In The News

New Literature

Plasma-Spray Coating—Principles and Applications

Robert B. Heimann, 1996. Approximately 225 pages with 170 figures. Hardcover.

Over the past two decades, thermal spraying of metallic, ceramic, and composite coatings has emerged as a powerful tool for surface engineering with many new applications and markets continually being developed. This book will help materials scientists and engineers to choose the most appropriate combination of materials, equipment, and operation parameters for the design of high-performance coatings with new functional properties and improved service life. It includes: treatment of the fundamental physical processes governing plasma spray technology, assessment of advantages and disadvantages of the method compared with other surface coating techniques, a discussion of basic equipment requirements and limitations, and case studies and typical applications to solve industrial problems.

From the Contents: Introduction, Principles of Plasma Spraying, The First Energy Transfer Process: Electron-Gas Interactions, The Second Energy Transfer Process: Plasma-Particle Interactions, The Third Energy Transfer Process: Particle-Substrate Interactions, The Technology Transfer Process: Solutions to Industrial Problem, and Quality Control and Assurance Procedures and Design of Novel Coatings.

Order from: VCH, P.O. Box 10 11 61, D-69451 Weinheim, Germany. List price $175.00.

Corrosion Resistance Tables

Philip A. Schweitzer. Metals, nonmetals, coatings, mortars, plastics, elastomers and linings, and fabrics, 4th ed., revised and expanded (in three parts) 3256 pages, illustrated.

This fourth edition of a standard reference presents corrosion resistance data on all the important materials currently used to fabricate systems, commodities, and structures that come into contact with chemicals.

Order from: Marcel Dekker, Inc., 270 Madison Avenue, New York, NY 10016; tel: 212/ 696-9000; or Hutgasse 4, Postfach 812, CH-4001 Basel, Switzerland; tel: 061-261-8482. List price $495.00 (sold only as a set).

Corrosion Engineering Handbook

Philip A. Schweitzer, Ed., 1996, 742 pages, illustrated.

Written by experts from business and industry, *Corrosion Engineering Handbook* provides detailed analyses of corrosion-testing techniques, materials handling and fabrication procedures, on-stream and off-stream corrosion monitoring, design methods that prevent or control corrosion, the mechanisms of corrosion, and proper fabrication and installation techniques.

Order from: Marcel Dekker, Inc., 270 Madison Avenue, New York, NY 10016; tel: 212/696-9000; or Hutgasse 4, Postfach 812, CH-4001 Basel, Switzerland; tel: 061-261-8482. List price $150.00.

JPCL Archives II

JPCL Archives II, is the new, revised edition of a CD-ROM containing information about protective coatings. There are nearly 1600 technical articles published by JPCL from 1984 through 1995, plus a state-of-the-art search engine that enables quick and easy retrieval of information to answer questions, solve problems, or research any protective coatings topic. This information can be marked for future reference, printed, or downloaded to a word processing file.

JPCL Archives II has been updated with 19 of the latest issues of JPCL, giving access to more articles, graphics, and selected photographs. JPCL Archives II has been upgraded from DOS to Windows, making it easier to navigate and to get full use of this comprehensive source of protective coatings information.

JPCL Archives II includes: research articles from 139 issues of JPCL; ability to search for information by key words, phrases, or topics; access to hundreds of graphics or photos; capability to print articles or graphics; and capability to download the text of articles to a PC.

Order from JPCL, 2100 Wharton St. Ste. 310, Pittsburgh, PA 15203; tel: 800/837-8303 or 412/431-8300; fax: 412/431-5428; e-mail: tpcbooks@usaor.net. List price is $189.00.

Sulzer Metco

The web site is accessed at http://www.sulzermetco.com and covers thermal spray products and applications, explanations about processes and troubleshooting tips, corporate history, literature, personnel and job opportunities, and contact information worldwide.

The web site includes an e-mail address: info@sulzermetco.com to further enhance communications.

Defense Technical Information Center

The Defense Technical Information Center (DTIC) supports the Department of Defense (DoD) Small Business Innovation Research (SBIR), and Small Business Technology Transfer (STTR) programs by providing scientific and technical information to assist small businesses competing for federal research and development funding for the development of a product or concept.

DTIC contributes to the management and conduct of defense research, development and acquisition efforts by providing access to and transfer of scientific and technical information to the defense community. DTIC supplies technical reports, journal articles, conference proceedings, DoD directives and instructions, and so forth.

DTIC services are available to SBIR/STTR users year round. Special services are available during SBIR solicitations. For most current SBIR topics, DTIC prepares a Technical Information Package (TIP). TIPs are bibliographic listings based on searches of DTIC's Technical Reports database for general background information relating to the topic. Most SBIR services are free, including ten technical reports per solicitation period. STTR information services are provided on demand and are fee-based at reasonable costs.

Access to all DTIC SBIR services is available on the Internet at: http://www.dtic.mil/dtic/sbir. On the SBIR Home Page you will find On-Line TIPs (OLTIPS) which offers keyword search topic identification, on-line bibliographies, and on-line document orders. The SBIR Interactive Topic Information System (SITIS) allows participants to pose technical questions on any active SBIR or STTR topic for response by the appropriate DoD technical personnel.

SBIR/STTR publications are on-line: FTP: asc.dtic.mil—logon is "anonymous"; password is your e-mail address; files are in "/pub/sbir" or Gopher: gopher.dtic.mil.

Measurements Group

Visit the Measurements Group on the World Wide Web located at: http://www.measurementsgroup.com. This web site is intended to supplement the printed material currently available from the Measurements Group (Raleigh, NC). Pages of interest include: microstrain: an on-line version of the Measurements Group newsletter; What's New: current information about new products and services; Tech Tips: a spotlighted application technique; Web Express: listings of the current versions of our product and technical literature, software status, and an on-line version of the Wall Chart of Reference Data for Precision Strain Measurement; Training Program: dates and locations of Measurements Group training programs around the world; Meetings & Events: conferences and exhibitions in which the Measurements Group participate; and Mind Benders: puzzles for engineers.

News from NASA

Nonintrusive Stress Measurement System

In the mid-1970s personnel at the Arnold Air Force Base Engineering Development Center (AEDC) in Tennessee began developing a technique called the nonintrusive stress measurement system (NSMS) to help test gas-turbine engines. The purpose was to develop an alternative to the traditional strain-gage method commonly used to make stress measurements on gas-turbine engine rotor blades during simulated altitude testing of aircraft engines.

Before NSMS was developed, engineers would attach strain gages directly to the blade surfaces with their signals exiting the engine through slip rings or by radio telemetry. These surface-mounted gages and the associated wiring would often interfere with the aerodynamic performance of the engine. Also, whether they lasted hours or failed within a matter of seconds, these traditional gages had a very limited life span because of the engine's extremely high temperatures. When the gages failed, replacing them was very expensive, because engineers would have to disassemble the engine to install new gages.

