In The News

Conference Spotlight

Near-Net Shape Manufacturing Conference

27-29 September 1993, Pittsburgh, PA, USA

The 3rd Near-Net-Shape Manufacturing Conference, to be held 27-29 September in Pittsburgh, PA, has been structured to gather together the diverse technical groups associated with near-net-shape manufacturing. The conference is sponsored by ASM International's Materials Shaping Technology Division, and is co-sponsored by the American Foundrymen's Society, Concurrent Technologies Corp., Engineering Research Center for Net Shape Manufacturing, Forging Industry Association, Investment Casting Institute, Metal Powder Industries Federation, the Institute of Advanced Manufacturing Sciences, and the Precision Metal Forming Association.

The conference theme is "Competitive Processes." Through the efforts of industry leaders serving on the organizing committee, the sessions have been structured to provide manufacturing and product and materials engineers the advantages and limitations of near-net-shape processes.

Nearly forty technical papers, focusing on advancement in technology, case studies and applications, will cover bulk forming, incremental forming, powder metallurgy techniques, casting, and sheet metal forming, giving engineers enough information to make value judgment on whether their current processes can be improved or changed by using near-net-shape manufacturing techniques.

The presentations focus mainly on applications and case studies of commercially implemented processes, but new methods are included. Additionally, the application of process-modeling tools to assist both process implementation and improvement is covered. A special conference feature is the Keynote Lecture by Bart Huthwaite, of the Institute of Competitive Design. His speech, addressing "Competitive Design: How to Benchmark Your Concurrent Engineering Effort," will provide a step-by-step tool to measure the success of concurrent engineering efforts. Also being offered is a dinner presentation on "Eastern European Technologies," by Dr. Raymond Decker of University Science Partners, and a tour of the Concurrent Technologies Corp.'s Johnstown Facility.

Circle (4)

NTSC '94, 20-24 June 1994

Hynes Convention Center, Boston, MA, USA

A new format has been adopted for NTSC '94 in Boston, Massachusetts. The new format organizes the conference around six key industries: aerospace, power generation, automotive, petrochemical, medical and infrastructure to encourage greater participation from these end-user industries. Six individual symposia will offer a unique opportunity for both presenters and attendees involved in specific interest areas to share common concerns and ideas and exchange technical information.

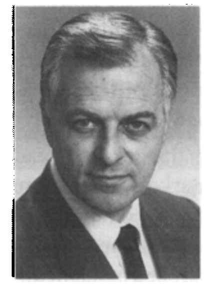
If you plan to present a paper at NTSC '94, target your presentation toward one of these key technical industries. Papers can be either technical in nature or a case study. Case studies should not be commercially oriented, but should recount an engineering problem and its related solution. Abstracts (about 150 words) or requests for information should be addressed to:

Ms. Lisa Hemeyer
Sr. Conference Administrator
ASM International
Materials Park, OH 44073
Tel: (216) 338-5151
Fax: (216) 338-4634

Abstracts must include company name, address, telephone and fax numbers for all authors, and should indicate to what key industry it is related and whether it is a technical presentation or a case study.

Circle (5)

Daniel Parker Named Conference Chairman for NTSC '94



Daniel Parker

ASM Manager of Conference Development and Technical Divisions, Edward Kubel, has announced the appointment of Daniel Parker of General Plasma as Conference Chairman for NTSC (National Thermal Spray Conference) 1994. The ASM chairman of the Thermal Spray Division, Mark Smith, extended the invitation to Mr. Parker on behalf of ASM earlier this spring. "We believe this appointment will bring a new and varied input to NTSC programming, as well as bring some new faces to the committee," said Kubel.

Mr. Parker, Senior Vice President of Sales and Marketing, General Plasma, East Windsor, Connecticut, and now concluding his term as Chairman of the International Thermal Spray Association (ITSA), has been a strong advocate for stronger participation in NTSC by thermal spray users, and his appointment is expected to bring about a balanced conference that reflects the interests of thermal spray users, practitioners, manufacturers and the academic community. "One of the goals of ASM," said Kubel, "is to expand the horizons of this event and attract people who have never attended an NTSC event."

NTSC '94 will be held in Boston. Mr. Parker met with his committee at NTSC '93, held June 7-11, in Anaheim, California, to launch plans for NTSC '94.

Gorham Advanced Materials Institute Conference on Thermal Spray Coatings

12-14 September 1993, Orlando. FL, USA

The purpose of the conference at the Orlando Airport Marriott, Orlando, Florida, USA is to assess the non-aircraft industrial applications for thermal spray coatings that will fuel near term market growth for all thermal spray coating industry participants. This conference is designed to be of maximum benefit to companies wishing to decrease their dependence on the aircraft industry.

Global markets for thermal spray powders, equipment and supplies were estimated to be between $1.9 and $2.2 billion in 1992 and are projected to reach between $3 and $4 billion by the year 2000. This growth will be led by new applications of thermal spray coatings and technology using HVOF, automated work stations, and new classes of advanced materials.

In the decade ahead, new applications and markets for thermal spray will increasingly come from industrial non-aircraft applications in the pump, valve, biomedical, petrochemical, chemical, automotive, diesel, pulp and paper, printing, packaging, power, oil and gas drilling, and steel industries.

The latest business developments, market trends, and new products from worldwide business, marketing, and technical experts will be presented. The conference offers a mix of presentation and networking opportunity time. A major emphasis is placed on new and developing applications, advances in manufacturing technology, economics, and market trends and forecasts.

Circle (6)

Spray Forming Conference

13-15 September 1993, Swansea, Wales, UK

The International Conference on Spray Forming will be held at the Swansea Marriott. A full program of about 30 papers will focus on applications of spray deposited materials, including: Automotive, Aerospace, Electrical and Wear Components. Several speakers will assess the market needs and potential of such materials, and there will also be papers on future developments of the process. Alongside the main meeting there will be a workshop on fundamentals of monitoring and modeling the Osprey Process.

Circle (7)

Review: Coatings for Advanced Heat Engine Workshop

3-6 August 1992 Monterey, CA, USA

The DOE Office of Transportation Technologies (OTT), along with other agencies involved in surface transportation engines, conducted the Coatings for Advanced Heat Engines Workshop at the United States Naval Postgraduate School facilities. Agencies organizing the workshop were the U.S. Army Tank-Automotive Command (TACOM), U.S. Naval Surface Warfare Center, NASA/Lewis Research Center, The Association of American Railroads (AAR), U.S. Maritime Administration, and Oak Ridge National Laboratory (ORNL).

Overviews of current programs and engine requirements were given by federal and state government agencies, diesel engine manufacturers, and other organizations. Presentations followed on thermal-barrier coatings (TBCs) for thermal insulation, hot-corrosion, and erosion resistance. Tribology topics discussed included high-temperature liquid lubricants, solid-lubricant coatings, and wear-resistant coatings. New technologies described included metal ion-implantation facilities, diamond and related material coatings, powder-metal materials, multilayer coatings, laser cladding, chemical vapor deposition, metal plasma-immersion surface modification, and ceramic-metal joining techniques. Workshop chairman John Fairbanks (DOE OTT) concluded the conference with a survey of emissions-reduction techniques for heavy-duty diesel engines. Highlights of the sessions follow, adapted from a summation by Fairbanks.

Overviews And Engine Requirements

Federal Programs

John Brogan (DOE)—DOE OTT programs;

Walter Bryzik (TACOM)—activities of and requirements for Army advanced ground-propulsion technologies; and

Steven Hsu [National Institute of Standards and Technology (NIST)]—lubrication of ceramics.

