ceramic manufacture. The application deadline for participation/fellowship is 15 June 1998.

Contact: Lisa C. Klein, Rutgers University, Ceramic & Materials Engineering, 607 Taylor Road, Piscataway, NJ 08854-8065; tel: 732/445-2096; fax: 732/249-8890; e-mail: licklein@rci.rutgers.edu.

1998 Training Opportunities from the Society for Protective Coatings (SSPC)

Fundamentals of Protective Coatings

Instructors with real-world experience provide a practical overview of the issues and concerns affecting coatings operations today:

- Corrosion: Identify the types of corrosion and understand the components of a total corrosion control program including design, resistant metals, nonmetallics, inhibitors, altering the environment, cathodic protection, and coatings.
- Surface preparation and coatings application: Get the facts on preparing surfaces, selecting tools, and maintaining cleanliness to ensure abrasive blasting and coatings jobs are top rate. Learn the different procedures for coating both steel and concrete structures.
- Quality control: Quality and safety are planned components of a successful coatings project. Understand how the writing of solid specifications for a project and the role of the inspector can maximize quality.
- Total protective coatings program: Learn how to minimize risks by building into a project each of the components necessary for success.

This course is for those who sell coatings for an industrial coatings manufacturer, specify protective coatings projects, manage coatings projects, are contractors whose work includes industrial coatings jobs, or are working in the protective coatings industry and want to sharpen their knowledge of the basics.

Specifying and Managing Protective Coatings Projects

- Get the inside track on how to become efficient and cost effective when specifying and managing coatings projects.
- Achieve economical protection with coatings. Learn when coatings are the preferred material in construction and how performance data can assist in writing specifications.
- Come away with an overview of common strategies and understand how to

conduct facility condition surveys and analyses.

- The overall success of a job often hinges on the quality of the workmanship in the job's various components. Learn how to prequalify, manage, and inspect a contractor's work to ensure that specifications are met to your satisfaction.
- Learn to identify types of coatings failures, their causes, and how to repair coatings failures when they do occur. Be prepared to take on coatings failures with confident know-how.
- Understand which regulations are in place to protect workers and the environment, and learn what is expected of a project manager, to ensure compliance.

Contact: SSPC, 40 24th Street, 6th Floor, Pittsburgh, PA 15222-4656; tel: 412/281-2331; fax: 412/281-9993; e-mail: meetings@sspc.org; www.sspc.org.

Recent Conferences

Metallic Coatings Specialty Workshop

Manufacturing and Materials Issues with Aluminide and Platinum Aluminide Coatings for Advanced Gas Turbine Applications, 16-17 April 1997, Stevens Institute of Technology, Castle Point on Hudson, Hoboken, NJ. Sponsors: Advanced Gas Turbine Systems Research (AGTSR) Consortium, NASA Lewis Research Center, Oak Ridge National Laboratory.

The production of aluminide (NiAl) and platinum aluminide (NiPtAl) coatings is an integral part of manufacturing today's gas turbine components for aircraft-propulsion and power-generation systems. The success of these coatings in the gas turbine market is well manifested by the fact that a significant number of new hot-section turbine components currently undergo aluminizing and/or platinum-plating processing steps. Although aluminide coatings have served the gas turbine industry remarkably well in the past several decades, considerable processing and materials issues still exist and need to be resolved and better understood. The purpose of this workshop is to provide a special forum of engineers and scientists from original equipment manufacturers, coating suppliers, government laboratories, and universities to discuss the long-term precompetitive R&D issues and challenges associated with these aluminide coatings and processing methods.

Contact: Dr. W.Y. Lee, Dept. of Materials Science and Engineering, Stevens Institute of Technology, Hoboken, NJ 07030; tel: 201/216-8307; fax: 201/216-8306; e-mail: wlee@stevens-tech.edu; Dr. Ian Wright, Oak Ridge National Laboratory, Oak Ridge, TN 37831-6157; tel: 423/574-4451; fax: 423/574-5118; e-mail: wrightig@ornl.gov; Dr. Daniel Fant, Advanced Gas Turbine Systems Research, 386-2 College Avenue, Clemson, SC 29634-5180; tel: 864/656-2267; fax: 864/656-0142; e-mail: dfant@clemson.edu; Dr. James Smialek, NASA Lewis Research Center, Cleveland, OH 44135; tel: 216/433-5500; fax: 216/433-5544; e-mail: James.L.Smialek@lerc.nasa.gov.

Second Industry Workshop: Intelligent Processing of Materials for Thermal Spraying

23 April 1998, GE Corporate Research and Development Center, Niskayuna, NY.

GE Corporate Research and Development has been executing a project funded by a NIST Advanced Technology Program Cooperative Agreement since 1995. The purpose of the three-year, cost-shared project is to develop intelligent processing of materials (IPM) technology for plasma deposition of high-quality thermal barrier coatings (TBCs) on components of advanced gas turbines.

This workshop brought together end users, suppliers, and researchers to discuss the state of the art and future direction of intelligent processing of materials for thermal spraying in the power generation, automotive, medical, heavy equipment, and aerospace industries.

The goals of the workshop were:

- To inform the thermal spray community about progress in the intelligent processing of materials for thermal barrier coatings project at GE CRD.
- Promote cross-fertilization of experience and knowledge to accelerate development of IPM.
- Identify future developments in sensors and controls needed for advanced thermal spray processes.

Contact: Dr. Y.C. Lau, GE CRD, K-1 MB243, 1 Research Circle, Niskayuna, NY 12309; tel: 518/387-6017; fax: 518/387-7495; e-mail: lau@crd.ge.com; Dr. Jim Ruud, GE CRD, K-1 MB165, 1 Research Circle, Niskayuna, NY 12309; tel: 518/387-7052; fax: 518/387-7495; e-mail: ruud@ced.ge.com.

ICMCTF '98 Conference

27 April-1 May 1998

Papers:

- "The Contributions of Research over the Past 25 Years to the Development of Coatings for Gas Turbine Airfoils," F.S. Pettit, G.H. Meier, The University of Pittsburgh
- "Progress in Coatings for Gas Turbine Airfoils—A Brief History," G.W. Goward, Consultant to Turbine Components Corp.
- "Burner Rig Tests on Turbine Airfoil Sections Coated with EB-PVD TBCs from Different Suppliers," G.A. Kool, E.F.M. Jansen, J.A.M. Boogers, National Aerospace Laboratory NLR
- "EB-Preheating of Turbine Blades—The Completion of EB-Technology for Thermal Barrier Coating," E. Reinhold, C. Deus, B.-D. Wenzel, Von Ardenne Anlagentechnik
- "Studies of the Bond Coat Oxidation and Phase Structure of TBCs," N. Czech, W. Stamm, Siemens AG, Power Generation Group (KWU); M. Juez-Lorenzo, V. Kolarik, Fraunhofer-Institut für Chemische Technologie (ICT)
- "Relationships between Residual Stress, Microstructure and Mechanical

Properties of EB-PVD TBCs," C.A. Johnson, J.A. Ruud, GE Corporate Research and Development; R. Bruce, D. Wortman, GE Aircraft Engines

- "Development of a Process Window for NiCoCrAlY Plasma Sprayed Coating," A.C. Leger, J. Wigren, M.O. Hansson, Volvo Aero Corp.
- "Mechanical Properties of Zirconia Thermal Barrier Coatings Measured Using Instrumental Indentation," D.T. Smith, J.S. Wallace, National Institute of Standards and Technology
- "Strain Gradients in Plasma Sprayed Zirconia TBCs," P. Scardi, M. Leoni, Universitá di Trento; L. Bertini, Universitá di Pisa; F. Cernuschi, ENEL—Centro Ricerche Ambiente e Materiali
- "Mechanical and Thermophysical Properties of Thick PYSZ Thermal Barrier Coatings—Correlation with Microstructure and Spraying Parameters," D. Schwingel, R. Taylor, UMIST; T. Haubold, BMW Rolls Royce; J. Wigren, Volvo Aero Corp.; C. Gualco, Ansaldo Ricerche
- "Microstructure Formation in Plasma Sprayed Functionally Graded NiCoCrAlY/Yttria Stabilized Zirconia Coatings," Z.L. Dong, K.A. Khor, Y.W. Gu, Nanyang Technological University
- "Phase Stability in Scandia, Yttria-Stabilized Zirconia TBCs," M. Leoni, P. Scardi, Universitá di Trento; R.L. Jones, U.S. Naval Research Laboratory
- "Sintering and Creep Behavior of Plasma Sprayed Zirconia and Hafnia Based Thermal Barrier Coatings," D. Zhu, R.A. Miller, NASA Lewis Research Center
- "High-Temperature Coatings in the Utility Industry: Problems in the Past and their Resolution; New Challenges for the Future," J. Stringer, Electric Power Research Institute
- "The Characteristics of Alumina Scales Formed on HVOF Sprayed MCrAlY Coatings," C. Toma, W. Brandl, J. Krüger, FachhochschuleGelsenkirchen; H.J. Grabke, Max Planck Institut Düsseldorf
- "Paramert Studies on HVOF Spraying of MCrAlY Coatings," E. Lugscheider, Werkstoffwissenschaften; L. Zhao, C. Herbst, Aachen University of Technology
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- "X-Ray Determination of Stresses in Alumina Scales on High Temperature Alloys," C.N. Sarioglu, E. Schumann, J.R. Blachere, G.H Meier, F.S. Pettit, The University of Pittsburgh
- "The Significance of Phase Distribution for the Oxidation Properties of Ni(Co)CrAlY Coatings," W.J. Quadakkers, J. Penkalla, Forschungszentrum Jülich
- "Formation of Aluminide and Platinum-Modified Aluminide Coatings Using a Slurry-Based Aluminization Processes," T. Kircher, B. McMordie, S. Shankar, Sermatech International; K. Richards, Drexel University
- "Oxidation Resistance of Low-Sulphur NiAl and NiPtAl Coatings on a Desulphurized Ni-Based Superalloy," Y. Zhang, P.K. Liaw, University of Tennessee; W.Y. Lee, Stevens Institute of Technology; J.A. Hayes, I.G. Wright, B.A. Pint, K.M. Cooley, Oak Ridge National Laboratory
- "Magnetron Sputtered Ti-Cr-Al Coatings for Oxidation Protection of Titanium Alloys," C. Leyens, J.-W. VanLiere, M. Peters, W.A. Kaysser, DLR-Germany Aerospace Research Establishment
- "Influence of the Surface Roughness on the Oxide Scale Formation on MCrAlY Coatings Studied in situ by High Temperature X-Ray Diffraction," N. Czech, Siemens AG Power Generation Group (KWU); M. Juez-Lorenzo, V. Kolarik, W. Stamm, Fraunhofer-Institut für Chemische Technologie (ICT)
- "Molten Aluminum Corrosion Resistance of Ceramic Thermal Spray Coatings," Y. Wang, General Motors Corp.
- "Plasma Spray Deposited Pt Group Metal Coatings," G.B.A.S. Schuster, Engelhard-Clal LP
- "Relation between the Oxidation Protection of Stabilized ZrO_2 Coatings at High Temperatures and Residual Coating Stress," M. Andritschky, P. Alpuim, Universidade do Minho; C. Funke, D. Stover, Research Center Jülich
- "CVD Mullite Coatings for Corrosion Protection of Si-Based Ceramics," J.A. Haynes, K.M. Cooley, D.P. Stinton, Oak Ridge National Laboratory; W.Y. Lee, Stevens Institute of Technology
- "Deposition of Functional Oxide Layers for High Temperature Application by Filtered Cathodic Arc Plasma Deposition," F. Koch, W.J. Quadakkers, H. Bolt, Forschungszentrum Juelich; B. Bliznakovska, University Skopje
- "Thermal Stability of Al-O-N PVD Diffusion Barriers," R. Cremer, M. Witthaut, D. Neuschuetz, RWTH Aachen
- "Life Time Modeling at the High Temperature Oxidation of Coatings and Alloys for Gas Turbine Blades," E.S. Kartavova, P.G. Krukovsky, Institute of Engineering Thermophysics
- "Corrosion Behaviour of Plasma-Spray Coated Functionally Gradient Materials," A.S. Demirkiran, E. Avci, Sakarya University; E. Celyk, Florida State University
- "Oxidation Behaviour of Plasma-Spray Coated Functionally Gradient Materials," E. Celyk, Florida State University; A.S. Demirkiran, M. Yargan, E. Avci, Sakarya University

Contact: Mary S. Gray, IMCTF 98 Conference Administrator, Suite 136, 14011-F Saint Germain Dr., Centreville, VA 20121.

1998 International Conference on Powder Metallurgy & Particulate Materials

31 May-4 June 1998, Las Vegas, Nevada

Spray Forming

Session Chairman: A. Moran, United States Naval Academy

- "Use of the Phase-Doppler-Anemometry for the Analysis and the Control of the Spray Forming Process," K. Bauckhage, University of Bremen (Germany)
- "Thin Foils of Iron Aluminide Strips by Thermo-Mechanical Processing of RS-LDS Deposits," M. R. Hajaligol, Phillip Morris, USA; N. Grant, A. Farah, Massachusetts Institute of Technology (USA)
- "Influence of SiC Reinforcement Particles on the Microstructure of an Al-Si MMC Processed by Atomization and Deposition," J.L.H. Estrada, Hector Herrera, National Polytechnic Institute Mexico; E. Lavernia, University of California, Irvine (Mexico & USA)

Contact: Metal Powder Industries Federation, 105 College Road East, Princeton, NJ 08540-6692; tel: 609/452-7700; fax: 609/987-8523.

Eighth Middle East Corrosion Conference

18-20 May 1998, Manama, Bahrain

- "Resistance of Selected Thermal Spray Coatings to Salt Spray Corrosion," J. Quets, Praxair Surface Technologies
- "Cost Optimization of Plasma Sprayed Coatings in Industrial Applications," J.P. Khedkar, Louisiana State University

Contact: Robin Tems, Chairman, Organizing Committee; tel: 966-3-874-6130; fax: 966-3-873-0988; e-mail: temsrd@aramco.com.sa.