NSMS uses light probes to detect passing events on blade tips (Fig. 1). Engineers mount the probes (Fig. 2) through

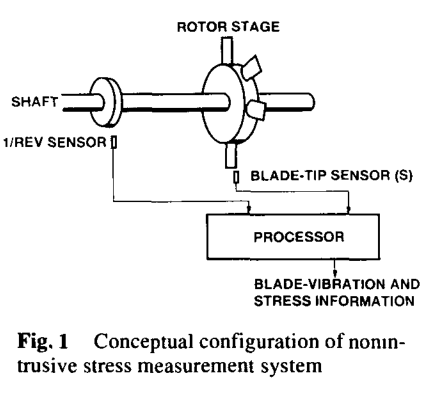


Fig. 1 Conceptual configuration of nonintrusive stress measurement system

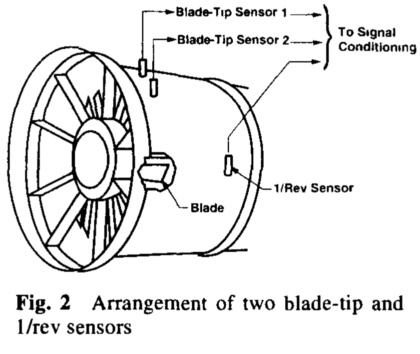


Fig. 2 Arrangement of two blade-tip and 1/rev sensors

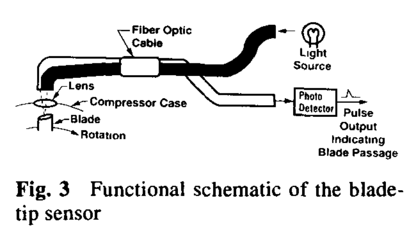


Fig. 3 Functional schematic of the blade-tip sensor

the engine's casing along the blade's rotation path. Light from a laser is transmitted through optical fibers (Fig. 3) and focused through a lens into the blade tip's path. As a blade passes, a portion of the light is reflected back through the lens into a receiving fiber optic photodetector. By timing and processing these events, engineers can determine blade-tip vibratory deflections.

From one to four light probes are used for each rotor stage, depending on the measurement requirements. One probe can measure vibration amplitudes; two probes allow vibration phase and frequency to be determined. Four probes are needed to detect vibration frequencies that are integer multiples of the rotor speed. Probe separation angles around the case's circumference are determined by the blade's vibration frequency range or by the bladed-disk system-mode vibration pattern.

The AEDC NSMS can provide monitoring of selected or all blade rows simultaneously. Unprocessed digital data are continuously stored on optical disk. Processed data can be displayed in a variety of formats, including Campbell diagrams, FFTs, modal analyses, and vibrational amplitude presentations. Stress conversions are possible where the deflection-to-stress transfer functions have been entered into the database.

The advantages of using the NSMS to support engine testing are improved sensor reliability, increased measurement coverage to all blades in the instrument row, improved measurements in the hot sections of the engine, and minimized repair due to failed sensors. Potential additional applications of the NSMS technique are routine health monitoring of aircraft engines in flight and the monitoring of industrial machinery with rotor blade assemblies.

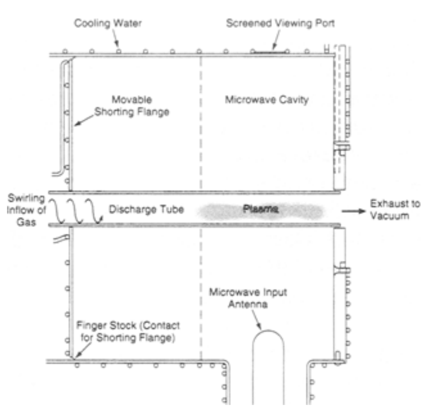
Nonintrusive measurements of rotor blade vibrations using light probes are currently being applied and improved by major U.S. engine manufacturers. The NSMS technique has proved to be a valuable supplement to the strain gage and has replaced the latter in some engine tests.

This work was done by Svedrup Technology, Inc., propulsion contractor for the US Air Force's Arnold Engineering Development Center. Inquiries concerning rights for the commercial use of this invention should be directed to Henry Jones or Joe Babilon, AF/DOPT, Arnold Engineering Development Center, Arnold AFB, TN 37389-5050; tel: 615/454-4330. (Extracted from *NASA TechBriefs,* Vol 20 (No. 8), 1996, p 19a)

Generating a Stable, Rotating, Free-Floating Plasma

The figure illustrates an apparatus for generating a controlled high-power plasma that could be useful as a pulsating and/or rotating source of electromagnetic radiation and/or ionization. A gas, in which the plasma is to be formed, flows through a cylindrical dielectric discharge tube that extends through a microwave cavity. The cavity is tuned to an electromagnetic-field mode in which the electric-field lines are concentrated along the axis of the cavity and discharge tube.

The gas is injected into the tube in a swirling flow about the cylindrical axis. The flow rate and pressure of the gas and the power of the microwave signal are adjusted to form a plasma discharge in the tube. This plasma forms at the location of the most intense standing wave electric field in the microwave cavity. As the flow rate, pressure, and microwave power are increased, the shape, location, and rotation of the plasma change. First, the plasma coalesces into a nonaxisymmetric volume, at least one end of which is attached to the inner wall of the discharge tube. Next, the plasma begins to rotate around the cylindrical axis, the rate of rotation increasing with increasing vortical inflow of the gas. Finally, the plasma contracts inward from the inner wall of the discharge tube to a diameter substantially less than that of the tube, becoming a symmetric spike that spins around the cylindrical axis, or another axis close to it, and remains fixed in location.



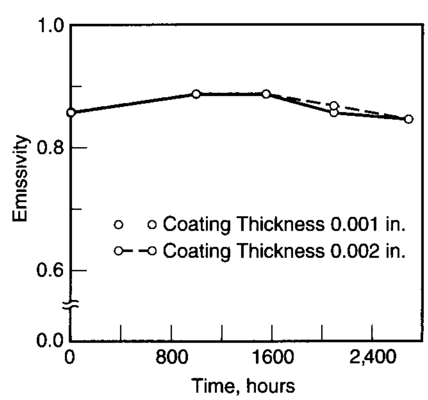
A stable, rotating plasma is formed within the discharge tube, away from the wall.

Once the plasma spike has been established, it can be maintained at any operating point within considerable ranges of absorbed power, flow rate, and pressure. These ranges extend both above and below the levels at which the plasma spikes initially. On increasing the power, the spike becomes elongated along the cylindrical axis and its diameter increases somewhat, while its basic shape, rotation, and axial location remain unchanged. The described phenomena have been observed at absorbed power levels up to 5 kW and pressures up to 1.2 atm in nitrogen, helium, and hydrogen gas flows and should be generic to other gases.

This work was done by John L. Power of Lewis Research Center and Daniel J. Sullivan of the Ohio Aerospace Institute. Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Lewis Research Center; tel: 216/433-2320. Refer to LEW-15802. (Extracted from *NASA TechBriefs,* Vol 20 (No. 9), 1996, p 73-74)

Durable High-Emissivity Coatings for Solar-Energy Systems

Mixtures of alumina and titania can be used to form high-temperature-durable, emissivity-enhancing surface layers on components of solar thermal-energy receivers and heat radiators. Depending on the specific component and application, enhancement of emissivity can provide either or both of two benefits: redistribution of heat away from local hot spots (with consequent increase in



Durable high emissivity

service life) and/or reduction in the size of a radiator surface necessary to radiate a given thermal power (with consequent reduction of weight).

Alumina-and-titania surface layers have been applied to the interior of the solar-heat-receiver, canisters made of Haynes 188 alloy, and to a stainless-steel parasitic-heat-load radiator. The surfaces of these components were prepared by grit blasting, then the surfaces were coated with the alumina/titania mixtures in a detonation-gun process.