Canada

Anthony Davies (National Research Council of Canada) presented results from experimental work on the influence of TBCs on the cold startability of diesel engines. Results of this work indicated that cold startability was improved with TBCs in the engine combustion chamber.

State

David Hatfield [California Energy Commission (CEC)] described the CEC Energy Technology Advancement Program (ETAP), which was established in 1984 as a hardware funding program for developing energy technologies. CEC-funded projects develop advanced energy technologies and demonstrate innovative energy projects. ETAP offers funding to qualifying projects for research contracts, repayable research contracts, and loans. Matching funds are required for all contracts funded under ETAP. Currently, there are two jointly funded DOE-OTT/CEC programs.

Private Sector

Tim Belian [Coordinating Research Council, Inc. (CRC)] described the history of CRC and gave an overview of current programs related to environmental air pollution, including a cooperative program with the DOE National Renewable Energy Laboratory (NREL) on alternative fuels.

Conan Furber (AAR) reviewed development requirements for railroad locomotive materials, including reduction of oxides of nitrogen (NOx) emissions. The cost of new railroad locomotives makes retrofit solutions feasible. Methanol is not considered a good alternative fuel for rail applications because of the low-energy density of methanol when compared with diesel fuel. Liquefied natural gas (LNG) is a good alternative but does not reduce NOx emissions.

Industry

Representatives from Caterpillar Inc., Cummins Engine Company, Inc., and Detroit Diesel Corporation (DDC) provided overviews of current and future use of coatings in diesel engines. Charles Kuhn (Caterpillar) indicated that face coatings for compression rings have been in production for 15 years. Ceramic-coated exhaust valves are under evaluation for reliability, durability, and resistance to corrosive attack. Current coating life is less than the goal for cyclic operation. Zirconium oxide coatings are being considered for wastegate shafts in residual fuel engine turbochargers. Ceramic-coated exhaust manifolds are in field testing. Kuhn emphasized the need to match customer wants and needs with technology requirements.

Ed Owens (Cummins Engine Company) noted that Cummins' current coating applications for abrasive wear control include corrosion resistance and property improvement. Coatings are currently used on anodized piston crowns, graphite piston skirts, stellite valve crossheads, stellite valve faces, and piston rings. Future applications at Cummins include thermal insulation to improve thermal fatigue life and reduce particulate emissions and coatings to control friction, wear, and scuff and modify surface mechanical properties. However, cost and integration of these coatings into production systems continue to be challenging.

James Bennethum (DDC) reported on ceramic coating use in production of diesel engine components; the coatings contribute to higher power output ratings for engines, improved performance at high altitudes, and improved performance with low-grade diesel fuels. Zirconium oxide TBCs are used on the piston crowns, cylinder head, and valve faces of the Series 149 DDC engines.

Thermal Barrier Coatings

Thirteen papers were related to TBCs. Walter Bryzik (TACOM) discussed heat rejection from ceramic-coated heat engines and its impact on advanced heat-engine design. Key research objectives were to reduce heat rejection, cooling power requirements, radiator size, and fuel consumption and to increase power density. Key factors for meeting the objectives were to fully insulate the combustion chamber, reduce liner and head cooling, and eliminate aftercooling.

Brad Beardsley (Caterpillar) discussed material development of thick-thermal-barrier coating (TTBC) systems for low-heat-rejection engines, and Chris Berndt (SUNY at Stony Brook) described bond coats for TTBCs. Tom Yonushonis (Cummins) and Klod Kokini (Purdue University) described their work on the development of TBCs for pistons.

Compressive fatigue behavior of a TBC was discussed by Bob Miller (NASA/Lewis Research Center), and life prediction and extension of TBCs in gas turbine engines were discussed by Richard Sisson, Jr. (Worchester Polytechnic Institute). Ben Nagaraj (General Electric Aircraft Engines) presented TBC corrosion and erosion resistance based on laboratory and service experience with marine gas-turbine engines.

Sputtered TBC processes were described by Mike Saunders [Optical Coating Laboratory, Inc. (OCLI)], advances in electron beam deposition coaters for TBC applications were discussed by Dave Rigney (General Electric Aircraft Engines), and William Beauchamp (OCLI) discussed his company's work on oxygen barrier coatings. Studies on the hot-corrosion resistance of India-stabilized (In_2O_3) zirconia were described by Robert Jones and Fred Smidt (both of Naval Research Laboratory) discussed the tribological coating deposited by ion-beam-assisted deposition and pulsed-laser deposition.

Tribology

Tribological topics included an overview of the evolution of the DOE tribology program, as well as various discussions on high-temperature liquid lubricants, solid lubricant coatings, and the effects of methanol fuel on diesel crankcase oils.

William Sproul (BIRL, Northwestern University Industrial Research Laboratory) spoke on unbalanced magnetron (UBM)-sputtered tribological coatings for engine applications. Traditionally, sputtering can be used to apply hard, wear-resistant coatings at low substrate temperatures without macro-particles. However, properties are not as good as those obtained using low-voltage electron beam or cathodic arc evaporation because of the low amount of ion bombardment during the growth of a sputtered coating. This problem has been overcome with use of UBM sputtering. Most of the early UBM work involved use of titanium nitride (TiN), which is the workhorse of the physical vapor deposition (PVD) coatings industry. A very effective tool coating, TiN can extend the life of cemented carbide and high-speed steel tooling by a factor of 4 or even as high as 20 or more. PVD hard coatings such as TiN are ready for use in many different conventional tribological applications on components such as gears, cams, and bearings. Test data look promising for TiN, which has performed extremely well in rolling-contact fatigue, scuffing, and sliding tests. Compared with the overall costs of electroplated coatings, PVD coatings are less expensive and are more effective in preventing wear. PVD coating processes are significantly less polluting than is electroplating.

Synthetic, high-temperature liquid lubricants are of interest in low-heat-rejection engines because of their high-temperature requirements. In addition, they are of interest for production diesel engines because of the need to further reduce particulate emissions. Current conventional petroleum-based lubricating oils contribute about 25% of the particulate emissions from diesel engines. Synthetic or part synthetic lubricants with low-ash formulations can significantly reduce the lubricant contribution of particulate emissions from current production diesel engines.

Two separate development and evaluation programs on high-temperature lubricants are under way at Cummins. One program described relates to lubricants required for U.S. Army advanced diesel engines; the other program relates to liquid lubricants for advanced commercial heavy-duty diesel engines. In the U.S. Army diesel engine program, both laboratory and engine tests are being run to evaluate oxidation and deposit-forming tendencies of the candidate lubricant formulations. Engine tests are being conducted with a Cummins 110 engine at temperatures representative of future military engines. With the oxidation tests, good correlation (98%) was reported between laboratory bench tests and engine tests. With deposit tests, the correlation was only 59%.

Cummins is developing high-temperature liquid lubricants for advanced heavy-duty engines, demonstrating their capability, and investigating their potential for reducing particulate emissions. The test engine has been modified to eliminate coolant flow around the cylinder liner, and the lubricating oil is used for coolant in the cylinder head. Test condition temperatures are 300 °F, oil sump; 200 °F, head coolant; and 150 °F, inlet air. Results to date indicate that synthetic low-ash formulations can reduce cylinder and ring wear, piston deposits, and particulate emissions, when compared with a mineral oil with a high-temperature additive package.