The Cost of Lead Removal from Infrastructure

Tearing Down the Lead Monster: The Safe Demolition of the Williamsburg Bridge South Roadways

Workers, the public, and the environment can be protected from lead paint hazards when bridges in urban areas are dismantled.

by J. Valenti, P.E. Greenman-Pedersen, Inc., and D.E. Wallace, Eder Associates

When a structure such as a bridge has exceeded its useful life, it must be replaced or demolished. Demolition projects involving steel structures coated with lead-base paint have a significant potential for exposing workers and the public to lead dust. Demolition is generally accomplished in one of two ways: by blowing it up or by knocking it down. The method is usually determined by the location of the structure.

For massive structures located over densely populated areas and highly traveled waterways, the risk of releasing lead and other contaminants into the community prohibits aggressive demolition, and, instead, manual dismantling is a practical solution. Such is the case with New York City's Williamsburg Bridge, which underwent a demolition and replacement of the south side roadways beginning in Jan 1995.

This article examines the reconstruction project with a focus on mechanical demolition techniques, engineering controls, worker and ambient air monitoring, and community concerns.

The Williamsburg Bridge is a major traffic route in New York City, providing access for approximately 100,000 vehicles per day between the boroughs of Manhattan and Brooklyn. When it opened in 1903, the structure was the longest suspension bridge in the world. Fiscal woes over the years led to neglect of the structure, including a lack of preventative maintenance. As a result, significant corrosion of the steel occurred and, in the late 1980s, the New York Department of Transportation (NYCDOT) decided to rebuild the bridge in place.

The first phase of the $500 to $600 million rehabilitation was the reconstruction of the South Roadways. The project consisted of:

- Removal and replacement of the main-span road deck and pedestrian footwalk
- Dismantling to grade and reconstruction of the approach roadways
- Excavation and reconstruction of the overhead roadway support piers

The full text of this article can be reviewed in JPCL, January 1998, p 46.

Industrial News

Nooter Corporation, Nooter Fabricators, and Nooter Construction Company Announce New Appointments

Building on its recent corporate restructuring to better reflect the company's broad range of technical expertise and engineering solutions, Nooter Corporation recently announced several new appointments at Nooter Corporation, Nooter Fabricators, Inc., and Nooter Construction Company, including the appointment of Raymond B. Rohrbacker, former vice president, secretary, and treasurer of Nooter Corporation, to vice president and chief financial officer of Nooter Corporation, Thomas G. Remsecher, former assistant secretary of Nooter Corporation, to secretary, Robert M. Kerr, former controller of Nooter Corporation, to treasurer, Terry L. Jansing, former chief accountant of Nooter Corporation, to controller of Nooter Fabricator, Inc., and John G. Rogoz, former chief accountant of Nooter Construction Company, to controller of Nooter Construction Company.

"These strategic appointments will improve our operating efficiency and level of expertise," explained George P. Bouckaert, Chairman of the Board and Chief Executive Officer, Nooter Corporation. "With these advancements, we are well positioned to continue expanding the breadth and geographic scope of our services."

Wyatt Field Service Company Expands with New Tray Services Division

Wyatt Field Service Company, a subsidiary of Nooter Corporation, announced the creation of a new division, Wyatt Tray Services. The division will operate as an extension of Wyatt Field Service Company.

"The move comes in direct response to increased customer demand for quality companies who can perform modification and renovations of trays and other tower internals," said Richard Korfhage, managing director of Wyatt Tray Services. "As distillation equipment ages and energy costs rise, refineries are doing whatever they can to increase efficiency. This can mean replacing or modifying trays, or renovating towers, to take advantage of newer technology."

Refinery management concerned with limiting downtime will benefit from the company's tray and tower specialists' experience with tower internals. Korfhage emphasized that with the new focus on safety, efficiency, and high-quality standards, the division is not merely a renamed, repackaged portion of Wyatt Field Service Company.

Wyatt Tray Services' craftsmen and supervisors specialize in trays and are dedicated to tray services, with a combined 20 years of experience with tower internals. Because it is a division of Wyatt Field Service Company, customers can now deal with a single contractor and be assured of continuity, quality control, and efficient scheduling.

Korfhage said that there is a lot of work that goes into revamping a tower. It is critical to have the personnel with the necessary skills and the understanding of the importance of getting the job done safely and correctly so the tower can go back into operation as soon as possible.

New Colmonoy Brochure Celebrates 60 Years

Wall Colmonoy Corporation (World Headquarters, Madison Heights, MI) has published a new brochure commemorating 60 years of the Colmonoy product line. This eight-page, full-color brochure provides compositions, hardness ranges, fusing temperatures, and successful applications for more than 20 nickel-base wear-resistant alloys. Features of the Colmonoy Spraywelder and Fusewelder Torch are also included. Colmonoy alloys are available as powder, rod, castings, and ingot for use in the glass, plastics, pulp and paper, petrochemical, transportation, and power-generation industries.

Contact: Tanya Anandan at 248/585-6400, ext. 224; or fax: 248/585-7960.

Howmet Expands Coating Capabilities

Howmet Corporation today announced that it is nearing completion of a major expansion to its coating capabilities for the gas turbine market. With the installation of both a low-pressure plasma spray (LPPS) coating system, currently in the final stage of setup, and an electron beam physical vapor deposition (EBPVD) system, which will begin processing customer orders by the end of March 1998, the Thermatech Coating operation will fulfill its commitment to meet customer requirements across the entire spectrum of OEM gas turbine coating.

"The market value of these new systems is in the $16 to $18 million range," said James R. Stanley, Howmet's senior vice president, U.S. operations. The LPPS system was ordered last year from Sulzer-Metco, a Swiss manufacturer. The EBPVD system was designed and constructed by Howmet's Manufacturing Technology Operation. Both systems will be located at Howmet's Thermatech Coating facility in Whitehall, MI.

This expansion supports Howmet's strategy to increase its share of the global OEM coating market, which is estimated to have $350 million in annual sales revenue. According to Cliff Sickles, general manager of Howmet Specialty Products, which includes Thermatech Coating, strong demand from customers prompted the company's decision to expand its coating capabilities. He says, "Many customers want finished, ready-to-assemble parts. Howmet is uniquely positioned in the industry to offer customers hardware that is cast, coated, machined, and delivered in ready-to-assemble condition by a single supplier—Howmet."

Thermatech Coatings Business Center manager, David Punola adds, "The number of advanced components that require multiple coatings on a single part is increasing. These components sometimes require up to four different coating types. Now Howmet, already a leader in Chemical Vapor Deposition (CVD), will add these additional advanced overlay coating capabilities to its market offering. The new LPPS and EBPVD systems give us a dual benefit: greater depth in our traditional business, plus a greatly expanded range of coating options for advanced parts."

Contact: Doreen Deary at Howmet Corporation, 475 Steamboat Road, Greenwich, CT 06836-1960; tel: 203/625-8735; fax: 203/625-8771.

Howmet to Install $5.2 Million Vacuum Furnace

Howmet Corporation's Dover Alloy operation today announced plans to install a new, $5.2 million vacuum furnace. "This new furnace is designed to do more than increase our melting capability; it will also provide the flexibility we need to ship alloys faster. Today customers want short, highly reliable delivery cycles," said James R. Stanley, senior vice president, U.S. operations.

Although Dover Alloy had increased productivity 8% in 1997 compared to 1996 levels, the operation needed more production flexibility to respond to demand for faster delivery. "The new vacuum furnace will handle charge weights in the 5000 to 10,000 lb range," said Jack Bodner, general manager of the alloy operation. "The new furnace permits quick changeover from one melting campaign to the next. This feature will give us the flexibility we need to make cycle-time improvements."

Contact: Doreen Deary at Howmet Corporation, 475 Steamboat Road, Greenwich, CT 06836-1960; tel: 203/625-8735; fax: 203/625-8771.

Howmet Reports Annual Earnings

Howmet International Inc., announced income of $72 million or $0.67 per share for the year ending 31 Dec 1997, before an extraordinary item, compared to $25.6 million or $0.21 per share last year. Net income for the year ending 31 Dec 1997 was $59.7 million or $0.55 per share. The current year income included an outstanding charge of $12.3 million or $0.12 per share, related to debt restructuring charges. Sales increased 14% over the prior year.

David Squier, president and chief executive officer, commented, "Our core businesses continue to perform extremely well resulting in record sales for 1997. Continued focus on operational improvement and cost reductions resulted in improved margins and enhanced customer satisfaction. In addition to our excellent operating performance, in December we completed our debt refinancing to take advantage of favorable interest rates; in November we completed our initial public stock offering, which resulted in the listing or Howmet International Inc., on the NYSE; and in September we sold our refurbishment business for net cash proceeds of approximately $45 million. Production levels remain high, and we continue our commitment to manufacturing improvements, customer satisfaction, and investment in new growth opportunities."

Grant Awarded for Advanced Ceramic Coatings Technology

The U.S. Commerce Department's National Institute of Standards and Technology (NIST) announced that it will renew a multiyear research award under the Advanced Technology Program (ATP) for ceramics coating research conducted by Praxair Surface Technologies, Inc.

The research focuses on technology to apply high-quality ceramic coatings to the internal surfaces of cylindrical parts. According to NIST, a practical technology for such coatings would improve the durability and reliability of heavy equipment because ceramic coatings are far more resistant to corrosion and wear than the electroplated chrome coatings now in use.

The award renewal is for $115,835. The three-year project, initiated in 1995, is projected to receive a total of approximately $793,000 in ATP funding, matched by approximately $400,000 in industry funding. The ATP awards are designed to help industry pursue risky, challenging technologies that have the potential for big payoffs for the national economy and that otherwise would be ignored or developed too slowly to compete in rapidly changing world markets. For more information, contact Michael Baum, NIST, ADMIN A903, Gaithersburg, MD 20899; tel: 301/975-2763; e-mail: michael.baum@nist.gov.

Plasma Coating System is Low Temperature, Earth Friendly

An advanced plasma surface-modification system aimed at reducing hexavalent chromium, a known carcinogen, is to be developed through a Phase I Small Business Innovation Research (SBIR) contract, reports ISM Technologies, Poway, CA. The process can be carried out at very low temperatures—low enough to coat plastic and aluminum parts without damaging them. The process will combine the company's metal ion sources with standard vapor deposition technology to allow both conductors and insulators to be implanted and coated. The metal ion sources generate a broad, high-current beam of metal ions at very high energies—up to 80,000 V. Bombarding the substrate with the high-energy metal ions while depositing metal from a vapor source (cathodic arc, evaporative, or sputtering) in the presence of a reactive gas, such as nitrogen, produces a surface coating that is very hard and very tightly adherent.

ISM Technologies, including its ToolPeen metal ion implantation process, has recently been acquired by Cutting Edge Products Inc., San Diego, CA. However, the company will continue to operate under the ISM name and has reportedly quadrupled its capacity.

For more information, contact Jim Treglio, ISM Technologies, 13100 Kirkham Way, Suite 211, Poway, CA 92604; tel: 619/513-1190; fax: 619/513-1197.

Thermal Spray Coating is Pore-Free, 50% Harder

Coatings have now been fabricated that exhibit an unusual combination of hardness, toughness, abrasion-resistance, and adherence, according to the Office of Naval Research, Arlington, VA. The Navy anticipates wide use of the coatings on ships, aircraft, and land vehicles to prevent wear and erosion and to reduce the need for expensive maintenance.

The coatings are produced by the high velocity oxyfuel (HVOF) process, in which a material is injected into a hot, supersonic gas stream and directed against the surface being coated. The materials stock consists of nanoscale tungsten carbide particles cemented by a cobalt alloy. It produces a pore-free coating that is reportedly more than 50% harder than conventional carbide coatings, and it resists cracking and spalling even when subjected to mechanical peening.

The material was originally developed under an ONR research grant and is now produced by Nanodyne Inc., New Brunswick, NJ, which was formed through a partnership between Rutgers University and Procedyne Corporation. Research and development will be undertaken to better understand the properties of the coatings and to optimize the production process.

For more information contact Larry Kabacoff, ONR 332, Office of Naval Research, 800 N. Quincy St., Arlington, VA 22217-5660; tel: 703/696-0934; e-mail: kabacol@onr.navy.mil.

News from NASA

Testing Corrosion Prevention in Reinforced Concrete

An accelerated-testing method has been developed for evaluating the effectiveness of various measures taken to prevent the corrosion of steel reinforcing bars ("rebars") cast into concrete. Such measures can include chemical admixtures incorporated into the concrete, coatings, penetrants, modified concretes, new reinforcing materials, and corrosion-inhibiting chemicals that migrate after being applied. The method is an improvement of standard G 109-92 of the American Society for Testing and Materials (ASTM). In preparation for testing, concrete blocks are cast with rebars inside, along with any appropriate corrosion inhibitor(s). Holes are drilled into the blocks for measurement of electrical potentials at interior locations; other holes are drilled to promote intrusion of salt-water. During exposure of a block to a saltwater or other corrosive environment, electrical potentials are measured at rebars as well as in holes. Corrosion currents are also measured, and polarization resistances are determined. Optionally, potentials can be applied to accelerate corrosion. At the end of a test, blocks are broken for visual examination of the rebars.

This work was done by Rupert U. Lee of Kennedy Space Center and Joseph J. Curran of Dynacs Engineering Co., Inc. For further information, access the Technical Support Package (TSP) free on-line at www.nasatech.com under the Materials category. Extracted from *NASA Tech Briefs,* Feb 1998.

Elevation Corrections for Absolute-Pressure Measurements

A method of correcting absolute-air-pressure measurements for small differences in the elevations of pressure taps and pressure transducers as been devised. The variation in air pressure with elevation is well documented; nevertheless, in such disciplines as process control and laboratory experimentation, it has been common practice to account for pressure differences associated only with large differences in elevation along tubes that connect pressure taps to transducers. The emergence of highly accurate multiport pressure-measurement systems, coupled with the need for increasingly accurate pressure measurements, has made it necessary to correct for pressure differences associated with elevation differences as small as a meter or so. The present method can be readily incorporated into future pressure-measurement procedures to provide the necessary correction; it can also be used to reprocess previous measurements to increase their accuracy.