In testing conducted by NASA LeRC in a vacuum at a temperature of 827 °C, coatings with thicknesses of 0.001 in. (0.025 mm) and 0.002 in. (0.050 mm) on Haynes 188 alloy provided emissivity >0.8 for more than 2600 h (see figure). The test was conducted in a vacuum because the original application was expected to be in outer space, but these coatings may be suitable for terrestrial use.

This work was done by Kim K. de Groh and Richard K. Shaltens of Lewis Research Center and Dilipkumar R. Shah of AlliedSignal Inc. Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Lewis Research Center; tel: 216/433-2320. Refer to LEW-15949. (Extracted from *NASA Tech Briefs*, Vol 20 (No. 9), 1996, p 76, 78)

Alumina-titania surface layers on Haynes 188 alloy retained high emissivities for a long time when heated to a temperature of 827 °C in a vacuum of residual pressure $<10^{-6}$ torr ($<10^{-4}$ Pa).

Society News

German Welding Society (DVS)

The German Welding Society (DVS) is a nonprofit technical and scientific association that promotes welding technology in the interest of the German economy. The roots of DVS go back to the closing years of the 19th century, when in 1897 the Calcium Carbide and Acetylene Gas Association was founded in Frankfurt am Main. Thus, in 1997 the DVS celebrates its 100th anniversary. Prof. Dr.-Ing. D. von Hofe is the Executive Director of DVS.

The association is noncompetitive and as such acts as an essential link between industry, the skilled-trades sector and the state in all matters regarding the joining, cutting, and coating of metallic and nonmetallic materials as well as combined materials. Among the technical and scientific associations in Germany, the German Welding Society plays a special role due to the number and structure of its members. With more than 21,000 members in 14 state branches and 94 district branches, the entire range of Germany's economy is represented; from companies engaged in skilled manual trades to major industrial enterprises, from the welder to the board of directors.

The services offered by the DVS in the field of thermal spraying are detailed below.

Training, Qualification and Certification

With the aid of its nationwide network of more than 500 registered training centers, the DVS offers a standardized system throughout the country of highly regarded qualification courses, which are also recognized internationally. It includes the whole range of expert and supervisory personnel required in industry and skilled trade. The DVS—through its certification body "DVS-PersZert," which is accredited in accordance with DIN EN 45013—is capable of fully complying with all the industry's requirements concerning the certification of welding personnel. In terms of thermal spraying, the SLV Munich, an institution of the DVS, trains and certifies personnel. In close cooperation with the "Gemeinschaft Thermisches Spritzen" (GTS), product-related specifications for certification are worked out. Founded in 1992 by the most renowned thermal spray companies in the German-speaking area, GTS nowadays is a European consortium of companies, institutions, and sponsors of thermal spraying with the aim to ensure and increase the quality standard of this technology.

Standardization

In more than 30 working groups and more than 130 subgroups from the Technical Committee (TA) there are more than 1000 experts in the DVS from the commercial side, the field of science, and various bodies, as well as authorities, who are involved in formulating welding worksheets, guidelines, and standards. Through close cooperation with the German Institute of Standardization (DIN), an optimal use of existing employee capacity as well as the available knowledge is achieved, and duplication of work is avoided. The welding code of rules at DVS presently covers more than 450 worksheets and guidelines. The working group V7, "Thermal Spraying and Thermal Sprayed Coatings" is cooperating with DIN, CEN/TC240 in the European standardization and ISO. Several standards are published concerning all fields of interest in thermal spraying, including equipment, materials, coatings specifications, and the qualification of personnel.

Transfer of Technology

By staging national and international conferences, meetings and seminars, the DVS offers experts the possibility for a comprehensive exchange of experience and opinions. This offer is made complete by the Annual Welding Conference organized by the DVS, as well as an extensive range of opportunities at the regional level through the district and state branches. In this way, tens of thousands of people have the opportunity to brush up and expand their knowledge, both for their own benefit and for that of their companies.

Research and Development

Research and development are likewise decisive factors in the welding sector for safeguarding Germany's economic strength in the long term. The Welding and Cutting Research Association of the DVS makes a significant contribution to supporting primarily small and medium-sized companies in the field of thermal spraying. Regarding thermal spraying, this research work is mainly carried out by the Aachen University of Technology, University of Dortmund, University of the German Armed Forces Munich and Hamburg, University Chemnitz, and University Ilmenau. The provision of financial support from private and public sectors, as well as funds from the association, enables the DVS to execute applied research projects in the precompetitive area. By publishing the results of the research, every company can obtain and use the knowledge acquired.

Publication

The DVS offers through its publishing house (Deutscher Verlag für Schweisstechnik DVS-Verlag GmbH) an extensive range of up-to-date specialized books, training literature, worksheets, guidelines, videos, and software for welding and allied processes. Furthermore, the DVS publishes several monthly trade journals that all have a large circulation. These are *Schweissen und Schneiden* (Welding and Cutting), *Der Praktiker* (The Practical Welder), and *VTE-Verbindungstechnik in der Elektronik und Feinwerktechnik* (Joining Technology in Electronics). With the exception of *Der Praktiker* all the magazines appear with an English supplement. This wide range of publications is rounded of by several other journals that appear periodically.

Quality Management

With the necessity of introducing quality-management systems, the need has arisen among a number of companies for relevant information and expert assistance. Through DVS-Zert (DVS Certification), which is a legal and independent institution established by DVS in accordance to DIN EN 45012, the association offers these companies a number of services. In the future this will be extended to the certification of products. Additionally, in the field of thermal spraying the GTS has started certification in close cooperation with DVS. This certification suits the demands of thermal spray companies because it qualifies the product, the process used, and the personnel for thermal spraying.

International Cooperation

In the age of the increasing worldwide network of economic interests, international cooperation among specialists is gaining more importance beyond the borders of nations and beyond political views. Accordingly, the DVS plays an active role in all significant international welding committees. This applies to the International Institute of Welding (IIW) as well as to the European Federation of Welding, Joining and Cutting (EWF), the European standardization authorities (CEN, CENELEC), and the International Standardization Organization (ISO).

International Trade Fairs and Exhibitions

The DVS is the initiator and ideal supporter of the International Welding Fair in Essen, the world's largest welding fair, which takes place every four years. Due to the great success of this fair, welding associations from other countries have approached the DVS requesting know-how on the organization of fairs in their own nation. The DVS provides this support in close partnership with renowned German fair and exhibition organizers. At present welding fairs are supported by the DVS in Beijing, Shanghai, St. Petersburg, and Kiev.

The Thermal Spraying Committee

The Thermal Spraying Committee was first mentioned in the 1949 annual report of DVS. At that time it was chaired by Prof. Krekeler, a well-known professor from Aachen University of Technology. Also the father of the present DVS-Executive, Director Prof. Dr.-Ing. D. von Hofe chaired the committee from 1952 to 1959. The number of Committee members rose from 15 to 20 in the beginning to present numbers of more than 70. Within the last 47 years the Thermal Spray Committee has worked out more than 20 DVS guidelines and has participated in the preparation of several national and European standards.

Another important field of activity is the organization and performance of national and international conferences. The series of thermal spraying events was started in 1969, when the first event in thermal spraying took place in the city of Essen. The first Thermal Spraying Conference (TS) was held in Essen in 1990. When Prof. Dr.-Techn. E. Lugscheider was elected as Chairman of the Thermal Spraying Committee in 1992, he brought in new ideas and directions to both the Committee's work and to the conference. Alongside the traditional lecture program, E. Lugscheider as Chairman looked for new ways to involve participants more actively in the conference events. The Poster Show, Workshops, Industry Forum and Experts Exchange are four elements that contribute to this. The concurrently held Exhibition and the Film and Applications Forum made the TS conference an exceptional experience with something to offer for everyone. This diversity, for which the Program Committee strives consciously, coupled with high-quality standards, ensures that the Thermal Spraying Conference holds an outstanding position in its special field throughout Europe.