Research is under way at Caterpillar to evaluate high-temperature liquid lubricants for low-heat-rejection engines. Important characteristics of the lubricants include low deposit-forming tendencies, adequate viscosity at high temperatures, low volatility, good thermal stability, materials compatibility, and good water/fuel handling capability. Evaluation tests include micro-oxidation, thermogravimetric analysis, differential scanning calorimetry, bearing corrosion, engine friction, and wear.

Based on a report from Pennsylvania State University, much more work is necessary to develop high-temperature lubricants for methanol engines. In current lubricant formulations, methanol causes the additive package to separate from the lubricating oil. Test results show significant differences in behavior among the commercial lubricants evaluated; significant effects were noted on fuel additives in the methanol, as well in adverse effects on the lubricant if the methanol is contaminated by 2% water.

Other papers in the tribology area included reports on solid lubricants by Adiabatics, Inc., and on development of wear-resistant ceramic coatings for diesel engine components by Caterpillar and Cummins. In addition, Combustion Technologies, Inc., reported on its piston-ring coating developments.

New Technologies

Topics discussed included:

- Development of a very-large-scale metal ion-implantation facility at Lawrence Berkeley Laboratory
- Status of diamond and related material coatings
- Stability of diamond films in oxygen at high temperatures
- Powder-metal materials for use in diesel engine cylinder liners
- Multilayer coatings for tribological applications
- Laser cladding of several nickel- and cobalt-based alloys.

Also mentioned were ceramic-metal joining, chemical vapor deposition of Ta_2O_5 corrosion-resistant coatings, piston ring-cylinder liner interface tribology, and the new surface-modification processing technique of metal-plasma immersion.

Conclusion

Workshop chairman John Fairbanks concluded the workshop with a survey of emission-reduction techniques for heavy-duty diesel engines. He said that available engine designs and particulate-control systems apparently will enable engine manufacturers to meet the 1994 EPA emission standards for heavy-duty trucks, with after-treatment use of catalytic converters rather than particulate traps.

Further reductions in emissions beyond 1994 are being sought by employing cleaner diesel fuels with higher cetane numbers, lower aromatics, and possibly lower-sulfur levels than the 0.05 wt% level mandated for October 1, 1993. Synthetic or partial synthetic lubricants with low-ash formulations can reduce the lubricant contribution to particulate emissions as well as reducing oil consumption.

Participants noted that when in-cylinder parameters are adjusted to reduce NOx, particulates are increased; the converse is also true. Fuel additives or after-treatments that successfully reduce NOx could permit operating at temperatures high enough at the end of the stroke to burn off particulates. This advance could open a market for TB-coated in-cylinder components for new engines and retrofit of older engines. In one year this market could involve coating more parts than have been coated in the aircraft gas turbine engine in 28 years.

The two commercial chemical after-treatment schemes for reducing NOx emissions are based on introduction of NH_3D or HCNO into the diesel engine exhaust stream. The most exciting approach for reducing NOx emissions is a collaborative program (Texaco Inc., Cummins Engine Company, Sandia National Laboratories, and University of Wisconsin), in which HCNO is attached to the molecular structure of the fuel, released during the combustion process, and protected until it reacts with the newly formed NOx. Another method under study is electronic NOx reduction in which either oscillating-wave or pulsed-plasma schemes are used to dissociate the NOx in the exhaust gas stream.

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Circle (8)

Literature/Media

Industry Report on Protective Coating Processes

Protective Coating Processes 1991-1992, featuring documentation on 1,000 research studies from over 800 companies on protective coatings processes, applications, and technologies currently in use or under development around the world, has recently been published. Compiled and published by Materials Information, a joint service of ASM International and the Institute of Materials (UK), this report covers technical and business-related developments in protective coatings derived from international databases between January 1992-December 1992.

Coverage is given to the most current information on coating technology and applications, addressing equipment, automation, selection, effects, characterization, resistance, failure, and industries using protective coating processes. Included are applications and innovations in thermal spray coating methods; specifically arc, plasma, flame, powder, and wire spraying.

Also addressed are the various types of coatings and processes. Arranged by materials and source, the report provides information on the assessment, production and selection of protective coatings and coating methodology. The format design allows the user to spot trends in protective coatings research by taking note of how companies spend their R&D dollars.

Protective Coatings Processes 1991-1992 features short project summaries, full abstracts, and original source documentation, and an introductory editorial summarizes topics, trends, developments, and research directions. Also included is a glossary, addresses for cited corporations and universities, and patent review. The personal computer (PC) diskettes provided with the report include the entire database of documents found in the research section. The diskette version offers the user expanded search capabilities.

Protective Coating Processes 1991-1992 joins a growing number of Industry Reports. The series is designed to provide comprehensive, organized corporate intelligence on materials and/or process-related topics for specific industries.

Circle (9)

Sixth Edition of Source Journals in Metals and Materials

The *Sixth Edition of Source Journals in Metals and Materials* has just been released by Materials Information. This directory, published February 1993, includes all the scientific, trade and business journals abstracted in Materials Information's four databases: METADEX, Engineered Materials Abstracts (EMMA), Materials Business File, and Metals Datafile.

Over 3,300 journals are listed from 1,470 publishers, including 923 inactive titles. The 135-page directory is comprised of three sections. The first section includes a list of journal titles, giving abbreviations, frequency and years of publications, publisher and ISSN, and languages of publication. The second section presents a list of publishers, giving full addresses, phone, fax and telex numbers plus a list of their journals. The third section is a subject index, that groups the journals by major subject emphasis.

This edition includes 400 more titles than the previous edition, published in April 1990. The increase reflects Materials Information's continuing expansion of its coverage of the materials science field. All new titles in the sixth edition have been re-indexed using the new controlled vocabulary index. All languages of publications are now included.

Circle (10)

Recycling Case History 1993: Technology and Strategies

Recycling Case Histories 1993: Technology and Strategies, an extensive, current review of initiative undertaken by governments and industries worldwide to promote materials recycling, has recently been published. Compiled and published by Materials Information this report covers technical and business-related developments in recycling derived from international databases between the period January 1992 to December 1992.

Recycling Case Histories 1993 is an organized study of specific actions undertaken by companies responding to increased public concern for health and safety and to legislative demands for environmental responsibility. The activities of more than 800 organizations are included, as they relate to the commercial practices and production systems designed to manage waste, conserve resources, and achieve environmental compliance.

Divided into six major sections, the report offers a comprehensive guide to business trends, developments, and forecasts as well as technical advances and current expertise in reprocessing and reapplication of recovered products and industrial scrap, effluents and by-products. The list of materials cited includes not only steels, ferrous and nonferrous metals and alloys, but also plastics, polymers, and composites.

The information is arranged by materials and source in tabular format. The tables serve as an international directory to the array of materials involved in recycling efforts and to the individual manufacturers, suppliers, companies, universities, institutes, and associations involved in related research, development and commercial ventures worldwide.

The personal computer (PC) diskettes provided with the report include the entire database of documents found in the research section. The diskette version offers the user expanded search capabilities. *Recycling Case Histories 1993: Technology and Strategies* joins a growing number of Industry Reports. The series is designed to provide comprehensive, organized corporate intelligence on materials-and/or process related topics for specific industries.