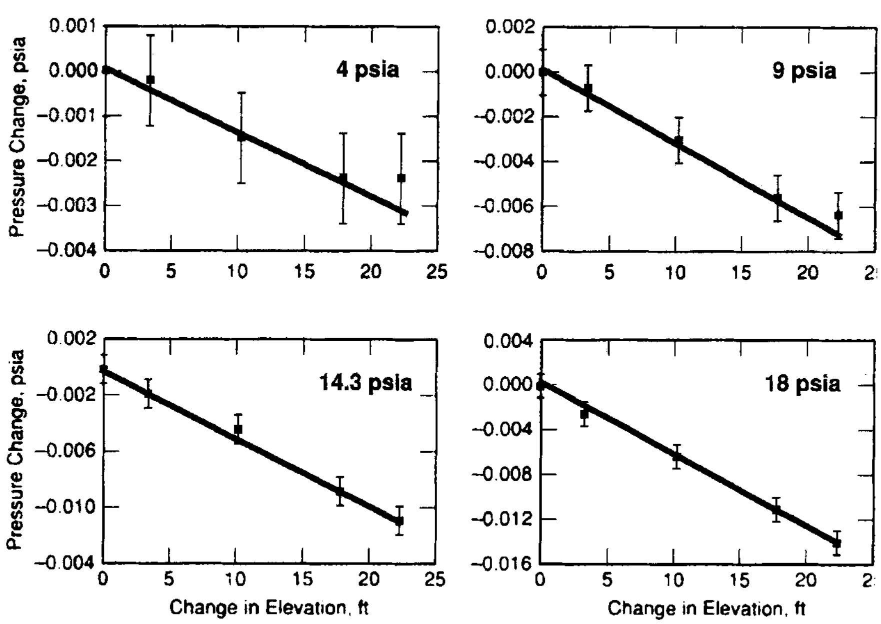
The method is based on the fact that pressure at the bottom of a measurement tube will be higher than the pressure at the top due to weight of the column of air in the tube. It is assumed that the fluid (air) is at a static equilibrium and that the temperature and the gravitational acceleration do not vary significantly over the measured height. The resulting equation for correcting a pressure reading is:

$$P = P_0 e^{-(g\rho_0/P_0)\,y}$$

where P is the pressure at the pressure tap (the corrected or actual pressure, which one seeks), P_0 is the reading of the pressure transducer, g is the gravitational acceleration, ρ_0 is the known density of air at the known temperature and pressure P_0 and y is the difference in elevation from the transducer to the pressure tap. At 20 °C, $g = 9.8$ m/s^2, $\rho_0 = 1.205$ kg/m^3, and $P_0 = 1.01325\times 10^5$ Pa; therefore:

$$P = P_0 e^{(-1.16546\times 10^{-4})\,y}$$

The method was tested in a series of measurements in air at a temperature of 70 ± 5 °F (~21 ± 3 °C) on two commercial pressure gages at various pressures and elevations. After corrections for biases between the two gages, the results (see figure) indicate that the predicted and measured variation of pressure with height agree with each other to within 0.001 psi (~7 Pa).



Calculated and measured changes of pressure agreed with each other within the range of nonrepeatability of the pressure-gage readings [about 0.001 psi (≈7 Pa)].

This work was done by Joseph W. Panek and Mark R. Sorrells of Lewis Research Center. For further information, access the Technical Support Package (TSP) free on-line at www.nasatech.com under the Physical Sciences category.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7-3, 21000 Brookpark Rd., Cleveland, OH 44135. Refer to LEW-16499. Extracted from *NASA Tech Briefs,* Feb 1998.

Evaluation of Droplet-Evaporation Models for Gas/Liquid Flow

A report presents an evaluation of eight mathematical models of the evaporation of liquid droplets—models that are used in the numerical simulation of a variety of gas/liquid flows, including cooling sprays, burning liquid-fuel sprays, fire-suppression sprays, and air/fuel-premixing flows in combustors. Included in the study were two versions of a classical model that includes transient drop-heating effects, four versions of a heat-mass-transfer-analogy model, and two nonequilibrium models based on the Langmuir-Knudsen evaporation law. The models were used to predict evolution of droplet diameters and temperatures, and the predictions were compared with experimental observations, for droplets of benzene, decane, heptane, hexane, and water vaporizing in convective air flows. All models performed nearly identically at low evaporation rates at gas temperatures significantly lower than the liquid-boiling temperatures. For gas temperatures at and above boiling temperatures, there were large deviations among the various model predictions. Nonequilibrium effects were found to become significant for initial droplet diameters <50 μm and to increase with slip velocity. The models based on the Langmuir-Knudsen law agreed most closely with the experimental results, though not because they account for nonequilibrium effects; instead, the superiority of these models was attributed to the incorporation of a corrected heat-transfer equation.

This work was done by Josett Bellan, Kenneth Harstad, and Richard Miller of Caltech for NASA's Jet Propulsion Laboratory. To obtain a copy of the report, "Evaluation of Equilibrium and Non-Equilibrium Evaporation Model for Many-Droplet Gas-liquid Flow Simulations," access the Technical Support Package (TSP) free on-line at www.nasatech.com under the Physical Sciences category. Extracted from *NASA Tech Briefs*, Feb 1998.

A Multicolor Imaging Pyrometer

Physical Sciences Inc. (PSI) designed, constructed, and delivered a prototype passive imaging pyrometer capable of accurately measuring and controlling the temperature distribution across a specified surface. The device was originally designed, under a NASA SBIR contract (solicitation year 1985) monitored by Jet Propulsion Laboratory, for space application with a material processing acoustic levitation furnace, and thus the software allowed for registration of a surface that was allowed free motion within a defined range.

The multicolor imaging pyrometer was designed specifically to measure temperatures from 900 to 2500 K with spatial resolution of 2 mm. These parameters can be extended and customized for other applications.

Like all pyrometers, this instrument determines the temperature of a material by measuring the emitted radiation. However, unlike most other pyrometers, temperature measurement errors associated with a lack of knowledge about the heated sample's emissivity are minimized by utilizing an optical system that operates at short wavelengths compared to the peak of the blackbody spectrum for the temperature range of interest. In this regime, the radiant power increases faster than exponentially with temperature.

Because of this extreme sensitivity to temperature, the emissivity of the source plays a relatively small role in determining the emitted power. The short wavelengths therefore provide more accurate measurements of the temperature than can be made using longer wavelengths, assuming equally poor knowledge of the sample's emissivity. The penalty paid for this accuracy is that the dynamic range of the pyrometer's CCD image detector places rather narrow limits on the range of temperatures that can be measured at a single short wavelength. To cover a broad range of temperature, six wavelengths—each sensitive to a specific temperature range—are provided.

An optical head projects distinct images at all six wavelengths onto the detector concurrently. Computerized data acquisition and analysis enable the user to capture data and store it on videotape, interactively examine and interpret the data either immediately after capture on upon replay of the videotape, or to automatically analyze the pyrometer's output. In the latter mode, the pyrometer provides a display of the object's temperature distribution in a false color image on a video monitor, a calculation of the temperature distribution's mode value in a feedback loop for controlling the object's temperature.

The pyrometer technology was later extended under a National Science Foundation grant to allow rapid nonintrusive measurement of particulate and gas temperatures in extremely hostile environments. The resulting optical temperature monitor, again employing multiple wavelength measurements, was originally sold commercially as GasTemp. Following this successful demonstration and commercialization, PSI established a subsidiary to manufacture and enhance the product. It was soon apparent that this company had additional opportunities in the environmental monitoring instrumentation market, and a second optical instrument, the SpectraScan line, was developed. SpectraScan directly measures trace concentrations of ammonia, hydrogen fluoride, hydrogen sulfide, and other regulated gases in either extractive or open path modes.

As the applications of SpectraScan became clear, the company's name was changed to Spectrum Diagnostix, and the SpectraTemp optical temperature monitor was introduced. The Massachusetts Capital Resource Company and The Venture Capital Fund of New England invested $1.7 million, allowing spectrum Diagnostix to grow to almost 20 employees. In 1996, spectrum Diagnostix was sold to PSI's marketing partner, Bovar Western Research, which now manufactures and distributes SpectraTemp. It provides continuous accurate and reliable temperature monitoring of hot particulate-laden gas streams.

SpectraTemp determines particulate temperature by measuring light emissions from the particulates at three different wavelengths. These are selected to avoid interferences from cool heat-transfer surfaces (e.g., broiler walls). SpectraTemp provides a temperature range of 350 °C (675 °F) to 1600 °C (2900 °F). Its design gives it a unique capability to determine a line-of-sight average temperature all the way across a particulate-laden stream. Automatic calibration, fault detection, and alarms are incorporated into SpectraTemp, and both analog and digital outputs are supplied for interfacing with plant control systems.

SpectraTemp has most commonly been used for monitoring furnace-exit gas temperature in utility and industrial boilers fired by coal, heavy oil, wood, or municipal waste. In these installations, SpectraTemp reduces operating costs by providing better control of furnace-wall blowers and soot blowers, better burner

Spectratemp Specifications

Methodology performance	Three-wavelength optical temperature monitor
Lowest measurable temperature	350 °C (675 °F)
Highest measurable temperature	1600 °C (2900 °F)
Absolute accuracy	± 25 °C (± 50 °F)
Relative accuracy	± 15 °C (± 30 °F)
Measurement field of view	6° cone
Outputs: Analog	0-10 VDC; 4-20 mA
Digital	RS-232
Installation	
Electrical classifications	General purpose
Physical dimensions and weight	1200 × 250 × 180 mm (46 × 9.5 × 7 in.) 18.2 kg (40 lb.)
Port	50 mm (2 in.) port in boiler sidewall

Table 1 Compositions of coatings PS200 and PS300

Composite coating material	Constituents and proportions							
	Metal-bonded Cr_2O_3(a)		Metal-bonded $Cr_3C_2C_2$(b)		Ag		BaF_2/CaF_2 eutectic	
	wt%	vol%	wt%	vol%	wt%	vol%	wt%	vol%
PS300	80	80.3	...	...	10	5.5	10	14.2
PS200	...	...	80	77.1	10	6.4	10	16.5

(a) By wt%, $80Cr_2O_3 + 16Ni + 4Cr$. (b) By wt%, $54Cr_3C_2 + 28Ni + 12Co + 2Mo + 2Al + 1B + 1Si$

control (tilt and excess air), and superior stream-temperature control.

SpectraTemp can also be used for improved process optimization in other industrial processes where accurate control of the temperature of particulate-laden gas streams is important. Examples of such processes include waste incinerators, cement kilns, and smelters. For more information on SpectraTemp, contact Norman Stein, Bovar Western Research, 714/789-1084

This work was done by Physical Sciences Inc. under a NASA SBIR Contract monitored by Jet Propulsion Laboratory. Information on customized imaging pyrometers can be provided by George Caledonia, Physical Science Inc., 20 New England Brothers Center, Andover MA 01810; 978/689-0003. Extracted from *NASA Tech Briefs,* Jan 1998.

Self-Lubrication Composite Coating for High-Temperature Use

PS300 is a self-lubricating solid coating material for use in sliding contacts at temperatures up to 800 °C. PS300 is a composite of metal-bonded chromium oxide with barium fluoride/calcium fluoride eutectic and silver as solid lubricant additives. The "PS" in the name of this and other self-lubricating high-temperature composite materials that have been reported in *NASA Tech Briefs* signifies that the material is applied to a substrate by plasma spraying of a powder blend of its constituents.

PS300 is similar to a previously developed material of this type, called PS200. The main difference between the two materials is that instead of metal-bonded chromium oxide, the major constituent of PS200 is metal-bonded chromium carbide (Table 1).

In either material, the major constituent serves as a tough, wear-resistant matrix. The additives provide lubrication by virtue of their low shear strengths. In particular, silver lubricates at low temperatures; at higher temperatures, where silver is too soft to support an appreciable load, the fluoride eutectic phase softens and behaves plastically.

The big disadvantage of PS200 is high cost. The metal-bonded chromium carbide is a highly processed, expensive constituent, and the presence of chromium carbide makes it necessary to resort to costly diamond grinding to polish the coating to the requisite finish prior to use. Moreover, at temperatures above 800 °C in air, the chromium carbide oxidizes, with a resultant increase in friction and loss of resistance to wear.

The metal-bonded chromium oxide in PS300 costs less than does the metal-bonded chromium carbide in PS200. Metal-bonded chromium oxide can be ground and polished by silicon carbide tools, eliminating the need for diamond finishing. Inasmuch as the chromium in PS300 is already in an oxidized state, the coating has potential for better tribological performance in air at high temperatures. Yet another advantage of PS300 over PS200 is that at high temperatures, chromium oxide is a good solid lubricant. Finally, in comparison with PS200, PS300 exhibits less of a tendency to clog spray-gun ports and can thus be plasma sprayed more easily.

PS300 and PS200 have been tested under identical conditions on a pin-on-disk tribometer. In tests at temperatures up to 650 °C in air, the two materials exhibited comparable friction and wear properties.

This work was done by C. DellaCorte and B.J. Edmonds of Lewis Research Center. For further information, access the Technical Support Package (TSP) free on-line at www.nasatech.com under the Materials category.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7-3, 21000 Brookpark Road, Cleveland, OH 44135. Refer to LEW-16413. Extracted from *NASA Tech Briefs,* Jan 1998.

Thermodynamic Detection of Defects in Refractory Composites

Thresholds of detectability have been determined.

Significant effort and resources are being expended to develop ceramic-matrix composite (CMC), metal-matrix composite (MMC), and polymer-matrix composite (PMC) materials for high-temperature engine components and other parts in advanced aircraft. The development of composite materials is also being pursued actively in the automobile and sporting-equipment industries, among others. A portion of the development effort involves the assessment of nondestructive-evaluation (NDE) techniques for detecting flaws in these materials. Recent advancements in infrared-camera technology and computer power have made thermographic (infrared) imaging systems worth reconsideration as reliable tools for NDE of these materials. Thermography offers the advantages of real-time inspection, no contact with samples, nonionizing radiation, capability for inspection of samples with complex shapes, variable sizes of fields of view, and portability.