Success, however, means at the same time an obligation to safeguard the special nature of this event in the future, through new ideas and sector-relevant creativity. In this, the German Welding Society (DVS) and the Program Committee of the Thermal Spraying Conference see a permanent challenge, which they regard as crucial. In meeting this challenge they hope, as in the past, to enjoy the energetic support of professionals in the fields of economics, science, and politics. Conferences like the TS are not an end in themselves, serving only to promote the image of the organizers, but are an essential instrument for technology transfer. They form the crucial link between theory and practice; that is, between research, development, and application. Only when the latest achievements of research and development are converted innovatively into marketable applications will the considerable funds spent by the state, commerce, and third parties be meaningfully used.

To give young scientists and engineers, from commerce and science in particular, an incentive to further develop of thermal spray and promote its expansion with new stimuli, DVS initiated four promotional prizes at TS'96. The winners of the prizes for the four best contributions have been decided by a jury using specified quality criteria.

Another important event under the chairmanship of E. Lugscheider was the mutual agreement between DVS and the ASM International Thermal Spraying Society (TSS) to hold an annual joint Conference and Exhibition on thermal spray technology and application, starting with the first joint conference in Indianapolis, 1997. The two societies, as a result of this agreement, will organize, market, and develop joint presentation and commercial programs within the conference and industrial exhibition. This agreement links the world's two strongest thermal spray technical organizations, thus enabling a globalization of the conference.

DVS is looking forward with great interest and pleasure to the upcoming joint activities. The participation of the DVS Deputy Executive Director, Dr. -Ing. G. Kraume, and of Prof. E. Lugscheider and other DVS experts in the NTSC '96 in Cincinnati is a first step to convert the agreement into practice.

ITSA Profile: Bender Machine

As one of the world's largest independent thermal spray operations, Los Angeles-based Bender Machine is internationally recognized as a leader in the thermal spray industry. Founded by Arthur Bender in 1946, much of the success the firm enjoys today can be attributed to the Ritchie family that now owns the firm: the father, Jack Ritchie, who became affiliated with Bender in 1953 and who now serves as president, and his son, Gary Ritchie, who joined Bender in 1976, and serves as the vice president and general manager.

While Jack Ritchie has been with Bender, he has seen the company grow from a small firm that specialized in metal spraying of used automotive and truck crankshafts to an advanced facility that now uses seven different thermal spray processes—many pioneered and developed by Bender—and that employs more than 200 kinds of coating materials. "When I first started with Bender," says Jack Ritchie, "I saw the tremendous potential that existed for thermal spray in the Los Angeles area. It was a hub of major machinery manufacturers, as well as aircraft manufacturers, all of which need strong, reliable service organizations. When Dr. Browning invented the JetKote system, we purchased a unit almost immediately and, working in concert with some other thermal spray companies, we developed the technology, and very soon we were delivering HVOF coatings to a large segment of the repair industry." Bender is now preeminent in a number of thermal spray areas, one of which is a global market for the thermal spraying of the huge Yankee Dryer cylinders.

Jack Ritchie, in addition to his responsibilities to Bender, has become an important contributor to the industry as a whole. A Fellow of ASM and a member of the Thermal Spray Division (now TSS), he has played a prominent role in NTSC and ITSC events and has presented numerous papers to tech-trade associations, including the Japan Thermal Spraying Society.

Gary Ritchie oversees the firm's heavy international and U.S. customer commitments, which include a large part of the West, the United Kingdom, Europe, and the Far East, for the turbomachinery, paper, steel, aerospace, printing, petrochemical, and automotive industries.

Gary, who is a member of TSS and secretary/treasurer of the ITSA, stresses the important role that trade associations and technical societies play in today's commercial thermal spray environment. "There's no way a modern job shop can compete in today's world without the benefits of the information and technology exchange that can be accessed through an organization such as the ITSA or TSS, and I'm certain much of Bender's success can be traced to our associations with these and other thermal spray related organizations."

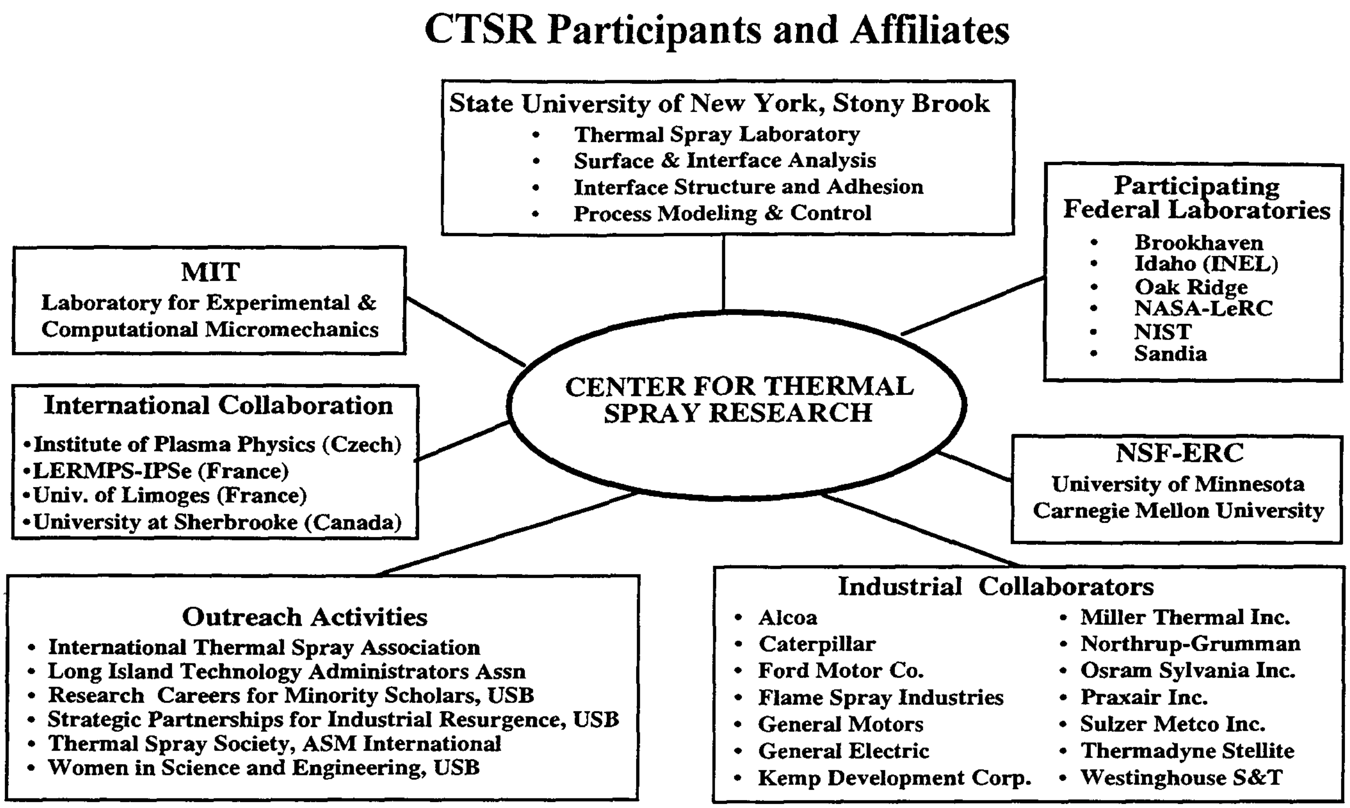
Center for Thermal Spray Research at Stony Brook