Circle (11)

Brochure from General Magnaplate

The PLASMADIZE® group of composite coatings, composed of layers of ultra-fine ceramic particles infused with polymers to enhance structural integrity, is described in an illustrated brochure from General Magnaplate, Linden, New Jersey. These coatings are composites of super-hard ceramics, lower modulus matrix materials and dry lubricants, and may be used on most metals, including aluminum.

The free brochure describes five major benefits derived from PLASMADIZE® surface enhancement: sealing of surface voids to eliminate porosity; lending structural integrity to the coated part; reduced loss of particles resulting in longer wear; permanent, non-stick dry lubrication; and exceptional mold release. Photos illustrate various applications, and a Taber Abrasion Test chart shows wear performance results. Technical data concerning friction properties, corrosion and abrasion resistance, electrical properties, thickness and hardness, as well as specific benefits of the twelve members of the PLASMADIZE® family are included.

Circle (12)

ASTM Directory of Scientific & Technical Consultants & Expert Witnesses 1993-1994

Whether you need litigation support, solutions to complex problems, or someone who's on top of Federal and state regulations, you'll find the right expert for the job in the new ASTM Directory of Scientific & Technical Consultants & Expert Witness 1993-1994. Answers to inquires such as—"Can you refer me to a structural engineer?"; "We need to talk with someone about ground water."; "Do you know anyone who can help us with our ISO 9000 program?"; "My firm needs to find an expert witness on trampolines."—may be addressed.

To meet such concerns, this book compiles over 1,000 experts and witnesses in 280 categories—areas such as The Environment, Construction Engineering Materials, and Testing. Each listing includes company name, address, phone & fax numbers; contact person; specialization; other services offered; geographic service areas; and whether or not the consultant is also an expert witness.

These professionals are ready to focus their analytical expertise and specialized services on meeting your needs. Many are available worldwide. The consultants listed are listed for a fee and are not certified by ASTM.

Circle (13)

Plasma Paradigms Software

Plasma Paradigms software was created to help both students and teachers understand plasma (an electrically charged gas) and its many uses in the fabrication of common and high-technology products. Examples of plasmas include the glowing discharge of neon signs, lightning, aurora borealis and sun. Plasma Paradigms explores the use of a plasma in the manufacture of semiconductors, compact discs, artificial implants and gas turbine blades, as well as a comprehensive introduction to plasma.

This educational software package was produced by The Engineering Research Center (ERC) for Plasma-Aided Manufacturing at the University of Wisconsin, Madison, WI, a laboratory which conducts plasma research to improve manufacturing processes. This ERC is funded by the National Science Foundation and involves a consortium of industrial members which enables research to become a reality on the production lines of major corporations.

Circle (14)

CERAC Publishes Full-Line Catalog of Specialty Inorganic Chemicals

CERAC, Inc., Milwaukee, WI, has published a full-line catalog of advanced specialty inorganic chemicals manufactured by the firm. The 282-page Advanced Specialty Inorganics catalog allows chemists and researchers to quickly reference CERAC's line of inorganic chemicals. From aluminum to zirconium, each chemical is identified by formula, purity level, particle size and lot.

The complete catalog also includes CERAC's line of evaporation materials, with formula, purity and form easily identified; evaporation cones; sputtering targets; deep-drawn metallic crucibles; hot-pressed crucibles; electron beam hearth liners; and rods.

Although it's virtually impossible for CERAC to list all inorganic chemicals and purity levels in a single catalog, this catalog acquaints users with CERAC's program of specialty inorganic chemicals and informs them that chemicals not listed and other purities can be prepared on a custom basis by an established manufacturer.

The catalog is filled with other useful charts and information. One chart is the complete listing of U.S. Department of Transportation (DOT) hazard class codes. There's also a detailed explanation of the X-ray diffraction and spectrographic analysis techniques CERAC uses as analytical tools as well as various techniques used to precisely measure particle size.

Circle (15)

An Examination of ISO 9000 in Three-Tape Videocourse

As ISO 9000 continues to gain in popularity and worldwide acceptance, more individuals and companies in the engineered materials field are looking for specific information about the benefits and implications of this international quality system. As a leading worldwide technical information resource, ASM International is responding to the demand for specific, comprehensive information on ISO 9000 as it relates to the engineered materials industry with a new videocourse: "Understanding ISO 9000: For Metalworking/Materials Companies."

The three, one-hour tapes address the following issues: Overview of ISO 9000/Q90; Certification requirements; Continuous improvement; Expense, manpower, resource allocations; Internal/external audits; Program maintenance; Developing a Quality Manual; Compliance vs. Certification; and Access to Other Markets.

Many companies operating in the very broad area of engineered materials are uncertain about what ISO 9000 may have in store for them—or even if ISO 9000 will affect their operations. A great deal of information is coming from many sources—colleagues, trade articles, and businesses offering services related to ISO 9000. This videocourse has been created in response to member demands for information regarding ISO 9000 that relate directly to metalworking/materials operations and the future of these businesses. The introductory-style tapes will also provide an understanding of ISO 9000 within all organizational levels.

The course instructors are Linda Morris, president of Quality Systems Management Corporation, and Jessica Gonzalez, president of Global Quality, Ltd. Ms. Morris is an independent quality assurance consultant with primary service in the field of ISO 9000, Total Quality Training, and quality systems auditing. Ms. Gonzalez is a quality engineer certified by the American Society of Quality Control. She has extensive experience in quality auditing.

A preview tape presenting an overview of the course content is available.

Circle (16)

Newsletter Receives Publication Award

The Ceramic Technology Newsletter of the DOE Ceramic Technology Project received an Award of Achievement in the 1992-93 Technical Publications Competition, sponsored by the East Tennessee Chapter of the Society for Technical Communication. Issues 34, 35, and 36 were judged in the newsletter category that included both internal and external distribution.

Receiving award certificates for their contributions were Judy M. Wyrick and Gloria M. Caton (Health and Safety Research Division) and Ceramic Technology Project staff D. Ray Johnson; Ernest L. Long, Jr.; Susan G. Winslow; and E. Sloan Bomar. Some 130 entries were judged on the basis of how well the publication met its technical communication objectives. STC is the world's largest professional organization, with over 14,000 members in more than 120 chapters, devoted to the art and science of technical communication, and it is one of the fastest-growing professional societies.

The newsletter and Ceramic Technology project staff wish to thank those who have contributed their time and efforts toward producing this publication. This Research was sponsored by the Ceramic Technology Project, DOE Office of Transportation Technologies, under contract DE-AC05-84OR21400 with Martin Marietta Energy Systems, Inc. Reprinted with permission from ORNL Ceramic Technology Newsletter, No. 38, Jan.-March, 1993.

Circle No. (17)

Guide Available for Packaging of Silicon Carbide Whiskers and Fibers

Recent news from ASTM of interest to the thermal spray area concerns the handling of powders. Subcommittee E34.70 on Single Crystal Ceramic Whiskers is making great headway in its effort to write health and safety standards for silicon carbide whiskers and fibers, tiny reinforcement materials used to increase the strength, toughness, modulus of elasticity, and hardness of composite metals, ceramics and, in some cases, polymeric materials.

The publication of the subcommittee's latest standard, E 1516, Guide for Packaging of Silicon Carbide Whiskers and Fibers, brings its total to four of a projected total of 13 standards on the subject. Of the remaining nine, two will advance to Society ballot within the next month, four are expected to reach main committee ballot this summer, and three are still in the developmental stage.