An experimental study sponsored by NASA Lewis Research Center was performed to evaluate the capability afforded by a thermographic imaging technique for detection of defects in four composite materials of interest as high-temperature structural materials. The materials studied were two CMC's, one MMC, and one PMC; artificial defects in the form of flat-bottom holes with diameters from 1 to 13 mm and depths from 0.1 to 2.5 mm into specimens (2 to 3 mm thick) of these materials. In the thermographic imaging technique used, the source of heat was a pair of xenon flash lamps that faced the same side of the specimen as that observed by an infrared camera.

In the experiments, limits of detectability based on the depths and diameters of the holes were determined for each specimen material. For a SiC/SiC CMC, it was found that defects with depths

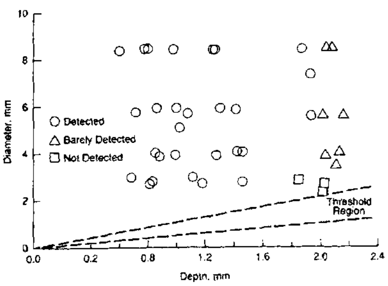


Fig. 1 An empirical rule for the threshold of detectability of defects in SiC/SiC is determined by plotting a distribution of defects and indications regarding detectability by the thermographic technique used in the experiments.

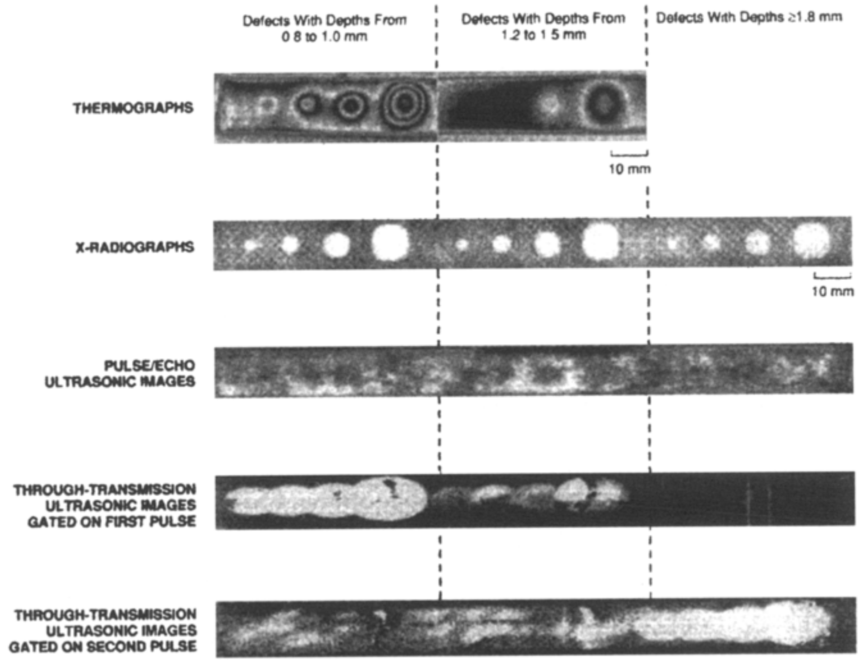


Fig. 2 Images of SiC/SiC specimens with defects, made by several different NDE techniques, show different capabilities for revealing the defects. The through-transmission ultrasonic images have been distorted by graphical manipulation.

≤1.8 mm and diameters ≥2.6 mm will probably be detected (See Fig. 1) by the technique used in these experiments. Similarly, it was found that for a composite of SiC fibers in a calcia/alumina/silica matrix (SiC/CAS) defects with depths ≤1.8 mm and diameters ≥1.6 mm will probably be detected; for a MMC of SiC/Ti, defects with depths ≤1.6 mm and diameters ≥3.2 mm will probably be detected; and for a PMC of graphite/polyimide, defects with depths ≤1.8 mm and diameters of about 3 to 12 mm will probably be detected. Depth appears to be the limiting variable with regard to detectability in the PMC.

As part of the study, thermographic images and observations about detectability were compared with results from ultrasonic and x-radiographic imaging to highlight the relative strengths and weaknesses of each imaging technique as applied to the composite materials studied. For example, Fig. 2 shows thermographic images along with film x-radiographic and ultrasonic images for SiC/SiC specimens. The x-radiographs clearly reveal all defects. The ultrasonic pulse/echo image gives very diffuse indications of most defects because of the porosity (about 15 percent) of SiC/SiC. The ultrasonic through-transmission image clearly shows all defects at shallow and intermediate depths.

Overall, this study has yielded baseline results that can be expected to enable material developers and component designers to determine whether the thermographic technique used can reveal "critical" defects. The technique is applicable to inspection of composite-material structures in any industry. Examples of materials and structures amenable to such inspection include tires, composite hulls of boats, composite frames of bicycles, and multilayer thick tapes.

This work was done by Don J. Roth of Lewis Research Center, James R. Bodis of Cleveland State University, and Chip Bishop of Bales Scientific, Inc. For further information, access the Technical Support Package (TSP) free on-line at www.nasatech.com under the Physical Sciences category.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7-3, 21000 Brookpark Road, Cleveland, OH 44135. Refer to LEW-16418.

U.S. Government News

Administration Seeks $715 Million for NIST in FY 1999

President Clinton has submitted to Congress a fiscal year (FY) 1999 budget request for the Commerce Department's National Institute of Standards and Technology (NIST) of $715 million—a 6.3% increase above the FY 1998 appropriations of $672.9 million. The proposed budget will fund the operation—in close partnership with the private sector—of NIST's civilian technology support programs that focus on the country's technology infrastructure. These are critical jobs that neither government nor industry can accomplish separately, but are vital to the nation's global competitiveness and economic future.

NIST leverages its funds to deliver broad-based economic benefits for all types of industries and all sizes of companies. Included in the FY 1999 request are three separate appropriations; $291.6 million for Scientific and Technical Research and Services (including $286.3 million for the NIST Measurement and Standards Laboratories and $5.4 million for the National Quality Program), $366.7 million for Industrial Technology Services (including $259.9 million for the Advanced Technology Program and $106.8 million for the Manufacturing Extension Partnership), and $56.7 million for Construction of Research Facilities (including $16.7 million to maintain and improve existing facilities and $40 million for the planned Advanced Measurement Laboratory) to help bring NIST's 30 to 45 year old research facilities up to the state of the art and meet U.S. industry and science needs well into the next century.

More data on the proposed budget are found in "FY99 Technology Administration Budget highlights," a document available by faxed request to 301/926-1630 or on the WWW at http://www.nist.gov.

New Study Demonstrates Significant Impact on Industrial R&D

A new study by NIST Advanced Technology Program reveals important new details on the program's role in promoting innovative industrial R&D, including evidence that the program has stimulated and accelerated the pace of technology development, that the research is enabling significant technological breakthroughs rather than simple incremental advances, and that industry is actively pursuing commercialization of ATP-sponsored technologies.

The comprehensive study of more than 200 projects funded from 1993 to 1995 draws on data collected by the ATP's novel computer-assisted Business Reporting system, which gathers quarterly and annual data from individual companies particularly in ATP projects. Significant findings in the study include:

- Eighty-six percent of ATP funded organizations indicate they already are ahead in their R&D cycle as a result of ATP funding—and many of the projects had only completed their first year. Of those, 39% believed they would not have started the project at all without ATP support.
- The companies surveyed have identified more than 1000 potential applications of the ATP-supported technologies and have developed commercialization plans for nearly 800 of those. Twenty-nine percent of the resulting applications are expected to have performance improvements of 100 to 500% or more, providing evidence that industry is pursuing "discontinuous" or "breakthrough" innovations—suggesting relatively high-risk R&D.
- Speed to market is considered "critical" or "important" for 98% of the commercial applications, and even at the early stage of R&D for most of the projects analyzed, about 15% had enabled advances that generated early revenues. Acceleration in time to market by two years or more is anticipated for 62% of planned commercial applications..

The results are documented in "Development, Commercialization, and Diffusion of Enabling Technologies, Progress Report for Projects funded 1993-1995" (NISTIR 6098), one of a series of evaluation and analysis studies commissioned by the ATP.

Advanced Technology Programs

Developed in response to suggestions from industry and academia, ATP focused programs identify specific, long-range research and business goals that require the parallel development of a suite of interlocking R&D projects. Focused programs allow the ATP to manage groups of complementary projects and reap the benefits of synergy among the participants. The ATP has established 16 focused programs to date.

The Manufacturing Composite Structures program was created to reduce the high initial costs of using advanced composite materials, traditionally found in military and sports applications, through cost-effective manufacturing processes to enable the use of these high-performance, lightweight, durable materials in large-scale commercial structural applications such as surface transportation, civil infrastructure, and offshore oil production. (First competition in 1994.) Contact Felix Wu, Program Manager; tel: 301/975-4685; e-mail: felix.wu@nist.gov.

The Materials Processing for Heavy Manufacturing program will develop and demonstrate innovative materials-processing technologies that will help U.S. heavy manufacturing companies make longer-lasting, more reliable, and more efficient products. The program concentrates on three major commercial markets: engines, power trains, and chassis for surface vehicles; heavy equipment for construction, agriculture, mining, and oil fields; and engines, turbines, rotors, and related components for power generators. (First competition in 1995.) Contact Clare Allocca, Program Manager; tel: 301/975-4359; e-mail; clare.allocca@nist.gov.

The Motor Vehicle Manufacturing Technology program fosters innovations in manufacturing technologies that can strengthen capabilities and lead to dramatic advances along the entire automotive production chain, including more versatile equipment, better control and integration of processes, and greater operational flexibility at all levels. Automotive suppliers are key partners and players in this program. (First competition in 1995.) Contact Jack Boudreaux, Program Manager; tel: 301/975-3560; e-mail: jack.boudreaux@nist.gov.

Popular Business Performance Excellence Guide Now Available for Education Organizations

Criteria designed to help education organizations improve their services and overall performance are available now from NIST. The criteria are based on the performance by NIST in conjunction with the private sector.

"Our greatest challenge to improve education is to insist upon accountability in exchange for the provision of sufficient human and fiscal resources to carry out our missions. The Baldrige Quality Award provides a framework for all educational organizations to demonstrate accountability," said Arnold R. Weber, chancellor, Northwestern University, and a member of the board of directors, Malcolm Baldrige National Quality Award Foundation.

Currently, the Baldrige Award is open to for-profit businesses. President Clinton's fiscal year 1999 budget proposal includes $2.3 million for new award categories for nonprofit education and health-care organizations. These organizations will be able to apply next year for the award if this funding is approved. In May 1997, the private Foundation for the Malcolm Baldrige National Quality Award announced a $15 million fund drive to raise an endowment to help establish an award program for these two sectors, provided federal funding also is available for support.

In 1995, NIST conducted a successful pilot award program to determine the interest and readiness of education organizations to participate in a Baldrige Award program. Nineteen education organizations submitted applications for the pilot. Lessons learned by the participants included the importance of well-defined measures of progress and the importance of partnering with all stakeholders, including parents, boards of education, students, and the community. In conjunction with the pilot, NIST distributed more than 15,000 copies of education performance excellence criteria modeled after the criteria for the business award. Since then, federal funding has not been available to continue the pilots or to establish award categories.

NIST developed the current performance excellence criteria for education organizations with funding from the U.S. Department of Education.

The Baldrige quality program was established by Congress in 1987; the first awards were presented in 1988. The award program's goals have been to enhance U.S. competitiveness by promoting quality awareness, recognizing quality and business achievements of U.S. companies and publicizing these companies' successful performance strategies.

Single copies of the educational criteria are available free of charge from NIST; tel: 301/975-2036; fax: 301/948-3716. The criteria and other information also are available on the Baldrige Award website at http://www.quality.nist.gov.

"Baldrige Index" Outperforms S&P 500 for Fourth Year

For the fourth year in a row, the fictitious "Baldrige Index" has outperformed the Standard & Poor's 500 by almost 3 to 1, according to NIST.

The "Baldrige Index" is made up of publicly-traded U.S. companies that have received the Malcolm Baldrige National Quality Award during the years 1988 to 1996. NIST "invested" a hypothetical $1000 in each of the six whole company winners of the Baldrige Award—ADAC Laboratories, Eastman Chemical Company, Federal Express Corporation, Motorola Inc., Solectron Corporation, and Zytec Corporation. The investments were tracked from the first business day of the month following the announcement of award recipients (or the date they began public trading) to 1 Dec 1997. Adjustments were made for stock splits. Another $1000 was hypothetically invested in the S&P 500 at the same time.

NIST found that the group of six outperformed the S&P 500 by more than 27.7 to 1, achieving a 394.5% return on investment compared to a 146.9% return for the S&P 500.

NIST also tracked a similar hypothetical investment in a group made up of the six whole company Baldrige Award winners and the parent companies of 12 subsidiary winners. This group of 18 companies outperformed the S&P 500 by 2.4 to 1, a 362.3% return on investment compared to a 148.3% return for the S&P 500.

Since the past few years have been one of the stock market's most profitable periods in the 20th century, NIST also tracked an "investment" in Baldrige Award winning companies for the period starting 2 Jan 1997 and ending 1 Dec 1997. In this study as well, the six whole company winners outperformed the S&P 500 by 1.4 to 1, achieving a 46.3% return compared to a 32.2% return for the S&P 500. Similar NIST studies since 1994 also found that Baldrige Award winning companies outperformed the S&P 500.

A copy of the three-page stock study is available on the Baldrige Award website at http://www.quality.nist.gov.

NIST Offers Short Course to Help Industry to Better Measure Temperature

Many industrial managers and engineers know that the accuracy of their temperature measurements has a big impact on the quality of their products or the efficiency of their processes.