Thermal spray technology is a rapidly evolving field that services a broad industrial community. Now, the State University of New York (SUNY) at Stony Brook has been awarded a new National Science Foundation Materials Research Science and Engineering Center. This Center for Thermal Spray Research (CTSR) is a consortium of a number of scientific institutions with a focus at SUNY at Stony Brook. Supported by a major five-year grant from NSF and working with a wide range of manufacturing companies, CTSR engages in the melt-spray production of thick, protective coatings and spray-formed, high-performance engineered components. Applications of thermal spray range from infrastructure maintenance to uses within gas turbine engines for aircraft and power generation to the formation of biocompatible coatings for prosthetic implants. While CTSR is fundamentally an academic consortium, the nature of the technology requires that the research have a strong industrial orientation. Thus, the faculty, research scientists, staff, and graduate research assistants of the Center actively seek wide interactions with industrial organizations and governmental agencies to fulfill the needs of both educating engineering professionals and of serving the industrial community. Participating with Stony Brook in these efforts are a number of North American and European universities and national laboratories.

The growing use of thermal spray has increased the need to understand the relationships between processing conditions and materials properties. The field has developed mainly empirically, application by application, eventually yielding satisfactory, even remarkable results, to the extent that thermal spray is today the mainstay of several established industries. However, the complexity of the process will limit such an Edisonian approach. Unless a concerted effort is made to place the technology on a sound scientific basis, its benefits will not be realized in the broader scope of functional and cost-critical applications. Thermal spray's principal limitation is a lack of basic materials-based knowledge of the deposits, their properties and performance, and the relations of these to the complex processes involved. For instance, little is understood of the deposit's structure (e.g., porosity and microstructural anisotropy) and its influence on properties/behavior. In addition, the deposit's internal interfacial physics and chemistry are poorly defined. This lack of such fundamental scientific-based structure-property relationships has been the Achilles' heel of the technology. In particular, there are several aspects of thermal spray that require scientific elucidation.

The Center will mount a concerted, integrated effort to address persistent questions associated with processing and materials and to develop a sound materials science and engineering foundation for the technology. It is envisioned that this "Distributed Center" will serve as a prototype research program connecting the scientific establishment with industry, as well as providing this burgeoning field with much-needed impetus.

The Center Director is Prof. Herbert Herman of the University at Stony Brook. Senior Investigators and Collaborators are C.C. Berndt, S. Sampath, C.R. Clayton, A.H. King, Z. Lin, and V.



CTSR participants and affiliates

Prasad (from SUNY at Stony Brook); A. Goland and R. McGraw (from Brookhaven National Laboratory); S. Suresh (from MIT); R.A. Neiser and M.F. Smith (from Sandia National Laboratory); J.R. Fincke and R.N. Wright (from Idaho National Engineering Laboratory); G.G. Long and S. Dapkunas (from National Institute of Standards and Technology); and R.A. Miller and W. Brindley (from NASA Lewis Research Center).

Affiliated participants are P. Fauchais and A. Vardelle (from University of Limoges, France); E. Pfender and J. Heberlein (from University of Minnesota); C. Coddet (from LERMPS-IPSe, France); P. Chraska (from Institute of Plasma Physics, Czech Republic); M. Boulos (from University of Sherbrooke, Canada); M.K. Ferber (from Oak Ridge National Laboratory); and L. Weiss (from Carnegie Mellon University).

Research Activities at the CTSR

The Center will focus on fundamentals of thermal spray processing and carry out state-of-the-art experimental and theoretical research on the synthesis, modeling, and properties of wide classes of traditional and novel materials and novel functional configurations. Two interdisciplinary research groups have been formed: Group I will focus on processing science and modeling of traditional and novel materials, while the Group II will apply advanced characterization and modeling techniques to evaluate the materials science of thermal spray deposits. The broad research areas are identified below. In the first year, the principal materials will include both model research systems as well as those of engineering interest. Among the metals, Mo and NiCrAlY will be initial candidates to be processed with atmospheric plasma spray and HVOF. In the case of ceramics, partially stabilized zirconia and alumina will be examined using plasma spray processes. Additional materials and processes of industrial interest will be included in the program in subsequent years.

Collaborative Opportunities for Industry

CTSR has had considerable experience in working with industry, both OEM thermal spray manufacturers and the engineering and manufacturing communities in general. It has consistently been our goal to create a mutually beneficial arrangement: the staff and students learning from industry and their aiding the applied sector through consultation and long-term programmed studies. These arrangements have been successful in introducing numerous industrial concerns to the assets of thermal spray and have aided the transformation of thermal spray from a "Band-Aid" approach to a prime reliant constituent in engineering design.

CTSR welcomes industrial participation in all aspects of the Center's activities, from sharing in research results to funded programs in specific study areas. Extensive facilities are available for exploratory research, materials processing, product development, and materials testing. Information on CTSR activities and research updates will be available through a Center Newsletter and the World-Wide-Web. We also encourage participation in the Center's Scientist/Engineer In-Resident Program.

Contact: Center for Thermal Spray Research, Department of Materials Science and Engineering, State University of New York, Stony Brook, NY 11794-2275; tel: 516/632-8480; fax: 516/632-7878; e-mail: info@CTSR. eng. sunysb.edu, html: http://DOL1. eng. sunysb. edu/tsl/.

Materials Resources International

Materials Resources International (MRI, Lansdale, PA) and Exotherm (Camden, NJ) have announced the signing of an agreement for manufacturing and marketing Exotherm's "SHS" process for producing both new, innovative thermal spray powders and a wide range of promising thin coatings .

Self-propagating high-temperature synthesis (SHS) has long been a laboratory curiosity with a technical foundation in the former Soviet Union. Developments now indicate that SHS has strong potential as an economical method to form intermetallic and composite materials as powders or as layers onto other substrates.

Joint efforts by the two companies over the last two years has proven the industrial utility of SHS-produced powders and thin coatings in a number of areas. Current work is centering on powders for thermal spray applications and thin, 50 to 200 μm (0.001 to 0.004 in.), diffused coatings. SHS processing permits the formation of a wide range of hard and lubricating oxides, carbides, and nitrides either as new phases in powder particles or directly as surface layers. The powders can be produced in combination with metal and/or intermetallic matrices. The powders have been shown to possess nanosize and coarser reinforcing phases which, when thermally sprayed as a coating, make extremely wear-resistant layers. Developments are also producing new powders for thermally sprayed low-friction coatings and new thermal barrier oxide coating systems. The SHS coating process, Exo-Coat, is a process where the components to be coated are immersed and heated in a proprietary pack of SHS powders and compounds. The parts are subsequently coated with any of a variety of thin tenacious, diffused coatings, depending on powder composition.