"Silicon carbide whiskers and fibers were becoming very actively used in industry and it was recognized that these materials required special handling", says Sam Weaver, chairman of E34.70, part of Committee E-34 on Occupational Health and Safety. "Like any hazardous materials dealt within the laboratory, you need to be careful how you use them. If they are used carefully, they can be used quite safely"' says Weaver. The standards provide the industry's experience on how to use these materials safely, he explains.

The newest of the standards, E 1516, covers the packaging of unbound silicon carbide whiskers and fibers and materials containing respirable silicon carbide whiskers and fibers. The standard addresses issues such as: materials characteristics to be considered in packaging design, packaging recommendations to limit potential personnel exposure, packaging and product quality concerns, labeling, recommended container characteristics, and disposal of used containers.

E 1516 adds to the subcommittee's existing three standards:

- E 1435, Practice for Handling Densified Articles of Aluminum Oxide Reinforced with Silicon Carbide Whiskers
- E 1436, Practice for Handling Densified Articles of Silicon Nitride Reinforced with Silicon Carbide Whiskers
- E 1437, Practice for Handling Silicon Carbide Whiskers.

The two E34.70 standards moving to Society ballot are: 1) Guide for Disposal of Wastes Containing Silicon Carbide Whiskers and Fibers, and 2) Guide for Medical Surveillance Program for Workers with Occupational Exposure to Airborne Silicon Carbide Whiskers and Fibers. The four standards expected to reach main committee ballot this summer were developed by the subcommittee and transferred to Subcommittee D22.04 on Workplace Atmospheres, part of Committee D-22 on Sampling and Analysis of Atmospheres. They include:

- Test Method for Determining the Concentration of Air-Borne Silicon Carbide Whiskers or Other Single Crystal Ceramic Whiskers in the Workplace Environment by TEM (Transmission Electron Microscopy)
- Test Method for Determining the Concentration of Air-Borne Silicon Carbide Whiskers or Other Single Crystal Ceramic Whiskers in the Workplace Environment by Phase Contrast Microscopy
- Test Method for Determining the Concentration of Air-Borne Silicon Carbide Whiskers or Other Single Crystal Ceramic Whiskers in the Workplace Environment by Scanning Electron Microscopy
- Guide for Determining the Concentration of Air-Borne Silicon Carbide Whiskers or Other Single Crystal Ceramic Whiskers in the Workplace Environment.

The three standards still under development address protective equipment, training, and administrative and engineering controls.

The subcommittee invites interested parties to participate in the development of its standards and will next meet during the Oct. 10-12 meetings of E-34- in Fort Worth, Texas. For more information on E34.70, contact Sam Weaver, Third Millennium Technologies, P.O. Box 23556, Knoxville, Tennessee 37933 (615/691-2170); for meeting information, contact Teresa Cendrowska, ASTM(215/299-5546).

News from NASA

Adjustable Powder Injector for Vacuum Plasma Sprayer

Workers at the Marshall Space Flight Center, Alabama have developed a device for external injection of powder with variable position and orientation into a plasma effluent.

An attachment for a plasma spray gun (see figure) provides four degrees of freedom for adjustment of the position and orientation at which powder is injected externally into the plasma flame. This adjustment is desirable because it can help to optimize deposition in the specific plasma process. Previous external injectors have been fixed or have been adjustable in only two degrees of freedom.

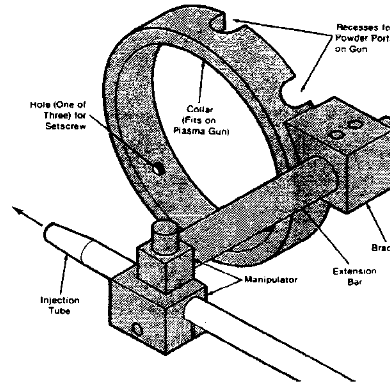
A collar on the injector is slipped onto the protruding cylindrical portion of the plasma gun and is positioned repeatably on the gun by three setscrews, spaced 120° apart, that rest in shallow holes on the gun. Three approximately semicircular recesses in one edge of the collar provide clearance to enable the internal injection of powder (injection of powder from within the gun into the plasma flame).

An extension bar holds the injection tube and a manipulator (which is essentially an adjustable clamp). The bar slides and rotates in a bracket, so that the axial position and the yaw angle of the injection tube can be adjusted. Scribed lines on the collar and extension bar indicate the yaw angle.

The manipulator provides for adjustment of the pitch angle of the injection tube. It can be set to inject powder at any angle ranging from perpendicular to parallel to the cylindrical axis. Scribed lines on the extension bar and manipulator indicate the pitch angle of the extension tube.

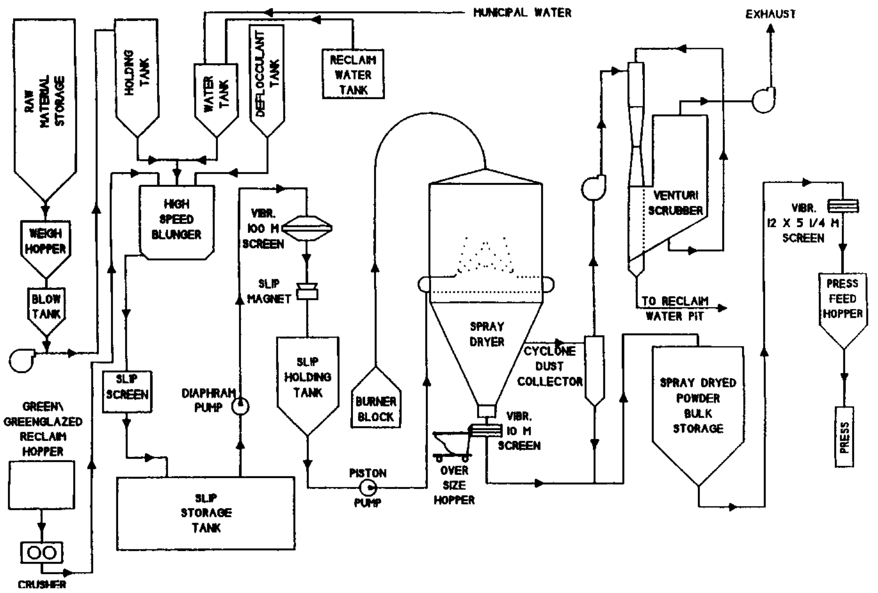
With the exception of the collar, the components of the injector can be used with a plasma gun of any size and type.(The collar must be changed to fit a gun of different diameter or design.) Therefore, vacuum plasma spraying that requires different guns in sequence can be done with only one external powder injector.

This work was done by D.H. Burns of Marshall Space Flight Center and W.H. Woodford, T.N. McKechnie, D.C. McFerrin, W.M. Davis, and G.P. Beason, Jr., of Rockwell International Corp. Used with permission from NASA Tech Briefs, 17 [7] (1993) p. 77.



The adjustable powder injector is mounted on a plasma gun. The collar can be changed to adapt the injector to a different gun.

Circle (18)



Typical body preparation process incorporating a spray dryer. Mannington Ceramic Tile

been established, both should be kept constant during operation to maximize thermal efficiency and to obtain a homogeneous powder humidity. Outlet temperature can be regulated by adding or reducing the number of spray nozzles working in the drying chamber. If the inlet temperature is constant and the number of working nozzles is increased, the outlet temperature will be reduced and vice versa. If the temperature in the drying chamber is too low, humid powder may be deposited on the interior walls. Typical drying chamber temperature range is 110-130 °C.