In order to help industry improve temperature measurement accuracy, NIST is offering a new short course, "Temperature Measurement by Radiation Thermometry," 1-5 June 1998. The course is designed to help industrial engineers and government or academic scientists better understand critical factors for accurate temperature assessment. Sponsored by NIST's Optical Technology Division, the course can accommodate 16 students and will be offered annually.

The course includes lectures and hands-on experiments. Taught by scientists in NIST's Optical Technology Division, the lectures will cover the fundamentals of radiometry, a noncontact method for surface temperature measurement used widely in industrial application and trials research. Laboratory experiments with a student-to-teacher ratio of four to one are the main component of the course. Students will participate in problem solving, skill-building laboratory experiments in which they will learn American Society for Testing and Materials voluntary industry standard test methods (E 1256-95). They will gain practical laboratory experience using commercial radiometers and blackbody sources and learn first-hand about the treatment of the measurement equation and proper uncertainty analysis.

Students who participated in the first radiation thermometry short course in May 1997 gave it "very good" to "excellent" ratings. "It really was helpful," says Andrew Clarkson, process engineer for Techneglas of Columbus, Ohio. "If we can't measure temperature correctly, we can't control our process."

Clarkson says he gained a better understanding of the factors that interfere with accurate noncontact temperature measurement and as a result can better select appropriate sensors. Techneglas makes glass parts for television sets. The Columbus plant manufactures a glass funnel that holds a television's electron gun in place and provides the vacuum it needs to operate.

The funnels form in a hot mold, and it is important for the temperature to be uniform and balanced throughout the mold as it presses molten glass into a funnel, Clarkson explains. Funnel production rates can be increased if the molds are cooled efficiently too, he says, but radiant heat from the molten glass can interfere with measuring the temperature of the mold. The NIST short course helped him to account for this interference on the production line. "I think that class was really worthwhile."

The laboratory experiments are a success because the equipment manufacturers lend radiometers and blackbody sources to NIST for participation in the short course. The ASTM Subcommittee E 20.02 on Radiation Thermometry facilitated the organization of this effort.

The fee for the course is $1230. For registration information contact Lori Phillips, B116 Administration Building, NIST, Gaithersburg, MD 20899-0001; tel: 301/975-3881; fax: 301/948-2067; e-mail: lori.phillips@nist.gov.

New Products

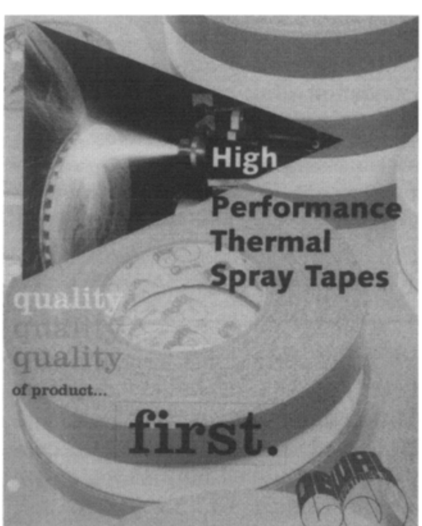
DeWAL Thermal Spray Masking Tapes

A new four-page, full-color brochure detailing the industry's most complete line of high-performance thermal spray masking tapes is now available from DeWAL Industries. There is a tape for every purpose, including HVOF, metal or ceramic plasma spraying, and grit blasting.

DeWAL's thermal spray tapes have been designed to save time and reduce costs. They are free of any carbonizing materials and form a protective mask for metal or ceramic plasma, arc spraying, HVOF, and grit-blasting applications. DeWAL's thermal spray masking tapes withstand rigorous grit blasting and provide protection from overspraying and splash in the coating process. They are strong, yet flexible and conformable—designed to resist punctures and tears. They are easily removed without leaving adhesive residue.

DeWAL thermal spray masking tapes are available in a wide variety of configurations including silicone rubber/Fiberglas, aluminum foil/Fiberglas, Fiberglas, double-ply, and special tapes designed for HVOF applications.

For a free copy of the brochure or more information, contact DeWAL Industries, Inc., 15 Ray Trainor Dr., P.O. Box 372, Saunderstown, RI 02874; tel: 401/789-9736; fax: 401/783-6780.



DeWAL Industries

Wall Colmonoy—New Corrosion-Resistant Alloy

As an exhibitor in the American Welding Exposition in Detroit, MI in April 1998, Wall Colmonoy Corporation, booth 751, will feature Colmonoy 98, a new nickel-base hardsurfacing alloy with resistance to a variety of corrosive aqueous media. Lab tests showed it to have superior corrosion resistance compared to most commercially available hardsurfacing alloys, particularly in sodium hydroxide, deionized water, salt water, and sulfuric acid. Available as a spray-and-fuse powder, applications include automotive piston rings, salt-water slurry pumps, marine and petrochemical components, paper/pulp machinery, and food-processing components.

Contact: Tanya M. Anandan, Marketing Manager, 30261 Stephenson Hwy., Madison Hgts., MI 48071-1650; tel: 248/585-6000, ext. 244; fax: 248/585-7960.

Praxair Introduces New High-Velocity Coating Equipment

Praxair Thermal Spray Products, Indianapolis, IN, and Appleton, WI, introduces the JetStar High-Velocity Air Fuel and FlameStar III High-Velocity Combustion Wire coating systems. The new thermal spray technologies provide high-quality coatings at considerably lower cost and easier operation.

Both systems are designed for a variety of thermal spray wear, corrosion, and oxidation protective coatings applications in a number of industries including gas turbine, petrochemical, automotive, steel, printing, fabrication, and maintenance.

The JetStar High-Velocity Air Fuel (HVAF) system employs the use of liquid fuel and air combustion technology to provide benefits over traditional HVOF devices. Designed to use readily available liquid fuels (kerosene, diesel, or jet) and just compressed air, the JetStar offers significant coating cost advantages as well as other functional advantages including air cooling, compact portable design, rugged construction, and reliable operation.


JetStar High-Velocity Air Fuel

The FlameStar III High Velocity Combustion Wire (HVCW) system is an innovative coating technology that combines the superior coating quality of high-velocity spraying with the convenience and reliability of a wire feed stock. Designed to provide particle velocities and coating quality similar to traditional HVOF, the FlameStar III also focuses on user-friendly features including easy and reliable operation, portable design, and rugged compact construction.

FlameStar III High Velocity Combustion Wire

Contact: Praxair Thermal Spray Products, 1555 Main St., Indianapolis, IN 46224; tel: 317/240-2650; fax: 317/240-2225.

Design Experiments Software for Windows

DESIGN-EASE software for Windows is the package that helps you find critical factors affecting your products and processes. This is version 5—the newest and easiest statistical Design for Experiments (DOE) for engineers, scientists, and industrial researchers.

Created by one of the oldest DOE software houses in the world—Stat-Ease Corporation—DESIGN-EASE v5 generates simple yet powerful, two-level factorial designs. Statistical and graphical outputs from this software often reveal breakthrough solutions. The DOE software offers rotating three-dimensional plots and interactive two-dimensional graphics.

DESIGN-EASE software comes with free technical and statistical support, and an illustrated tutorial makes learning easy. It retail for $395 and can be purchased "on approval" for a free 30-day trial.

For details, access www.statease.com; tel: 800/801-7191; fax: 612/378-2152.

Thermal Barrier Coatings

Nanocrystalline composites of Al_2O_3-ZrO_2 for thermal barrier coatings have been synthesized through four different processes at the Massachusetts Institute of Technology. These composites were evaluated in terms of their densification and ability to retain the metastable, tetragonal zirconia phase.

It was found that physical stabilization of the tetragonal phase is primarily dependent on the microstructure of the material, which is a strong function of the powder preparation method. Significant stabilization of the tetragonal phase after thermal treatments of 1200 °C was achieved with the colloidal processing approach.

Contact: J.Y. Ying; tel: 617/253-2899; fax; 617/253-3122; e-mail: jyying@mit.edu.

Awards Information

1998 AWS Foundation Scholarships

Applications are now available for the 1998 American Welding Society (AWS) Foundation Scholarships.

Each year $5000 is allotted to each of the 22 AWS Districts, for a total of $110,000, to be distributed to worthy applicants.

Each Named Scholarship awards $2500 annually to a student who best meets the selection criteria outlined on the application form. AWS named scholarships are:

- Howard E. Adkins Memorial Scholarship: Awarded to a full-time junior or senior student pursuing a minimum four-year bachelor's degree in welding engineering or welding engineering technology; however, priority will be given to welding engineering students. Applicant must have maintained a minimum 3.2 grade point average in the engineering, scientific, and technical subjects and a 2.8 grade point average overall. No financial need is required to apply.
- Edward J. Brady Scholarship: Awarded to an undergraduate student pursuing a minimum four-year bachelor's degree in welding engineering or welding engineering technology; however, priority will be given to welding engineering students. Applicant must have a minimum 2.5 overall grade point average, provide a letter of reference indicating previous hands-on welding experience, and complete a 200- to 500-word essay on "Why I Want to Pursue a Career in Welding." Proof of financial need is required to qualify.
- Donald F. Hastings Scholarship: Awarded to an undergraduate student pursuing a minimum four-year bachelor's degree in welding engineering or welding engineering technology; however, priority will be given to welding engineering students. Applicant must have a minimum 2.5 grade point average. Proof of financial need is required to apply.
- James A. Turner, Jr. Scholarship: Awarded to a full-time student pursuing a minimum four-year bachelor's degree in business that will lead to a management career in welding store operations or a welding distributorship. Applicant must have a minimum high school diploma and be employed (at least 10 h a week) in a welding store operation or at a welding distributorship at the time the application is submitted.
- Praxair International Scholarship: This is a new scholarship.

Applications available by calling the Foundation office at 800/443-9353, ext. 293.

News from Professional Societies

Cleveland State Gets Promising Results on "Dual Layer" TBCs

Dr. Lee and Dr. Tewari of Cleveland State University (CSU) are investigating advanced "dual-layer" thermal barrier coatings (TBCs) by using refractory oxides as thin intermediate layers between the bond coat and the YSZ top coat to reduce oxidation and enhance bonding performance. They have obtained good adhesion results for the test conducted at CSU, and they are in the process of performing cyclic oxidation tests in collaboration with NASA Lewis Research Center in Cleveland. NASA is also spray coating their samples using HVOF and APS. In addition, they have recently submitted a patent disclosure to CSU based on this advanced TBC concept. For additional information on the project, contact Dr. Kang Lee; tel; 216/433-5634; e-mail: kang.n.lee@lerc. nasa. gov.

AGTSR Program Status

The Advanced Gas Turbine Systems Research (AGTSR) Consortium currently has 93 Performing Member Institutions, representing 37 states, and seven cost-sharing gas turbine manufacturers as Industrial Members. AGTSR has initiated five Research Fund Proposals (RFPs) in collaboration with its Industry Review Board and has supported more than 50 research subcontracts throughout universities in the United States. AGTSR has also hosted ten technical workshops and has sponsored three summer internship programs. They are in the midst of planning another RFP and two new workshops for 1998. The industrial internship program will also be offered for the summer of 1998, and a faculty fellowship program is in works.

Contact: AGTSR Consortium, 386-2 College Avenue, Clemson, SC 29634-5180; tel: 864/656-2267; fax: 864/656-0142; e-mail: dfant@clemson.edu.

Commission of the European Communities Research Grants Call for Applicants

Sponsored by the European Community and hosted by the Technical University of Clausthal in Germany, COPES, Clausthal Centre of Process Engineering Systems-Design and Research offers a wide range of more than 80 facilities for research in the Natural and Engineering Sciences. The research activities united under COPES aim to develop new environmentally friendly processes applying advanced technologies and their industrial implementation. The TMR-Programme of the European Commission gives European researchers the opportunity to take advantage of this unique constellation.

Travel, accommodations, and daily allowance are provided. Applications are welcome from European academic or industrial researchers until April 1999.

Description of program and research facilities: http://www.imw.tu-clausthal.de/copes.html.

Contact: COPES Administrative Secretary, Gerhard-Rauschenbachstr. 4, D-38678 Clausthal-Zellerfeld; tel: 49-5323-9693-11; fax: 49-5323-9693-99; e-mail: copes@tu-clausthal.de.

Metallizing, Zinc Phosphate, and MIO are European Tools

Preferred coating systems in Europe differ from those commonly used in the United States, Switzerland, Germany, and the Netherlands typically specify multicoat paint systems that consist of primers pigmented with zinc phosphate and topcoats formulated with micaceous iron oxide (MIO). The United Kingdom uses thin coats of aluminum metallizing covered by multiple topcoats of epoxy, urethane, or silicone alkyd.

Recommendations for maintenance of paint systems are typically based on exposure environment, accessibility, and required durability. The report details the types of coating systems used in the host countries and reviews the prequalification of coating materials in the United Kingdom.

Based on the experiences shared by representatives of the European highway industry, the report identifies the following six areas of European bridge maintenance for further examination by team members.

- Bridge maintenance warranties
- The use of metallizing for bridges
- Soil and air monitoring practices
- Contracting and quality assurance procedures
- The use of zinc phosphate and MIO-pigmented coatings
- Past use of coatings containing polychlorinated biphenyls on highway structures

For more information about this report, write the Federal Highway Administration, Publishing and Visual Communications Branch, 400 7th St., S.W., Washington DC 20590; fax: 202/366-7079; refer to publication number FHWA-PL-96-031 HPI-10/1-97 (1M) E.

NACE Corrosion Network List Server

Sponsored by NACE International—The Corrosion Society, the goal of this new list server is to facilitate communications among professionals working in all facets of corrosion prevention and control—from coatings and linings and cathodic protection to materials and chemical inhibitors.

To subscribe, send an e-mail message to majordomo@nacecorrosionnetwork.com. Type "subscribe nace" in the text of the e-mail message.

If you have questions regarding the NACE Corrosion Network, e-mail: webmaster@mail.nace.org. You can also find e-mail addresses for numerous NACE departments and services by visiting the NACE website at www.nace.org, or call NACE at 281/228-6200.