Significantly, these ExoCoat coatings can range from metals to titanium nitride and refractory metal carbides to complex carbon-boron nitrides, any of which may contain lubricating phases. These thin, diffused coatings find application as thin, wear-resistant hard layers, corrosion-resistant layers and/or as low-friction layers. The MRI/Exotherm SHS technology is expected to find wide use in two areas: first in many innovative thermal spray applications where there is an increasing demand for tailored, high-performance coatings and, second, as directly applied thin coatings to be marketed as very economical alternatives to physical and chemical vapor deposition (PVD/CVD) coatings for use in electronics and braze joining prelayers to wear protection of cutting tools, drill, and dies.

Contact: Dr. Ronald W. Smith, Materials Resources International; tel: 215/393-5703; fax: 215/393-570; e-mail: solution @mri-bluebell.com.

High Velocity Technologies, Inc.

High Velocity Technologies Inc., of Lebanon, NH, has announced the entry of its AeroSpray II High Velocity Thermal Spray System to the market. The AeroSpray II operates solely on compressed air and fuel and does not require pure oxygen. The AeroSpray II is air cooled. The compressed air passes through the cooling jacket of the combustion chamber then enters the chamber where it mixes with the propane, then fuel oil for burning. Thus, the new process has been named "HVAF" (high velocity air fuel).

The lack of water cooling and the fact that the torch does not employ the use of any O-rings makes the system efficient and trouble free. The AeroSpray II is capable of spraying 15 lb/h of tungsten carbide-cobalt powder with high efficiency rates and coating hardnesses ranging from 1000 to 1300 DPH300 depending on the powder used.

AeroSpray II operates continuously with no nozzle clogging at a fraction of the cost of any other high-velocity spray system. Machine mounted and hand-held models are available. Samples and laboratory reports are available on various coatings upon request.

Contact: Bonnie Rogers, High Velocity Technologies, Inc., 103 Hanover St. #6, Lebanon, NH 03766; tel: 603/448-8823; fax: 603/448-4328; e-mail: hvt@valley.net.

High-Strength Bond Coat from Wall Colmonoy

Walcoloy Superbond is an advanced nickel-aluminum cored wire for use as a high-strength bond coat for two-step metallizing coatings. Now available from Wall Colmonoy Corporation (Madison Heights, MI), the wire is completely molten and atomized before impacting the base metal, thus creating higher bond strengths.

Walcoloy Superbond wire has a solid nickel core in an aluminum sheath, which provides faster deposition rates and can be applied with all combustion wire spray units. Walcoloy Superbond is also used as a traction coating on steel mill rolls or other surfaces that require an antiskid coating.

Contact S. Rangaswamy at 800/521-2412, ext. 243.

Rotating Arc Spray System from TAFA

TAFA Inc. has released the Model 8880 Rotating Arc Spray System for production. The system is designed to coat inside diameters when it is impossible or inconvenient to rotate the parts. The system employs a design that rotates the atomizing air, not the wires, for coatings on inside diameters. The 8880 also has a secondary motion along a single axis, and operators may vary the length and speed of the traverse function. The Model 8880 incorporates an "adjustable arc ball" feature for optimizing the spray pattern and angle.

The 8880 is a rugged, heavy-duty system that operates remotely in the thermal spray environment. The 8880 employs a 0 to 25.4 cm stroke (0 to 10 in.) with head revolutions over 100 rpm. The cylinder traverse speed ranges up to 254 cm/min (100 ipm) and is rated for 350 A.

Contact: Joan Rich, TAFA Inc., 146 Pembroke Road, Concord, NH 03301; tel: 603/224-9585; fax: 603/225-4342; Internet address: http://www.tafa.com.

On-Site Turbine Repair Procedure by TAFA

Responding to the high standards of the power-generating industry, TAFA Inc. has completed successful field applications of a premium-grade, chromium carbide coating on high-temperature steam-turbine generators. Using the high-pressure/high-velocity oxygen fuel (HP/HVOF) system , known as the JP-

5000, engineers were able to extend the service life of the buckets and blades by an additional two years.

Economic and satisfactory performance of all stages of turbine generators depend heavily upon the condition of the blades and buckets that convert the force of the steam to electricity. Contaminants, water vapor, and supersaturated steam impact the turbine buckets at supersonic speeds, causing erosion and reduced efficiency. Prior to on-site spraying, the rotors and blades were dismantled, shipped to a restoration facility, shipped to another plant for reassembly, and then shipped back to the power plant for reinstallation.

The on-site spraying saved shipping and labor costs and downtime, since the blades did not have to be removed, sprayed, and then reassembled. The coating was applied to a finished thickness of 0.2 mm (0.008 in.). The estimated life of the turbines blades prior to spraying was approximately four years. By using thermal spray to restore dimensional integrity, the turbines can perform for two more years without further maintenance.

Contact: Joan Rich, TAFA Inc., 146 Pembroke Rd., Concord, NH 03301; tel: 603/224-9585; fax: 603/225-4342; Internet address: http://www.tafa.com.

Manufacturers See Better Blades with X-Ray Vision

Manufacturers of jet turbine blades often can't tell if a blade has been "cooked" right until they remove the mold and take a look. Working with engineers at Howmet Corp., Whitehall, MI, National Institute of Standards and Technology (NIST) researchers have developed an x-ray sensor they hope will take some of the guesswork out of turbine blade technology. The instrument sends high-energy x-rays through a casting mold while a part is being made. By detecting the change in direction of the x-rays on the other side of the mold, the researchers can monitor the solidification of a molten metal into its crystalline state.

Ordinary solid metal objects contain a crazy-quilt of crystals that grew at many different angles. Turbine blades, on the other hand, are solidified in special "temperature-gradient" furnaces that cool the molten alloy down slowly so that a single crystal grows from one end of the blade to the other. The lack of crystal boundaries makes these single-crystal turbine blades stronger and more resistant to high engine temperatures. The NIST system should allow manufacturers to optimize their processes so they consistently grow single-crystal blades in the shortest amount of time.

Contact: Fred McGehan; tel: 303/497-3246. Extracted from NIST *TechBeat*, July, 1996.

TEKNA wins a Laureate

TEKNA Plasma Systems Inc. of Sherbrooke, Quebec, has been awarded a prize of "Laureate" in the Small Manufacturing Enterprise Class at the Estrie Region Reconnaisance Gala, held in early 1996. Following this success, TEKNA has submitted its candidature for the "Mercuriades Awards 1996," open to the whole of Quebec's business enterprises, in the category of Contribution to Regional Development—PME.

Contact: Prof. Maher I. Boulos, Sherbrooke University, 2500 boul. de l'Universite, Sherbrooke, Quebec, Canada, J1K 2R1; tel: 819/821-7168; fax: 819/821-7955; e-mail: boulos @plasma.gcm.usherb.ca.

Summary Note—Nickel-Based Superalloys

Ronald Dudley, Staff Member, Metals Information Analysis Center, IN

M. McLean of Imperial College has reviewed the current status and future potential of nickel-base superalloys. Superalloys have evolved from Nimonic 80, a Ni-Al-Ti-Cr precipitate-strengthened alloy developed by Mond Nickel Company in the 1940s in response to the need for a suitable turbine blade material for the first British aircraft gas turbine engine.

In the half-century since the development of Nimonic 80, the 1000 h at 150 MPa creep rupture temperature of superalloys has progressively increased by about 7 °C/yr. Specific alloy improvements have been: (1) increasing the γ volume fraction by alloying with Al and Ti, (2) increasing the γ solution temperature by alloying cobalt, (3) minimizing the γ/γ' lattice mismatch, (4) solid-solution strengthening (W, Mo, Ta, Re), and (5) alloying for improved ductility (Hf, B). Gas flow temperature has increased even more through the use of additional innovations such as thermal barrier coatings (TBCs) on the engine parts.