Drying Air. To obtain a constant moisture content of the powder, the outlet air temperature must be altered daily. The absolute humidity of the drying air varies daily because it is dependent upon the temperature and relative humidity of the ambient air. The higher the absolute humidity of the drying air, the less water this air can remove from the product.

Slip Properties. The dry material content of the slip supplied to the spray dryer must be kept as constant as possible. A variation in specific gravity, while inlet temperature and pump delivery are kept constant will result in a variation in the humidity of the powder.

Slip viscosity is determined and/or controlled by: the percent solids present in the slip; the amount of deflocculant added to the slip; and slip temperature. Typically, slip viscosity is maintained between 70 Cp and 180 Cp. As slip viscosity increases, larger drops are formed in the spray—which will dry less quickly—resulting in powder with a higher moisture content.

Surface tension varies from slip to slip. Generally, surface tension values are too low to influence atomization and/or drying; therefore, surface tension is much less significant than viscosity. However, if surface tension is sufficient to have an influence, then low surface tension yields small spray droplets. Thus, particle size distributions tend to become wider, and bulk densities increase. High surface tension slips are more difficult to atomize.

Deflocculant. Deflocculant agents are used to obtain acceptable viscosity levels with a low percentage of water in the slip. The amount and deflocculant type (organic or inorganic) used depends upon the type of clay and the drying process as a whole.

When using deflocculants to adjust the viscosity of the slip, use only the predetermined amount. Otherwise, over-deflocculation may result in: reversed effects (viscosity increases); a dilatant solution; rapid and uncontrollable settlement of the solids suspended in the slip.

Drying chamber pressure. To promote the best possible thermal efficiency, the drying chamber pressure should be maintained as low as possible, while yielding an acceptable product. As the internal pressure increases, the heat of vaporization of the water being evaporated increases. The result: decreased thermal efficiency and higher operating temperatures.

The operating chamber pressure also controls the powder/air loading in the exhaust air. The internal pressure should be such that the optimum dust-to-exhaust air loading is achieved for the greatest dust collection efficiency in the cyclones. The drying chamber pressure is regulated by a servo-driven damper in the exhaust duct.

Nozzles. To maintain nozzle performance, periodic cleaning is essential. Clogging, irregular spray patterns and/or reduction in throughput is likely to result if nozzles are not cleaned. If the nozzle is not to be reassembled immediately, the parts should be submersed in clean water. It is advisable to keep a set of clean, assembled nozzles on hand at all times.

Troubleshooting

Insufficient and/or erratic evaporative capacity. Check the slip piston pump; make sure the pump is not exceeding the normal pressure and is operating properly. Manually increase the inlet temperature, and check the powder moisture. If moisture content is still too high, verify inlet/outlet temperature thermocouples and controller calibration, and check fuel consumption.

If the inlet/outlet temperatures and fuel consumption have been verified and are correct, the air delivery/exhaust may be at fault. Check the following: position of the exhaust damper; antivibration joints in the dust system, making sure they are in good condition, correctly mounted and are not leaking; doors and port holes on the drying chamber should be tightly closed.

If the inlet temperature does not reach its normal operating value, check the burner block for blocked flame ports. Check the viscosity of the slip. An excessive viscosity can decrease considerably the evaporative capacity.

Powder deposits in the drying chamber. Causes and cures:

- Incorrect dryer start-up procedure. During start-up, the outlet temperature should be high enough to ensure the slip is sufficiently dried to prevent sticking. All nozzles should not be opened at once during start-up.
- Inadequate slip-pump pressure. If too low, the spray angle of the nozzles will be too narrow, and slip will be deposited on the top of the drying chamber

- Worn nozzle and/or orifice. May cause a deflection of the spray, resulting in slip being sprayed directly on the drying chamber walls. Drips formed at the nozzles result in dried slip stalagmites and periodic avalanches of moist product.
- Excessive slip viscosity. Detrimental to the spray pattern, it results in undried slip expelled in the chamber and onto the walls.

Last, but not least, establish a preventive maintenance schedule.

Editor's Note: This article was adapted from a presentation at the 1992 joint fall meeting of the Southeast and Southwest Sections of The American Ceramic Society at Nashville, Tenn. Reprinted with permission from Ceramic Industry, 140[6] June 1993.

Cummins To Continue Developing Coatings for In-Cylinder Components

In March 1993, Cummins Engine Company, Inc., entered into the second phase of a subcontract with the DOE Ceramic Technology Project to continue the development of wear-resistant coatings for diesel engine components. During the first phase of this contract several promising coating systems were identified. These systems were deposited with high-velocity oxy-fuel (HVOF) and plasma-spray equipment.

To evaluate these coatings, laboratory screening tests were used to simulate the tribological environment of the top compression ring in a heavy-duty diesel engine. This second-phase effort, which is a 24-month subcontract, will focus on improved ductility of HVOF cermet coatings, development of thicker PVD CrN coatings, and investigation of plasma-sprayed ZrO_2-Al_2O_3-Y_2O_3 materials.

These processes will allow top compression ring face coatings to be produced with actual piston-ring arbors. The coated piston rings will be evaluated for dimensional control, coating adhesion, microstructure, fatigue, thermal-shock resistance, and tribological properties. For wear testing samples machined from selected piston rings will be tested against samples cut from cylinder liners.

This Research was sponsored by the Ceramic Technology Project, DOE Office of Transportation Technologies, under contract DE-AC05-84OR21400 with Martin Marietta Energy Systems, Inc. Reprinted with permission from ORNL Ceramic Technology Newsletter, No. 38, Jan.-March, 1993.

Circle (23)

Business Notes

Metco Opens Singapore Technical Center

A Technical Center in Singapore has been opened by the Perkin-Elmer Corporation's Metco Division, headquartered in Westbury, New York.

"Our new Technical Center represents a major commitment by Metco to its customers in Asia," said K.X. Chu, regional manager for Asia. "We will be able to demonstrate Metco's full line of products and perform coating analyses right here in Singapore. Just as important, we will be able to provide technical training to our customers and distributors. The Center also establishes a home base for our service engineers in Asia."

At a Technical conference observing the opening of the Center, F. Gordon Bitter, Senior Vice President of Perkin-Elmer and President of the Metco Division said "Our Asian market has grown strongly in recent years and it is no longer practical to support it from New York. We must have a technical presence here where the customer needs it." In addition to Metco's international staff, the conference was attended by Metco distributors from 13 Asian nations. The new Technical Center includes demonstration and training facilities in addition to a fully equipped coatings laboratory.

Metco's products include materials and systems that apply sophisticated thermal spray coatings to a large variety of industrial and engine parts to increase their resistance to wear, heat and corrosion. Metco is a Division of Perkin-Elmer, the worldwide leader in analytical instrumentation systems.

Alusuisse-Lonza and H.C. Starck Sign Letter of Intent

H.C. Starck GmbH & Co. KG, Goslar, Germany, announced today that it has signed a letter of intent to acquire the fused aluminum oxide and engineering ceramic business activities of LONZA-Werke Gmbh, Waldshut-Tiengen, a company of the Alusuisse-Lonza group. Under the terms of the agreement, certain production equipment for the fused aluminum oxide and the engineering ceramic products in addition to the corresponding stocks will be taken over by H.C. Starck. The businesses in question include fused aluminum oxide for abrasives and refractories, oxide plasma spray powders and ultrafine silicon carbide powders for the production of engineering ceramic components.