NACE Technical Committee Discussion Groups

Now is your chance to get involved and get ahead by signing up for one of the new NACE Electronic Discussion Groups. Discussion groups are easy to use, all you need is internet access and an e-mail address.

Currently scheduled groups include:

- Aerospace/military equipment
- Cathodic protection
- Chemical processing
- Computer applications
- Concrete/rebar
- Coatings and linings
- Corrosion science
- Energy/power
- Marine corrosion
- Petroleum production
- Petroleum refining
- Pipelines and tanks
- Pulp and paper
- Solid waste
- Transportation
- Water and wastewater

To sign up, either send an e-mail message to NACE Headquarters, shelley@mail.nace.org, or go through the NACE home page at http://www.nace.org.

International Conferences on Thermal Spray Reflect Emerging Markets for Thermal Spray Applications

Elliot Sampson of TAFA, the only U.S. representative at the first International Thermal Spraying Seminar (ITTS) held in Haikou, China, 17 Nov 1997, reported that the event drew 70 participants—many of them very high level thermal spray personnel. He noted that, "This was an excellent turnout, considering the size of the thermal spray industry here, which is growing. With privatization, many of the people in China who were formerly in government research positions have become owners of thermal spray job shops, with two or three job shops located in each major city. They are eager to acquire new information on thermal spray and very interested in the presentation I made on 'Thermal Spray Technology Trends.' The 1 h presentation was followed by a discussion of trends for industries such as aircraft, automotive, diesel and job shop industries. Although they do not have the depth of information that we have, they are very up-to-date on articles, and they are already using HVOF and high powered PlazJet."

ITSA associate member companies that have now established a presence in China include TAFA, Sulzer Metco, and Praxair.

K. Kasai of KASAI International of Japan also presented a paper prepared with Masahiro Nakagawa of Sulzer Metco Japan. Mr. Kasai said that Japan-Korea and Japan-China thermal spray conferences were held last summer, and that a Japan-Korea-China conference is tentatively planned for 1999. ITTS'98 will be held in Wu Xi city in Oct 1998.

Another international conference—The Society for Protective Coatings (SSPC) International Conference in San Diego in Nov 1997 drew 3200 coating professionals, from 30 countries, to the four-day event at the San Diego Convention Center. The conference covered all aspects of corrosion control of steel, concrete, and other industrial substrates and included 11 seminar sessions with 60 presentations. Eighteen tutorials provided the framework for education and training. SPPC will hold the 1998 International Conference in Orlando, FL, on 15-19 Nov 1998 and has issued an invitation to submit paper and tutorials.

One of the emerging market areas for protective infrastructure coating is their proactive application at the OEM or preventative stages. According to infrastructure coatings expert Albert Kay of ASB Industries, ASB is now largely focused on coating components such as bridge expansion joints for OEM's, but he emphasizes that the new, easier-to-use and/or on-site thermal spray equipment produced by such manufacturers as TAFA and Thermion have made coating maintenance procedures for existing structures easier and more cost effective. Acceptance, he noted, is also growing among DOTs.

Mr. Kay is among the speakers listed in the newly published ITSA-TSS Speaker's Directory who is available to speak to groups on the subject of protective corrosion-control coatings for infrastructures.

For a copy of the ITST-TSS Speaker's Directory, contact Kathy Dusa, ASM TSS; tel: 440/338-5151; fax: 440/338-4634; e-mail; kmdusa@po.asm-intl.org.

TSS Committee Chairs Named for 1997-1998 Term

Robert C. Tucker, Jr., FASM, Corporate Fellow & Director, Business Development, Praxair Surface Technologies, Inc., Indianapolis, IN, has been appointed President of the Thermal Spray Society Board.

The ASM Thermal Spray Society will be the leading member-driven, international society for thermal spray to foster communication, information development, technology advancement, education, and scientific understanding.

Richard Mason, vice president, Metal Powder Sales and Marketing, Specialty Metal Products Division, AMETEK, Eighty Four, PA, has been appointed chair of the TSS Industry Development and Liaison Committee.

The TSS Industry Development and Liaison Committee supports the Thermal Spray Society vision and mission by developing high-quality marketing and public relations programs that enhance the thermal spray industry image as measured by new industry outreach accomplishments, growth of society membership, and society member satisfaction.

Mark F. Smith, FASM, senior member of Technical Staff, Sandia National Laboratories, Albuquerque, NM, has been appointed chair of the TSS Information Development/Delivery Committee.

The TSS Information Development/Delivery Committee will develop, compile, and disseminate relevant, high-quality accessible information in a timely fashion consistent with the needs of the thermal spray and engineering community. It will conduct and support efforts in education, information of topical interest, broad-based information of enduring interest, and detailed information of immediate interest for specific applications. It will draw on the available expertise to ensure that committee efforts are relevant to the community and consistent with Society goals.

John P. Sauer, Manager, Metallography, Failure Analysis and Central Coatings Lab (CCL), Metcut Research Associates, Cincinnati, OH, has been appointed chair of the TSS Recommended Practices Committee.

The TSS Recommended Practices Committee formulates a format and central system for the development of standards, specifications, and best practices that directly/indirectly affect the thermal spray discipline. It creates a vehicle/forum for discussions on both a domestic/international level to gather input/direction on the areas that require standards/specification and provides a standard format for development and writing of best practice/specification documents.

Paul A. Kammer, FASM, senior executive, Eutectic + Castolin Group, Flushing, NY, has been appointed chair of the TSS Program Committee.

The TSS Program Committee provides the leading forum for the exchange of information in the thermal spray community via technical programs, proceedings, and expositions at TSS-sponsored events and activities and to provide incentives for excellence in the research, development, and commercial fields of thermal spray through appropriate awards and other means of recognition.

Richard Knight, research professor and CPPM director, Center for the Plasma

Processing of Materials (CPPM), Drexel University, Philadelphia, PA, has been appointed chair of the TSS Training Committee. The TSS Training Committee is to develop, deliver, and support training programs that will best serve the needs of the thermal spray industry and its personnel and to develop educational materials for training and administer operator and technologist programs.

WWW Information

Downloadable Safety Information from New Zealand

SafetyNet, the website of Occupational Safety and Health (OSH) Service of New Zealand's Department of Labour, includes a catalog of standards and guidance documents at http://www.osh.dol.govt.nz/order/catalogue/index.html. A number of documents related to industrial maintenance painting, including solvent hazards, confined space work, respirator use, and lead-base paint removal, can be downloaded at no cost.

In addition to these publications, SafetyNet includes information on local OSH offices, regulations, and training resources. This information can be accessed from the home page at http://www.osh.dol.govt.nz/index.html. (From JPCL, January 1998).

Regional Network for Asia-Pacific Worker Health

The Asian-Pacific Regional Network on Occupational Safety and Health maintains gopher servers of information from countries participating in the Asian-Pacific Regional Programme on Occupational Safety and Health.

The servers can be accessed at http://www.nectec.or.th/bureaux/un/asia-osh/. Information is submitted to the servers from the International Labour Offices of participating countries. Each server includes files of documents such as research articles or training guides that can be read online. Server files organize information by technical area or country. Server for information on national and international standards and profiles of the agencies from each participating country are also included. In addition, articles published in the organization's newsletter are available. (From JPCL, January 1998).

Reduce Search Time by Visiting These Sites

For additional information about occupational health and safety resources from the Web, users should visit these sites:

- Users who find it frustrating to search through government agency sites for information relevant to industrial maintenance painting will welcome a new feature at the Construction Safety Council (http://www.buildsafe.org/cschome.htm) home page. The "Construction Compliance Hotlinks" provide customized links that guide users through the websites of U.S. OSHA, National Institute for Occupational Safety and Health, and Environmental Protection Agency and lead them to information directly relevant to the construction industry. Regulations such as OSHA's lead-in-construction standard as well as compliance assistance information can be accessed through the links.
- OSHWEB, a site maintained by the Institute of Occupational Safety Engineering at Tampere University of Technology (Tampere, Finland), is an index of Web resources for occupational safety and health information from around the world. Located at http://turva.me.tut.fi/~oshweb/ the English-text link page has the websites indexed by topics such as chemical safety, government agencies, and information services. Double-clicking on one of the general topics will provide a list of websites that address that topic.

(From JPCL, January 1998).

Web Offers Connection for International Marine, Shipyard News

Because ships travel through international waters, it is important for members of the shipbuilding industry to have an awareness of legislation and research from around the world.

The International Maritime Organization (IMO) is the United Nations agency responsible for improving maritime safety and preventing pollution from ships. Among IMO's current projects is a study on the environmental impact of antifoulant coatings that contain tributyl tin (TBT). According to a meeting summary available at the agency's website (http://www.imo.org), the committee is discussing the development of regulations that will restrict or ban these coatings. A report of IMO's Marine Environment Protection Committee can be accessed at http://www.imo.org/imo/meetings/mepc/mepc403.htm.

IMO's site also features the "Current Awareness Bulletin Index," accessible at http://www.imo.org/imo/Library/nov97cab.htm#7. The index, which is updated monthly, contains titles of articles published in the legal and technical press that are related to the maritime industry. The index appears in "Frames" format, and users can scroll through the index on the left side of the screen, which is organized by date and subject. By clicking on the link of interest, users are presented with a list of articles and publication information on the right side of the screen.

Users can also read summaries of treaties adopted by IMO. An index of treaties, referred to as "International Conventions," appears at http://www.imo/convent/index.htm. The index is organized by subject.

IMO's website is presented in English text; French and Spanish text versions of the site can be accessed from the home page. The site includes a page of links to other maritime organizations, located at http://www.imo.org/imo/links/links.htm.

NSNet, a site established as a Defense Advanced Research Projects Agency (DARPA) MARITECH project and maintained from the University of

Michigan, offers educational materials, news, and discussion groups for members of the maritime industry. The site's home page is located at http://www.nsnet.com.

The site's different pages can be accessed by clicking on a topic listed in a bar in the left side of the home page. Of particular interest to members of the protective and marine coatings industry are the following features:

- The Documentation Center allows users access to technical and nontechnical information related to ship design and production research and applications. An on-line catalog provides bibliographic information (including an abstract) for all documents and audiovisual materials housed at the Documentation Center. Access to the catalog is open to everyone by clicking on the "Search the Catalog" button. Electronic documents are available to NSNet users in the United States only at no cost. Users must register for a password to download documents by clicking on the "Register for Password" button. The downloadable documents are published in PDF format and can be viewed using Adobe Acrobat, a reader program that can also be downloaded for the site at no cost. Documents published by the National Shipbuilding Research Program (NSRP), the Maritime Administration, the U.S. Navy's Naval Sea Systems Command, and other agencies are available. Searches can be conducted by a number of parameters, including publisher, keyword, author, and title.
- Users can join on-line discussions with industry members by visiting the "Discussion Groups" page. Groups have been developed for a number of topics, such as environmental issues and ship manufacturers. Groups related to NSRP's technical panels, including SP-3 on Surface Preparation and Coatings, can also be accessed. Instructions for joining discussion groups are included on the page.
- NSRP's home page is also located within NSNet and can be accessed from the NSNet home page or by directing your browser to http://www.nsnet.com/nsrp/. The page provides background information about the program and its technical panels, as well as a calendar of the organization's activities.
- A calendar of events, a maritime glossary, and a link page are also included at the site. The link page includes a convenient search engine that allows users to find other maritime websites that have information about a particular topic.

As explained at its website, the Japanese organization Nippon Kaiji Kyokai, known as ClassNK or NK, publishes universally recognized standards for the design, construction, and maintenance of ships. Class NK's mission is to protect "life and property at sea and prevent marine pollution." The organization maintains a website with text in English and Japanese at http://www.classnk.or.jp/.

The site features information on technical studies and rule amendments. In addition, users can access a catalog of publications by clicking on the "Publications" button on the left side of the page. The catalog includes titles of standards, the date of publication, and the price in U.S. currency.

The following pages offer additional links to sites of interest to the shipbuilding and repair industry:

- The Naval and Maritime World Wide Web Virtual Library (http://www.iit.edu/~vlnavmar/)
- The World Wide Web Virtual Library for Naval Architecture (http://www.vl.naoe.ish.dtu.dk/)

(From JPCL, February 1998).

Discussion Topics and Threads on Thermal Spray

These questions and answers were extracted from the discussion group of the Thermal Spray Society of ASM International. During the three months of activity that were used to collate this summary, nearly 350 e-mails were submitted for discussion and comments. The comments has been edited for form and content. Note that the comments have not been reviewed. Any further discussion can be submitted to the Editor of JTST.

A note from the ASM Manager of this service.

Congratulations! The Thermal Spray discussion list is now one year old! Since its start as a subcommittee project of the Thermal Spray Society Information Development and Delivery Committee, this e-mail discussion list has grown in just one year to 323 subscribers. Participants come from the United States, Australia, Europe, South America, and well ... you know where you are. This list is truly international in its scope and discussion.

We're working on an anniversary article for some of the printed newsletters—if any of you can cite how this list has saved you time, money, or been of service to the thermal spray community over the past year, please send me your comments at the e-mail address below. So what do we do for an encore in year 2? We've kept both the electronic text and a printout of all the messages, which now easily fills a 3 in. binder. My hope is to take this archive of all the past (and future) discussions and make them searchable via the website. After all, there's been a lot of good information sharing over the past year that we don't want to lose!

And of course, if there are things you'd like to suggest to improve the utility and content of this list or any other Thermal Spray Society activity, please feel free to contact either myself or Kathy Dusa at kmdusa@po.asm-intl.org at ASM headquarters.

Happy Birthday!

Leslie Hayton Chom, LHChom@po.asm-intl.org, Manager, On-line Services for ASM International; tel: 440/338-5151, ext. 510; fax: 440/ 338-8629. Visit ASM's web site at http://www.asm-intl.org.

Question 1—Spraying of PZT: Does anyone know of any references on the thermal spraying of PZT (Lead Zirconate Titanate) please?

Answer 1.1: The following are three references about PZT.