The processing improvements for turbine blade applications have been: (1) forging while the heat treatment window was wide enough to allow reliable thermomechanical processing, (2) investment casting, (3) directional solidification to produce an elongated grain structure and a $\langle 001 \rangle$ crystal texture parallel to the solidification direction, and (4) single-crystal alloys. The most advanced superalloy turbine blades now operate at a homologous temperature in excess of 0.85. The melting point of nickel provides a natural ceiling for future development.

Turbine discs operate at lower temperatures than the turbine blades, but at higher stresses. Thus, disc materials are designed for high yield strength and crack resistance, while the important consideration for the blades is high creep resistance. Discs have been produced by forging or by powder metallurgy. Quality is maintained in both processes through careful control of alloy cleanliness to eliminate inclusions or clusters of precipitate particles that can constitute a critical defect. Standard procedures to control inclusion content include vacuum arc refining (VAR), electroslag refining (ESR), and electron beam cold hearth refining (EBCHR). Novel approaches for evaluating very low inclusion contents are still under development, but include electron beam button melting (EBBM).

Superalloys derive their attractive mechanical properties from the disposition of as much as 70% volume fraction of coherently dispersed γ' precipitate. The general consensus is that the intermetallic γ' phase strengthens as a consequence of thermally activated cross-slip onto cube planes, which produces sessile dislocation segments that inhibit dislocation glide on octahedral planes. The γ' behavior alone does not explain the creep properties; thus the coexistence or interaction of the γ and γ' phases is what probably results in the deformation that is radically different from what would occur in either phase alone. New models of creep deformation consider the dispersed particles to inhibit glide in the matrix, and these models explain observations of the creep behavior of superalloys that were not explained in earlier models, including: (1) creep rate in both tension and compression progressively increases, rather than at a steady state, (2) plastic strain increases the creep rate relative to the unstrained material, rather than leading to strain hardening, and (3) strain softening results from increased stress, not just from reduction in area.

In the future, analysis and design will include numerical simulations of the performance of a component involving multiaxial stresses and variable stresses and temperatures. Superalloy creep deformation has already been modeled into a set of constitutive equations using continuum damage mechanics. The uniaxial creep rate is expressed as a function of state variables (or damage parameters) that represent the current condition of the material. Sets of equations have also been used to represent anisotropic creep.

The accuracy of such models has been assessed through three different experimental validations. Low-cycle fatigue creep prediction has been remarkably accurate. Predictions about loading along complex crystallographic directions have given good agreement with experiment. Model simulation of the drift of crystallographic orientation has also been largely consistent with experiment.

One remaining challenge to the modeling of discs is accounting for the possible presence of defects that are too dilute to be characterized by metallographic or conventional NDT techniques. EBBM has been useful in estimating the general cleanliness of various materials, but it samples only a small fraction of the alloys from which components are manufactured. More attention needs to be focused on material quality assurance through control of the entire processing cycle. This could be done by modeling the critical processes, such as VAR, ESR, and EBBM.

(Excerpted from *MIAC Newsletter,* Vol 6 (No. 3), June 1996, p 1, 4-6. Original source: Nickel-Base Superalloys: Current Status and Potential, *Philos. Trans. R. Soc. (London) A,* Vol 351, 1995, p 419-433. For further information on MIAC/CINDAS contact: Purdue University, 2595 Yeager Road, West Lafayette, IN 47906; tel: 317/494-9393 or 800/2-CINDAS; fax: 317/496-1175; www: http://cindas.ecn.purdue.edu/miac/)

People in the News

Steffens Honored

The annual Dortmunder University colloquium is dedicated this year to Prof. Dr.-Ing. Hans-Dieter Steffens on his 65th anniversary. This conference took place on 17 and 18 Oct at the Renaissance Hotel, Dortmund. A future issue of *JTST* will be dedicated to Prof. Dr.-Ing. Steffens.

Baboian Honored with LaQue Award

The Francis L. LaQue Award was presented to Dr. Robert Baboian at the 50th Sea Horse Institute meeting on 6 Aug in Wrightsville Beach, NC. Bob Baboian, Senior Principal Fellow at Texas Instruments, Inc., Attleboro, MA, was recognized "for significant contributions to the field of marine corrosion and corrosion prevention and qualities of enthusiasm and the ability to motivate others." The award, honoring the memory of the founder of LaQue Corrosion Services, consists of a specially designed and minted medallion bearing the likeness of "Frank" LaQue.

LaQue Award—Robert Baboian (left) and Harold Michels (right)

Dr. Baboian has established an outstanding record of service and leadership in the fields of corrosion science and engineering. He has pioneered electrochemical techniques for galvanic corrosion measurements, accelerated corrosion testing, and monitoring of corrosion. His leadership in the field of standards development has contributed to a worldwide system of standards in corrosion testing technology. He has given extensive pro bono activities and was a lead consultant to the National Park Service on the restoration of the Statue of Liberty. Dr. Baboian has also developed environmental tests for coinage materials used by the U.S. Mint.

Baboian has championed the use of corrosion-resistant materials and devices on automobiles and has researched the effect of road deicing salts and acid deposition on automotive materials. He has edited two books on automotive corrosion and one book on materials degradation caused by acid rain.

DeHaemer Named ASM Managing Director

Dr. M. DeHaemer

The Board of Trustees of ASM International has announced that Dr. Michael J. DeHaemer will lead the Society, the world's leading information resource on metals and engineering materials, into the next century as Managing Director. Dr. DeHaemer will be installed as the fourth Managing Director in ASM history on 1 Jan 1997 at ASM's World Headquarters in Materials Park, OH. Edward L. Langer, who has served as Managing Director since 1984, will retire after 30 years with the Society on 31 Dec 1996.

"Throughout his professional career, Dr. DeHaemer has gained excellent experience and success within the many dimensions required for his position," said ASM President William E. Quist, Principal Engineer, Boeing Commercial Airplane Group, Seattle, WA. "We feel that he recognizes and understands the important balance between the technical aspects and member needs that drive a society like ASM, and the necessity to lead and effectively manage the organization."

"Our committee was able to make our recommendation of Dr. DeHaemer with great confidence, because his background is highly appropriate to ASM's future growth opportunities," added John V. Andrews, President, Teledyne Allvac, Monroe, NC, and chairman of the ASM Board's Succession Committee. Andrews cited Dr. DeHaemer's strengths in information technology; technical data gathering and publishing; industrial operations; engineering technologies; education development; networking within the science and technology community; international science relations; and project management, administration, and leadership.

Dr. DeHaemer's professional career spans 36 years of management and leadership experience in military, academic, and industrial environments—most recently, in the production, publication, and distribution of technology information, the main purpose of ASM as a technical society. Dr. DeHaemer joined the Information Systems and Decision Sciences faculty at Loyola College, Baltimore, MD, in 1988, where he also served as codirector of the Lattanze Human-Computer Interface Lab. From 1992 to 1995, he served as Chair of the Information Systems and Decision Sciences Department.

Since 1993, Dr. DeHaemer has served as director of the Japanese Technology Evaluation Center and the National Science Foundation Studies on Technologies in Japan, also at Loyola. "His experience in teaching information strategy and technology management has enabled him to keep up with this rapidly changing field, while giving him background crucial for managing a supply of technical information," Andrews said. In addition, since 1991, Dr. DeHaemer has directed the World Technology Evaluation Center at Loyola, which is operated for the National Science Foundation to conduct benchmarking studies of foreign technologies.