Subject to the approval of the authorities, the final contract will be signed in a few weeks, and the transaction is to be concluded at the latest by the end of this year. Plans are to transfer the production equipment which is to be acquired to the H.C. Starck plants in Laufenburg and Goslar.

H.C. Starck—an affiliated company of Bayer AG, Leverkusen—is one of the world's major producers of powders made from refractory metals, intermediates for engineering ceramics and fused aluminum oxide products. By acquiring the fused aluminum oxide and engineering ceramic businesses of LONZA-Werke, H.C. Starck is seeking to further consolidate its position in the important markets for these products.

Jimmie Jones Inc. to Distribute Hobart Welding Equipment

Jimmie Jones, Inc., Tulsa, Oklahoma, recently signed a distributor agreement with Hobart Brothers Company, Inc. Jimmie Jones will provide Hobart welding equipment, orbital TIG machines, and filler metals to its customers.

With 13 stores located in Oklahoma, Arkansas, Kansas, and Missouri, Jimmie Jones supplies welding equipment products and services, maintenance alloys, adhesives and bonding products, and gas apparatus. The company is one of only a few companies of its kind to provide rare and exotic gases from its specialty gas plant for laboratories and research facilities.

Jimmie Jones serves a wide array of customers in the aerospace, oil and petrochemical industries, agricultural implement manufacturers, food producers, hospitals, and laboratories.

LTC Changes Name & Ownership

LTC International, Inc., Sterling, Virginia, has changed its name to LTC Americas, Inc. Formerly a subsidiary of the Dutch company, the new name reflects the purchase of the subsidiary by American investors.

LTC Americas will continue marketing its unique vacuum blasting equipment as the sole licensed company for sales in North America. Further, LTC Americas opened a new manufacturing plant on the East coast in early 1993 and will expand sales and equipment rentals in Canada, Central and South America, and in the Caribbean. In addition to the current line of equipment, LTC Americas plans to introduce new, more portable models of its vacuum blasting systems.

Owners of the new company are W.S. McPhee, president of the previous subsidiary and now of LTC Americas Inc., and J.M. Fischer P.E.

A Look at ISO 9000 Why We Should Be Interested in the International Quality Standards

By Mary Jenkins
DuPont Quality Management & Technology Center

ISO 9000 will have impact on all aspects of industry and manufacturing. The ASTM Board of Directors has named a team to study the feasibility of adopting the ISO 9000 series to the operations of ASTM. As Board Chairman Nancy Trahey says, "How do we know we are doing the best job that we can do! The ISO Quality Series gives us a way of tracking ourselves."

ASTM President Jim Thomas states in the 1992 Annual Report that "standards are the underpinning of the larger quality movement. Quality management systems, such as the ISO 9000 series, provide the framework on which a business can build its production and marketing strategy. An important aspect of that strategy is the organized use of technical standards to measure the performance and safety of materials, products, systems and services."

The ISO 9000 quality standards may provide a way for ASTM to "track" its continuous improvement strategies while ASTM's standards in turn provide test methods and other standards needed for a quality system. With this in mind, the Committee on Research and Technical Planning thought that a general overview would be helpful in creating member awareness of what the ISO 9000 series entails.

Background on the ISO 9000 Series

ISO 9000 is a series of five international standards that establishes the requirements for the quality systems of companies and other organizations. Compliance with the requirements provides assurance to customers and to management that the processes and systems the supplier uses to provide products and services do, in fact, consistently produce the level of quality that is specified by the supplier. The standards are generic and specify the necessary elements of a quality system. They do not, however, provide implementation requirements. They are designed to be used with and to complement industry, specific product standards and test methods such as those developed by ASTM.

The ISO 9000 standards were originally developed during the 1980s by the International Organization for Standardization (ISO) to provide uniform, worldwide quality assurance requirement. They were designed to be within the reach of any enterprise that wish to compete in the world market and evolved from established quality system standards. In particular, ISO 9000 was influenced by BSI-5750, developed by the British Standards Institution, and Mil-Q 9858A, used by the U.S. Department of Defense.

The standards achieved international prominence when they were adopted by the European Community (EC) and the nations of that community. The ISO 9000 series (or its European equivalent, the EN 29000 standard series) was seen by the EC as a means for guaranteeing cross-border quality as trade barriers were torn down by the EC 1992 agreement on the formation of a single market.

In particular, the EC adopted ISO 9000 as part of their modular approach to "conformity assessment" procedures for several product categories. Conformity assessment is the process the EC has established to provide assurance that products meet a uniform array of requirements. Conformity assessment activities include: the development of standards (specifications) which define what the purchaser wants and what the supplier agrees to provide; quality system registration (certification) which increases confidence in the supplier's ability to produce a product consistently; laboratory accreditation which increases user confidence in the validity of the data produced by the laboratory; and product testing and/or conformance of the product to specified requirements. The requirements are typically most rigorous for regulated products that have a major impact on health and safety.

Registration

In a growing number of instances, European buyers (and, to a lesser extent, regulators) are requiring the use of a third party registrar to ensure conformance to the appropriate ISO 9000 requirements. Third party registrars audit a company to ensure that its quality system, as documented and implemented , satisfies the requirements of the appropriate ISO 9000 standard.

European accreditation bodies recognized by their governments have accredited registrars (called certifiers) throughout Europe. Many of these registrars have operations in the United States. There is also a purely domestic arrangement, the Registrar Accreditation Board—a joint venture between the American Society for Quality Control and the American National Standards Institute—which accredits registrars in the United States.

As acceptance of ISO 9000 has grown, certification is widely viewed as a stamp of approval. As a result, ISO 9000 is becoming a defacto market requirement. This process has gone further in some industries and in some countries than in others. For example, in Britain, where the standards have been the most widely embraced, registration has become a virtual necessity for suppliers seeking new business. Over 80 percent of larger employers (payrolls of over 1,000 people) have become registered and even lawyers, doctors and schools are seeking registration.

ISO 9000 is also gaining in popularity elsewhere in the world. The Japanese and other Pacific Rim countries are gearing up for their registration programs as are countries in Latin America and Eastern Europe. ISO 9000 has now been adopted by over 50 countries and is seen as a passport to international trade.

Multinational corporations are also registering their U.S. operations. DuPont, for example, had secured registration for over 200 of its operations worldwide by the end of 1992; roughly one third of those have been in the United States. Kodak, Sun, AT&T, Union Carbide, General Electric, Hewlett-Packard and others are also playing leading roles.

The Standards

There are a total of five standards. The first in the series, ISO 9000, is the road map to the series. It also defines the key terms. ISO 9001, 9002 and 9003 are quality assurance standards specifying quality system models to be used in contractual situations. The three are a nested series: 9003 has the narrowest application (final inspection and testing); 9002 is in the middle (production and installation in addition to testing and inspection); and 9001 has the widest application (design and service in addition to the other functions). ISO 9004 provides extensive guidance on implementing the standards. It also provides some advice on what makes a quality system work well.

Most companies register to either ISO 9002 or 9001. Companies choose ISO 9001 if service and design are important to their customers; otherwise, 9002 is usually preferred. Many chemical companies select ISO 9002 because they are not contractually responsible for the design and servicing of products.

The standards recognize 20 distinct elements in a quality system and list the requirements for each element in a separate section. The 20 elements are comprehensive in that they include every activity in an enterprise that affects quality from design to contractual service. These include such things as management responsibility, document control, product identification and traceability, process control, inspection and testing, corrective action, internal quality audits, training, statistical techniques, and servicing.