- J.F. Fernandez, E. Nieto, C. Moure, P. Duran, and R.E. Newnham, Processing and Microstructure of Porous and Dense PZT Thick Films on Al_2O_3, *J. Mater. Sci.*, Vol 30, 1995, p 5399-5404
- H.-J. Gesemann, L. Seffner, and A. Schönecker, PZT-Dickschichten auf Al_2O_3, *Fortschrittsberichte der Deutschen Keramischen Gesellschaft: Werkstoffe, Verfahren, Anwendung*, DKG/DGM Symposium—Keramische Schichten, Deutsche Keramische Gesellschaft, Koblenz, BRD Vol 10 Heft 4, 1995, p 213-224
- W. Hässler, K. Fischer, G. Eckart, and A. Oswald, Herstellung und Eigenschaften von plasmagespritzten PZT, *Schichten Thermische Spritzkonferenz TS 93*, Deutscher Verlag für Schweisstechnik DVS-Verlag GmbH, Düsseldorf, Aachen, 1993, p 421-423

Question 2 - Air Supply Problems: I have a captive 20 to 25 cfh air compressor and an Ingersol refrigerated air dryer hard piped about 8 to 10 ft downstream from the air compressor. The air is hard piped to the spray cell with no flexible hose until the air is distributed to the gun and air coolers. During a snow storm, I noticed a lot of water being injected out of the pinched air jets. It appeared that there was very little water being diverted out of the dryer, it was going right through it. I reported this to the maintenance department. We cleaned out the exit filter on the dryer; it was full of dirt, oil, and metal shavings. The foreman called the compressor company, and they felt a change in humidity and temperature could cause the problem and that water could be condensing in the black pipe after it leaves the air dryer. Can anyone comment on this problem?

Answer 2.1: That's why many people use nitrogen instead of air—a cheap noncryogenically produced N_2 with a few percent of oxygen impurity or a more expensive cryogenically produced (O_2-impurity free) N_2.

Answer 2.2: I am working in a spray shop that is connected to a very large machine shop. The distance between the spray shop and the large-scale air compressor is more than 150 m. The main air pipe lays underground, so it is protected from the cold frosty weather during winter. Between the air dryer (which is located in the spray shop building) and the spray equipment, we have around 50 m more of air supply pipe. Nevertheless, we do not have condensation of water in the pipes.

Answer 2.3: Till you solve the problem you may try mechanical oil/water separators that you connect in line to the spray equipment.

Answer 2.4: The compressor is supposed to compress the incoming air, thereby removing most of the water vapors. There must be a drain valve of some type (either manual or auto) in your holding tank or near to its bottom. Water must be removed from this tank before distributing the lower humidity air downstream.

Answer 2.5: I suspect your dryer is the refrigerated type. That dryer is only capable of a 35 to 39° pressure dew point. Do your air lines pass outside or near a wall that could have been less than that temperature? That will cause condensation in your air lines even though the dryer is working properly.

Question 3—Plasma Kilowatt Performance: How can I check whether a plasma gun achieves 45 kW?

Answer 3.1: The simplest way is to measure the arc voltage (very carefully after the plasma has been ignited, so the HF won't destroy your voltmeter) and the arc current (using a good clamp-on ammeter) and multiply the two together to give you watts and then divide by a thousand to find kW. Arc voltage is best measured as close to the gun as possible, to eliminate voltage drops across cables, etc. This of course presupposes that the load is purely resistive, which in reality it is not, but this will be close to what gun manufacturers quote. Strictly you should use a proper, integrating wattmeter, which can account for phase relationships and the nonsteady waveforms (form factors) of the V and I, but that is a much more involved measurement.

Question 4—Sealing Spots on Coatings: Some of the sleeves we make are coated with Al_2O_3. They are sealed after cooling with a phenolic sealer and are then diamond-ground to final size. For the past six months, we have been experiencing small (0.5 mm) sandy-colored spots on the ground surface. There are perhaps 50 to 100 spots on a sleeve 10 cm diameter by 40 cm long. One of our customers actually rejected a sleeve for appearance. The powder from the manufacturer appears uncontaminated. My sprayers seem to feel the fault is in the phenolic, although we have thrown out the old phenolic, ordered a new batch, and it still appears. Has anyone experienced problems such as this?

Answer 4.1: If phenolic sealer seems to be leaving spots on the ceramic overcoat, try this; maybe it will help. Take a fresh can of the phenolic sealer and pour it into a clear jar. Observe whether you see any settling of solids or separation of the liquid into two colors. If so, maybe vigorous mixing (as at a paint store) could help. Also, ask when the sealer was actually made. I think the phenolic solution darkens gradually over time.

Answer 4.2: Phenolic varnish similar to your sealer was used as a binder in making a "nickel-aluminide"-type composite powder. A 55 gal drum (horizontal with a spigot) was kept outdoors and the phenolic would be poured out into a bucket when it was needed. After a long time, the viscosity and color seemed to change.

Question 5—Safety in the Booth: We will be operating a thermal spray process in a production capacity. My concern is personnel safety. What type of measures, if any, are commonly implemented to ensure no one is (or can be) in the booth during operation? We have discussed infrared motion detectors, light curtains, and photoeyes as possibilities. Any comments or suggestions would be appreciated.

Question 6—Application Information Needed: Is there any information regarding the use of thermal spray materials for supercritical water applications? The normal operating temperature would be 650 to 700 °C, and the fluid would be an organic material dissolved in a NaOH solution (~10 to 20% caustic). During the reaction the pH can change from 14 to 2. Liquids are present within this pH range in the critical temperature of the reactor. Is there information regarding the use of yttria-stabilized zirconia, titania, or any other ceramic that could be used in this application? The substrate material is either zirconium or a nickel-base alloy such as 276 or C-2000.

Question 7—Application for Arc Sprayed Coatings: I am trying to find which metal arc spray coatings, if any, are suitable for constant immersion in hot, slightly alkaline water.

Question 8—Application for Corrosion Resistance: I am looking for a coating that will provide long-term corrosion protection for the interior of a large steel tank that is used to hold extraction water at a fairly constant temperature of 200 °F. The water has a pH of 8.0 to 8.3, total dissolved solids = 1160 ppm, total suspended solids = 450 ppm, alkalinity (i.e., $CaCO_3$) = 692 ppm, hardness (i.e., $CaCO_3$) = 57 ppm, chlorides = 20.6 ppm, sodium = 305 ppm, and dissolved oxygen = 1 ppm.

Question 9—Nondestructive Testing: I am involved in the thermal spray deposition of a nonferrous, low-density coating onto an aluminum substrate of tubular geometry. I would like to know whether there is a nondestructive technique that can assess the bond properties between the coating and the substrate. Perhaps some sort of ultrasonic test?

Answer 9.1: There is a technique to determine the adhesive strength of chromium on copper substrates by ultrasonic c-scans. Results were compared with those from a standard tensile pull test (ASTM C 633-79, EN 582:93), and a reasonably linear relationship with respect to the adhesive strength was found. This technique is time consuming and tedious because a separate calibration curve must be developed for each substrate/coating combination. The technique has been described in:

- R.B. Heimann, *Plasma-Spray Coating, Principles and Applications,* VCH Weinheim, NY, 1996, ISBN 3-527-29430-9, p 257-261

Question 10—Spraying of Stainless Steel: We have 24 to 30 in. diam by 12 ft long metal cylinder with a very rough outer surface. We would like to spray stainless steel to 0.25 in. thickness at a rate of more than 20 lb/h. The operation is in air, and the substrate is at ambient temperature. If needed, the substrate may be heated to 1000 °F. Please recommend specific equipment.

Answer 10.1: Your requirement of 20 lb/h is likely not achievable by any current, established powder spray technique. The closest you could get to this rate would be to use wire-arc spray of stainless steel wire, not powder. A thickness of 0.25 in. is also limiting, so you may have trouble there too. The rough outer surface you mention may also fit better with wire arc. You are going to end up with a lot of material on a piece that size, so residual stress, cooling, and the like are going to be potential areas of concern with regard to cracking, etc.

Answer 10.2: Such rates are easily achievable by WSP technology (water-stabilized plasma at 160 kW input power and powder feedstock). With this system you can spray up to 200 lb/h. There are some limitations of this technique, but generally you can spray and achieve adhesion and porosities that are the same as with usual plasma spray techniques (APS) techniques.

Answer 10.3: If you are spraying martensitic stainless steel, wire arc spray will do the job. The deposition rate of arc spray could easily reach 30 lb/h. Arc sprayed martensitic stainless steel coatings generate relatively low stress, and 0.25 in. is not a difficult thickness for such coatings. You will encounter cracking problems if you want to spray austenitic stainless steels. Preheating may solve the problem.

Question 11—Effect of Carbide Distribution: Does anybody have theoretical and/or experimental experience on the effect of carbide size/distribution of thermal spray cermet coatings on the mechanical properties, particularly wear properties? I believe, by and large, that the finer the carbide size, the more wear resistant the materials. Is this true for thermal spray cermet coatings? If yes, is there any experimental work, or are there any aspects that exclude the thermal spray cermet coatings from general trends?

Answer 11.1: I have examined the effect of carbide size on the extent of decomposition and fracture behavior of a wide variety of WC-Co coatings and have related it to the abrasion rate of these coatings. I found that, in an oxidizing flame, the extent of decomposition of the WC (to W_2C, W_3C, CoW_xC_y, etc. phases) is correlated to the exposed carbide surface area in the powder. For example, if one starts with a powder that has a fine size distribution and 12% Co and another with 17% Co, the former will have a higher exposed carbide surface area, thus, allowing for a greater degree of decomposition in an oxidizing flame. The decomposition products normally segregate to the interface between the carbide and the cobalt or between the various lamellae. These products are normally more brittle and allow for easier crack propagation. Hence, in gist, I found, as opposed to the case of sintered WC-Co that: (1) the abrasion resistance of thermal spray WC-Co is more dependent on the indentation "interlamellar crack length" than the hardness of these coatings, and (2) a finer carbide size does not necessarily mean better wear resistance because decomposition of the carbide can lead to poor fracture strength of the coating. Some of this work is published in the following:

S. Usmani, S. Sampath, D. Houck, and D. Lee, Effect of Carbide Grain Size on the Sliding and Abrasive Behavior of Thermally Sprayed WC-Co Coatings, *Tribol. Trans.*, Vol 40 (No. 3), 1997

Answer 11.2: The wear resistance of sprayed cermets is most sensitive to the degree of chemical reaction that has occurred, and this is affected by particle size and many other factors. Some details are given in the latest *Proceedings of the Thermal Spray Conference* (ASM International, C.C. Berndt, Ed.), p 681.

Question 12: What is the "Rokide" Process?: I have come upon an application that requires the application of a "Rokide C" coating, or an equivalent. As far as I could find out, this refers to a flame sprayed chrome oxide coating. Is this correct, that is, is it possible to spray ceramic materials with such a system? How would this coating compare with a good-quality plasma sprayed chrome oxide?

Answer 12.1: Rokide C is a flame-deposited chrome oxide coating. It is much like the wire flame spraying process. However, a ceramic rod is used rather than feeding metal wire into the flame. The process has been used since the mid 1950s. It produces very hard, wear-resistant coatings. All the atomized particles are melted into droplets.

Question 13—Spraying onto Organic Materials: I am trying to find a way to gently coat organic materials with metal, preferably copper or brass. Flower petals and whole flowers are my main goal. The electroplating route I'm using now is slow and tedious, not to mention of low yield. Has anyone accidentally (or intentionally) sprayed a tree or a vine or, especially, leaves or flowers? Can the spray be "tuned" to a gentle mist?

Answer 13.1: We coat organic materials too, but ours are plastics. The method we use is called electroless plating rather than electroplating. It may be a useful method. I have seen flowers with metal coatings on them (or maybe it is just gold-colored paint!); however, I don't know how it is done. Sputter coating could also be used; however, the equipment is quite expensive and I am not sure if you would get the whole flower coated as it is a "line-of-sight" method.

Question 14—How to Measure Wetting Angle: We measure the surface roughness to characterize the nonstick properties of a coating. But in the moisture media, it seems to be important to know the wetting angle of our coating surface. What techniques and methods are available to characterize the wetting angle of coatings?

Question 15—Emissivity Data: Can anyone tell me where I might find emissivity data for thermal sprayed coatings? My initial thoughts are to use a polished white alumina coating for a low-emissivity coating.

Answer 15.1: The correct coating for the application depends on the wavelength(s) of light for which the customer requires low emissivity. Alumina that is white to the eye is in fact close to black for infrared light at wavelengths of greater that about 8 μm. In fact, virtually all ceramics tend to high emissivities at wavelengths greater than about 8 μm. Polished metal is a much better reflector at these high wavelengths than are ceramics. More information is required before an appropriate coating can be selected for the application.

Answer 15.2: Several papers have been published that provide some emissivity data. Although there are others, two references for data on plasma sprayed beryllium, boron, and boron carbide are:

- Advanced Infrared Optically Black Baffle Materials, SPIE, Vol 1330, *Optical Surfaces Resistant to Severe Environments*, 1990, p 164-177
- Advanced Baffles: Knife-Edged Diffuse-Absorptive and Dual Reflective Baffles, SPIE, Vol 1753, Stray Radiation in Optical Systems II, 1992, p 196-209

Question 16—Spraying of Titanium: Does anyone know of a thermal spray process using titanium powder? We are interested in spraying titanium, but are concerned about its reactivity with ambient oxygen.

Answer 16.1: Electric arc wire and plasma powder spraying of titanium has been described in proceedings of thermal spray conferences. A low-pressure atmosphere environment; for example, argon, is required to obtain purely metallic deposits, but good, hard composite coatings can be achieved by air-environment spraying of titanium (mixed with other metals) using N_2 gas.

Question 17—How is Deposit Efficiency Measured?: I need to measure deposition efficiency. I thought of using feed rate and the time of spraying to measure the amount of powder used, and then measuring the weight of the coating by taking the weight difference of the substrate before and after spraying. However, I was told that this measures target efficiency.