Prior to 1988, Dr. DeHaemer completed a Navy career that provided nuclear engineering experience with exposure to various metallurgy and materials issues related to ship construction and corrosive and high-risk environments. Following five years in command of a nuclear-powered submarine, he was named Manager, Anti-Submarine Operations on the staff of the U.S. Second Fleet, where he served as senior planner for seven large-scale NATO exercises, and served as representative to the NATO Maritime Warfare Committee. From 1983 to 1988, he served as Chair of the Naval Science Department at Rensselaer Polytechnic Institute, Troy, NY.

Dr. DeHaemer was graduated from the University of Notre Dame, South Bend, IN, in 1960 with a bachelor's degree in physics and received his master's degree in operations analysis from the Naval Postgraduate School in 1970. In 1986, he received his master's degree in industrial and management engineering and his MBA from Rensselaer Polytechnic Institute, and he received his Ph.D. in 1987, also from Rensselaer Polytechnic.

Sampath Wins Alcoa Foundation Award

Professor Sanjay Sampath of the State University of New York at Stony Brook was recently awarded an Alcoa Foundation Award to pursue fundamental studies on thermal spray technology.

From left: Roger Kaufold, Alcoa; Sanjay Sampath, SUNY at Stony Brook; and Yacov Shamash, Dean of Engineering at SUNY at Stony Brook

ITSA Scholarships Awarded

Scholarships Chairman Albert Kay named three winning 1996 applicants: Etienne Bouyer of the University of Sherbrooke; Elena Petrovicova of Drexel University, and Saifi Usmani of the State University of New York at Stony Brook.

Graduate students submitted applications from the University of Missouri, Iowa State University, University of Connecticut, Oregon Graduate Institute of Science and Technology, and University of Illinois. Applicants for the 1997 awards are invited to contact: The Scholarships Chairman, the International Thermal Spray Association, 2150 East 37th Street, Vernon, CA 90058.

NTSC Best Paper Awards for 1996

Five NTSC papers were recognized on 9 Oct 1996 in Cincinnati, OH, at the 9th National Thermal Spray Conference awards banquet. The two best paper awards were:

- "Computational Fluid Dynamics Analysis of a Wire-Feed, High Velocity Oxygen Fuel (HVOF) Thermal Spray Torch," by A.R. Lopez, B. Hassan, W.L. Oberkampf, R.A. Neiser, and T.J. Roemer, Sandia National Laboratories, Albuquerque, NM
- "Correlation Between Particle Temperature and Velocity and the Structure of Plasma Sprayed Zirconia Coatings," by M. Prystay, P. Gougeon, and C. Moreau, National Research Council Canada, Boucherville, Quebec, Canada

Three Certificates of Merit were awarded to:

- "Particle Velocity and Temperature Influences on the Microstructure of Plasma Sprayed Nickel," by R.N. Wright, W.D. Swank, J.R. Fincke, and D.C. Haggard, Idaho National Engineering Laboratory, Idaho Falls, Idaho
- "Influence of Shroud Gas Flow and Swirl Magnitude on Arc Jet Stability and Coating Quality in Plasma Spraying," by H. Chen, Z. Duane, J. Heberlein, and E. Pfender, University of Minnesota, Minneapolis, MN
- "Parametric Study of Suspension Plasma Sprayed Hydroxyapatite," by E. Bouyer, F. Gitzhofer, and M.I. Boulos, Plasma Technology Research Center, Sherbrooke, Quebec, Canada

The Panel of Judges were: Dr. Marita Allan (Brookhaven National Laboratory, NY); Dr. Vladimir E. Belashchenko (Consultant, VA); Prof. Christopher C. Berndt (SUNY at Stony Brook, NY); Dr. William J. Brindley (NASA-Lewis Research Center, OH); Dr. Serge Dallaire (National Research Council Canada, Quebec); Mr. Mitchell Dorfman (Sulzer Metco, NY); Prof. Joachim Heberlein (University of Minnesota, MN); Prof. Herbert Herman (SUNY at Stony Brook, NY); Mr. Frank Hermanek (Praxair Surface Technologies, Inc., IN); Dr. Richard Knight (Drexel University, PA); Dr. Robert McCune (Ford Motor Company, MI); Mr. Robert Miller (TAFA Inc., NH); Mr. Christian Moreau (National Research Council Canada, Quebec); Dr. Patrick Pei (NIST, MD); Dr. Sanjay Sampath (SUNY at Stony Brook, NY); Dr. Mark F. Smith (Sandia National Laboratories, NM); Dr. Ronald W. Smith (Drexel University, PA); Dr. Thomas Taylor (Praxair Surface Technologies, Inc., IN); Mr. Merle Thorpe (Thorpe Thermal Technologies, Inc., NH); Dr. Rajesh Tiwari (UCAR Carbon Company, Inc., OH); Prof. Thomas Trocynski (University of British Columbia, British Columbia); and Mr. Dominic Varacalle (Idaho National Engineering, ID).

Hall of Fame Inductees

The Thermal Spray Hall of Fame was established in 1993 by the Thermal Spray Society of ASM International. Induction into the Hall of Fame is a means of recognizing and honoring outstanding leaders who have made significant achievements and contributions to the science, practice, education, management, and advancement of thermal spray.

The first class of inductees (five members in 1994) were: William E. Ballard (deceased, Metallisation, Ltd., UK); Herbert Herman (SUNY at Stony Brook); Daniel R. Marantz (Flame-Spray Industries, Inc.); Merle L. Thorpe (Thorpe Thermal Technologies, Inc.); and Max Ulrich Schoop (deceased, inventor).

The second class of inductees (two in 1995) were: Jack Kittle (deceased, H.C. Stark, Inc.) and Walter B. Meyer (deceased, St. Louis Metallizing, Inc.).

The third class of inductees (four in 1996) are:

- Rea A. Axline, (deceased, President, Metco, Inc.). His citation reads "Founder of the Metalizing Engineering Company, Inc. (Metco). Pioneered the Thermal Spray industry worldwide. Provided a nurturing corporate environment that developed Engineers/Specialists who labored throughout the Americas, Asia and Europe."

- James A. Browning, (President, DRACO, Inc.). His citation reads "Inventor and implementor of numerous and unique Thermal Spray application devices which are mainstays of the Thermal Spray industry."

- Reginald McPherson (deceased, Professor, Monash University, Australia). His citation reads "Provided outstanding contributions in Thermal Spray research and graduate education. Elucidated the influence of voids and porosity relative to the deposit microstructure and properties."

- George H. Smith, (deceased, Manager—R&D, Union Carbide Corporation). His citation reads "Champion of advanced Thermal Spray devices, inventions, coating applications and industrial research. Co-inventor of high velocity oxygen fuel deposition. Mentor to Research Engineers, Scientists and Managers for over 40 years."

JTST Best Paper Award

A panel of five judges, under the Chairmanship of Dr. R.A. Neiser (Sandia National Laboratories, NM) reviewed Vol 4 (1995) of *JTST* and the following paper was judged as the best paper: "Microstructure Evolution During Reactive Plasma Spraying of $MoSi_2$ with Methane," by X. Liang, E.J. Lavernia, and J. Wolfenstine, University of California-Irvine, CA; and A. Sickinger, Sulzer Metco (Irvine), CA.