Answer 17.1: To measure either target efficiency or deposit efficiency, one determines the ratio of the powder accumulated on a target to the powder delivered to the target (powder feed rate times time spraying). The difference lies in the way the spray gun is moved over the target during the spraying. If the gun is held over the target at a 90° spray angle for the prescribed time, the ratio is the deposit efficiency. If the gun is moved back and forth over the target, including moving off the target and perhaps varying the spray angle, the resulting ratio is the target efficiency. Measured this way, the deposit efficiency is, therefore, not a function of the gun manipulation and only of the spray parameters.

Answer 17.2: The target efficiency varies with the motion of the gun and can be much lower than the deposit efficiency. This is due to the time spent spraying both off the target (and thus spraying into space) and off angle. The target efficiency is the practical number and describes what happens when spraying real parts. There are some things you will need to be careful about during the measurements.

1. Watch your temperatures to make sure they are characteristic of the actual application.
2. Be careful in measuring the powder feed rate. Make sure you capture all of the powder sprayed.
3. Measure the time accurately spent on the target.

Question 18—Alloys for Mold Manufacture: Are there any references on the alloy compositions and suitability of arc spray materials for mold making in the shoe industry?

Answer 18.1: Materials available for mold manufacture are typically low melting point and include tin- and zinc-base materials. They are relatively soft. Higher-melting-point materials such as copper and aluminum are a little more challenging due to the shrinkage upon cooling. If you have plasma spraying equipment, you may be interested in using higher-melting-point materials such as iron, nickel, Ni-Al, and Ni-Cr-B-Si. It is more difficult, but the end result will definitely give you a higher hardness. Molds made of these materials have been used in the rubber, glass, and plastics industry. I can refer you to an article published in *J. Therm. Spray Technol.* titled "Mold Manufacture with Plasma Spraying," by K.A. Gross and A. Kovalevskis, Vol 5 (No. 4), 1996, p 469-475.

Question 19—Protection against Molten Aluminum: I'm looking for a coating against molten aluminum. Work with magnesium oxide/zirconium oxide (magnesium zirconate coating) by plasma spraying were not that good.

Answer 19.1: Dense graphite or SiC-surface treated graphite, pure Y_2O_3, some types of ZrO_2-Y_2O_3, Al_2O_3-MgO-ZrO_2-type alloy oxides (like magnesium zirconate you mentioned), simple alkaline and alkali-earth metal fluorides, TiN, as well as TiB_2 are all to some extent resistant to molten aluminum under certain conditions, but each carries certain drawbacks. Some form protective reaction films (for example, stainless steel forms Cr_2O_3 on oxidation), but the stability of these depends on kinetics. All traditional mixed-oxide refractories will fail if they contain transition metal impurities such as FeO or Cr_2O_3.

Question 20—Deposition of Hydroxyapatite: I would like to APS deposit hydroxyapatite (HA) onto small titanium alloy dental implants. The process instruction specifies the following preparation of the implants: (1) grit blast (using white alumina, etc.), (2) soak 20 min in hot nitric acid (diluted to 30% using water), (3) neutralize in a cold carbonate solution, and (4) rinse in deionized water. Ostensibly, this is to "passivate" the surface. I have, however, been unable to find out why this was specified and what it is supposed to achieve. It is done at significant cost. Any remarks/suggestions would be most welcome.

Answer 20.1: The process you described is used to clean and condition the surface for proper adhesion of the subsequently deposited coating. If you choose not to do the above, then the deposited coating will be neither of uniform nor high bonding strength.

Answer 20.2: I believe that the described procedure chemically inactivates the titanium alloy substrate prior to plasma spraying of the HA material so that no reaction between the two occurs, and bonding of the HA coating system remains high.

Answer 20.3: The thermal spraying of hydroxyapatite is littered with company secrets on their approach in producing a good coating. During my involvement with hydroxyapatite over the last ten years, it has become apparent that independent studies produced different results, forming the performance philosophies of how hydroxyapatite should contribute to the successful integration of the implant. You will find very little in the literature on the interface between hydroxyapatite and titanium. The previous comments on this topic, in essence, all have the right idea. Hydroxyapatite does not need a bond coat like other systems. A requisite priori is that a thin oxide layer be on the surface of the titanium, so that upon deposition of hydroxyapatite, a perovskite reaction layer is created that in essence provides the bonding. One means of producing this oxide layer is through the method that has been described to you. If we move further into the coating, you need to avoid the amorphous phase, which can lead to loss of coating integrity during its function. You can find a more detailed discussion of these issues in the following four papers:

- K.A. Gross, C.C. Berndt, D.D. Goldschlag, and V.J. Iacono, In-Vitro Changes of Hydroxyapatite Coatings, *Int. J. Oral Maxillofac. Implants,* Vol 12 (No. 5), 1997, p 589-597
- K.A. Gross, V. Gross, and C.C. Berndt, Thermal Analysis of the Amorphous Phase in Hydroxyapatite Coatings, *J. Am. Ceram. Soc.,* Vol 81 (No. 1), 1998, p 106-112
- K.A. Gross, C.C. Berndt, and H. Herman, Formation of the Amorphous Phase in Hydroxyapatite Coatings, *J. Biomed. Mater. Res.,* Vol 39 (No. 3), 1998, p 407-414
- K.A. Gross and C.C. Berndt, Thermal Processing of Hydroxyapatite for Coating Production, *J. Biomed. Mater. Res.,* Vol 39 (No. 4), 1998, p 580-587

Question 21—Safety Issues with Nickel-Aluminum: Does anyone have experience with Ni/Al coatings? We suspect there may be some risk of explosion in our dust collector.

Answer 21.1: Here is some information for your consideration. (1) Plasma powders are too coarse to be considered explosive (however, the MSDS does warn of an explosion hazard). (2) The plasma spray process heats the aluminum powder to a molten state and any overspray (particles remaining airborne that end up in the dust collector) turns into a harmless aluminum oxide dust (not associated with any risk of explosion). (3) Although powders with high aluminum content are considered to be an explosion hazard, powders with lower aluminum content are considered safe. There does not appear to be any documentation that indicates the threshold level of aluminum, above which the powder becomes explosive.

Question 22a—Removal of Coatings: I would appreciate the group comments on the subject "To what extent the presence of the old residual sprayed coating may reduce the adhesive strength of the new coating."

Question 22b: We are looking for information regarding the same problem. We deal in turbine engine parts (wall thicknesses of 30-50 thousandths) and are having no luck in finding a reliable method to remove all the coating. Our problem coating is a NiCrAlY bond coat that we need to remove to ensure a quality weld repair of the base material, Hastelloy X. Because of the thin walls, abrasive removal methods cause more distortion than we can permit. Also, the NiCrAlY is tougher than the base material and leads to dramatic erosion of base material. The next method attempted was chemical removal by attacking the aluminum with HCl in an agitated bath. This loosened most of the NiCrAlY, but still required a mechanical method to finish the job. The HCl also attacked some of the welds in our parts. Our latest method is to try water-jet removal. Overall this appears to be the most promising, but leaves residual coating in places where the nozzle cannot get direct access. Any ideas on how to eliminate the residual coating would be greatly appreciated.

Answer 22.1: The rule of thumb is to remove any traces of residual coating prior to applying any new material. In my shop, on new parts being resprayed for whatever reason, you cannot spray over old coating. The reason being there is a very real possibility that the old coating will fail under the new coating.

Answer 22.2: There are times when we cannot remove 100% of the old material due to geometry and dimensional considerations. Since the material in question is usually a self-bonding restorative, NiAl or NiCrAl, the fear of failure is not as great, but it is there nevertheless. But if the choice is scrapping the part or crossing your fingers, we'll go for the repair. We also have quality control and visual inspection so the chances of a failed coating getting by us is slim.

Answer 22.3: Any substrate must be suitably prepared prior to thermal spray coating application. Thermal spray coatings, even the toughest of the self-bonding materials, must be removed by machining, dry abrasive blast, or water-jet stripping. The cost of old coating removal has to be factored into the cost of recoating the component, as the old coating must be completely removed.

Question 23—Self-Fluxing Alloy: I have a problem with some small-diameter components. We flame spray (hydrogen-oxygen) a self-fluxing Ni-Cr-Fe-Si-B-C alloy with 50 wt% WC-6Co onto 17-4 PH stainless steel with a 0.375 in. diameter. We vacuum furnace fuse these. The coating thickness is about 0.020 in. per side. We do not have the option to change the substrate or coating materials. The quantity requirements for these parts is very low, that is, ~10 to 20 per year. The problem is cracking of the coating. We've tried various furnace cycles from fast cooling from the fusing temperature (1915 °F) to room temperature to various slow cooling sequences with holds near and in the transformation range. The results have been fairly uniform, that is, longitudinal cracks and some crack networking. Some cracking (fine and tight) is acceptable. However, a complication that makes the fine cracks grow beyond an acceptable width is a liquid nitriding process that occurs after the coating has been ground to near finish size. The presence of this nitride and its place in the sequence of operations are also nonnegotiable. I am thinking of trying two things: (1) Spray a thinner coating and fuse at a higher temperature so a smooth finish is obtained to make sure the coating "cleans" during machining. (2) Spray using another process, with a thinner coating, and fusing (like HVOF). I realize we probably have unrealistic requirements, but we have them nonetheless.

Answer 23.1: When I had the task of spraying this self-fluxing alloy years ago, it became apparent that this material, sprayed to a 0.020 in. thickness, just forms large cracks when cooled following the fusing operation. We did not furnace fuse, the coatings were fused manually with a torch. Option 1 and 2 both have possibilities. Try option 1 at a 0.015 in. thickness and the fusing temperature that you are currently using. If you are using the Metco 5P torch, back off to an 8 in. spray distance if you are using a 6 in. spray distance now. Option 2 might be acceptable if the HVOF coating of the self-fluxing alloy possesses lower residual stress than the thermal sprayed counterpart. If this occurs, the thickness limitation of the coating should increase.

Question 24—Training in Thermal Spray: Are there currently any vocational/technical, community colleges, and so forth, offering training in thermal spray?

Answer 24.1: The ASM-Thermal Spray Society frequently offers short courses in thermal spray. The next is at the ASM Conference in Chicago in October. Contact ASM for more information.

Answer 24.2: The ASM, Materials Engineering Institute has an excellent home study course on Thermal Spray. It is both an excellent handbook and source of application knowledge. Contact ASM, MEI in Materials Park, Ohio.

Answer 24.3: The TSS Training Committee is currently developing training programs for a range of levels of thermal spray experience, ranging from "entry level" (persons with 0 to 12 months experience) up to "thermal spray technical engineer" (persons with more than 5 years experience), all also with varying educational levels/requirements. These programs will follow a workbook/video format. We are starting with the "entry-level" module, which will comprise the following submodules: Practices, Introduction to Materials, Introduction to Testing, and Processing. Are you interested in developing such programs, or does your inquiry come more from the perspective of a potential user? If you have some experience in program development, then we'd be glad to have you help with what we have in progress.

Question 25—Application for Nonwetting Powders: I'm looking for commercially available powders that have nonwetting/nonsticking properties and that are also wear resistant. I'm thinking of applications like rolls in the paper and pulp, printing industry, and so forth. The powders must have, for instance, a Teflon core and be cladded with ceramic, carbide, or stainless steel. This cladding is to prevent the burning and evaporation of the core material in the flame.

Answer 25.1: If I understand your end requirement for the paper industry, you are looking at manufacturing or repairing rolls for the paper industry. There are several major paper industry equipment manufacturers producing rolls with a tungsten carbide HVOF coating, which is then impregnated with a fluoropolymer or Teflon coating. Typically this is done by spraying a liquid Teflon mixture on the finished HVOF coating, then curing at temperatures of up to 320 °C. Another solution, used in the paper industry, is Teflon sleeves for the dryers located near the size press roll.

Question 26—Feedstock Dampness: How is the dampness of thermal spraying powders measured?

Answer 26.1: Take a representative sample of the powder and place it in a stoppered container. Next place a predetermined volume of solvent into the container to absorb the moisture. Finally, remove a representative sample of the solvent and do a Karl Fischer titration. The answer will be the ppm of H_2O present in the powder.

Answer 26.2: Another way to do this is by weight loss if you have a sensitive balance and if you do not need a precise value of very small moisture contents. Weigh a sample of powder—100 g if you have a sensitive balance—and then dry this sample in an oven at about 300 °F for 1 h. Spread the powder in a thin layer on some aluminum foil. Be careful not to lose any powder since this will result in errors. Immediately after removing the powder from the oven (let the powder cool to about 100 °F) reweigh the powder. Any weight loss expressed as a percentage of the original weight is the percent moisture.

Question 27a—Spraying onto Copper Materials: How are tungsten carbide, chrome carbide, and nickel composite materials applied to copper materials by HVOF spraying?

Question 27b: We need to spray a 1 mm thick layer of CaO or CaF_2 or mixture thereof onto a copper substrate, approximately 15 by 25 in.

Answer 27.1: In order to achieve satisfactory coating/substrate adhesion, the substrate must be grit blasted and then coated with a bond coat prior to the deposition of the overlay coating (in this case the CaO or CaF_2 material).

Answer 27.2: I have had experience in the plasma spraying of silicon-base powders to copper. In order to obtain satisfactory adhesion between the coating and the substrate, grit blasting (preferably 20 mesh size grit) and then a bond coat application is necessary prior to the deposition of the final coating. Without this intermediate step, the adhesion strength is very poor. The torch translation program must also be optimized to maximize heat dissipation. A too-great heat buildup promotes spallation of the coating.

Question 28—How to Spray Colored Thermal Spray Coatings: Has anyone ever heard of colored thermal spray coatings, especially with corrosion protection in mind? The colors of these coatings would not be limited to "blotchy gray" or "burnt oxide black," but should be available in virtually any color using a special technique.

Answer 28.1: Why not just paint the coating? You can then use virtually any color. Coatings used on bridges are painted to complete the application.

Answer 28.2: Polymer coatings are available in a wide spectrum of colors ranging from white to hazard yellow/red to customized color matching. Such coatings can be thermal sprayed for chemical/impact/erosion/weathering resistance or used as sealers on metallized coatings.