One of the most distinctive characteristics of ISO 9000 is the extensive documentation required. It requires complete and thorough documentation of all policies, objectives, activities, procedures, work rules, and forms and records that affect the quality system. It also requires that this documentation be maintained and updated.

Revisions to the Standards

It is important to note that revisions to the ISO 9000 series have begun. Publication of the minor revisions is targeted for late 1993 to early 1994. Major revisions will occur during the next review cycle which will occur in the late 1990s and will most likely move the documents closer to total quality management principles. The revised ISO 9002 will include servicing and will be identical to ISO 9001 except for those elements related to design. Six guidelines have also been issued: 9004-2, "Quality Management and Quality System Elements Part 2—Guidelines for Services"; 9000-3, "Guidelines for the Application of ISO 9001 to the Development, Supply and Maintenance of Software"; 10012-1, "Quality Assurance Requirements for Measuring Equipment Part 1—Management of Measuring Equipment"; and 10011-1,2 3, three standards on Guidelines for Auditing.

ISO 9000 Benefits

Although the impetus for the use of ISO 9000 has come largely from the market force, DuPont has found that adopting ISO 9000 is also a good investment. The company keeps a running record of instances where implementation has directly contributed to cost savings and qualify improvement. ISO 9000 implementation improves the overall performance of an organization as well. It clarifies roles and responsibilities and smooths the interfaces between different functions and departments.

ASTM and the Quality Standards

While ASTM has long been recognized as a well-run organization, there are few organizations that cannot find opportunities for improvement; particularly in the rapidly changing business environment that we experience today. The Board of Directors will decide whether the implementation of ISO 9000 would benefit the Society. ASTM would most likely use the standards given in ISO 9001 and the guidelines for service organizations given in ISO 9004-2.

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Circle (24)

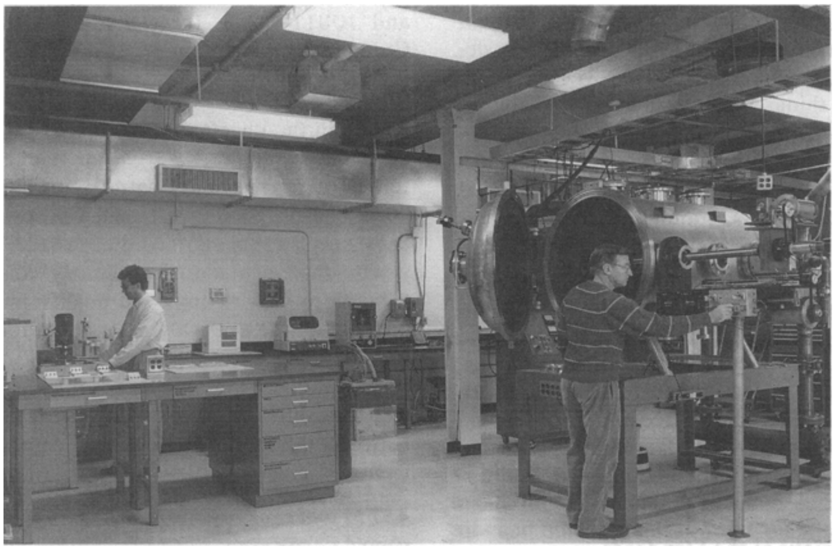
University Scene

The Center for the Plasma Processing of Materials at Drexel University
An Industry/University Collaborative Research Center

By Dr. Ronald W. Smith
Drexel University
Department of Materials Engineering

The Center for the Plasma Processing of Materials (CPPM) was founded at Drexel University in 1987. With support from the Ben Franklin Technology Center of Southeastern Pennsylvania and a consortium of industrial sponsors, it has gained an international reputation in the areas of thermal spray and plasma processing research. The Center is dedicated to the study of materials and processes utilizing thermal plasmas and places particular emphasis on thermal spray coating technologies. The CPPM links industrial users of thermal spray technology, equipment manufacturers and university researchers to provide an efficient, cost-effective, research network. The Center for the Plasma Processing of Materials has established a unique combination of university-based researchers and resources and industrial partners. Many of the CPPM's resources are currently being used to address fundamental issues in thermal spray processes and applications. The CPPM joins with the University of Minnesota's High Temperature Laboratory, as part of the US National Science Foundation's Engineering Research Center (ERC) for Plasma-Aided Manufacturing, centered at the University of Wisconsin-Madison. The CPPM, through support from the Ben Franklin Technology Center of Southeastern Pennsylvania, also offers to small and medium PA companies a Technical Extension Service. This service is provided with little or no company funding, thus enabling these companies access to the Center, its resources and its technical assistance.

Drexel University researchers and students in the CPPM, although conducting basic investigations in much of their research, are striving to apply their results to



Facilities of the Center for the Plasma Processing of Materials, Drexel University

industrial problems. The CPPM has its industrial members who advise and direct the CPPM's Core Research agenda on basic research projects, from which they share the intellectual property. The CPPM also has other Industrial Partners who collaborate on applied projects using the CPPM's knowledge gained by basic research. With this arrangement the CPPM provides a technological forum and a business networking opportunity between its University researchers and industrial participants. The Center has grown through membership, state support and from equipment and materials contributed by industry. Industrial grants from United Technologies Corporation and Ford Motor Company have also helped to advance the CPPM's mission and basic research agenda, while increasing the R&D facilities which serve the Center's Industrial Partners. CPPM members have included ALCOA; Air Products & Chemicals, Inc.; Electro-Plasma Inc. (Division of Sulzer Surface Technologies); Engineered Coatings, Inc.; Ford Motor Company; Sermatech International, Inc. and United Technologies—Pratt & Whitney.

The CPPM has extensive international collaborations with some of the leading European thermal spray and plasma processing institutes, (Werkstoffwissenschaften/ RWTH Aachen Germany; Katholieke Universiteit, Leuven, Belgium) and the former Soviet Union (E.O. Paton Welding Institute, Kiev, Ukraine and the P/M Association of Byelorus, Minsk). To further this international collaboration a formal Thermal Spray Research Group has been established and a sub-group, TiboTS, which focuses on tribological thermal spray coating technology has recently been organized. This research network supports and expands the CPPM's international resources, activities and capabilities. Further indicating the growing interest in international collaboration, and in an unprecedented action, the European Cooperation in Science and Technology (COST) Commission has approved Drexel University's participation in a joint research program on reactive plasma spray consolidation of powdered materials.

Thermal spray is a important and growing materials processing technology with a wide range of applications, consistent with its ability to process most materials into useful forms. Thermal spray technologies, although simple in concept, require specific knowledge about materials and process interactions. These interactions require more in-depth studies and knowledge. Research and development by University/Industry collaborative programs can further process and materials developments by developing increased process knowledge, specific coating property design data and reliable, and low cost processes. The CPPM and its industrial partners have recognized this and have identified several major areas for collaborative Industry/University R&D:

- Processing knowledge
- Education
- Materials and process data
- New low cost materials
- Innovative process controls.

Supporting this, The CPPM's research centers on thermal spray and plasma technologies as highlighted below.

Coatings: Coating processing and evaluations of coating materials are investigated at the Center using air plasma spray (APS), vacuum plasma spray (VPS), inert atmosphere spray deposition processes, and the Jet Kote II® High Velocity Oxy-Fuel (HVOF) combustion spray process. Coatings range from corrosion-resistant alloys to coatings for wear and/or erosion resistance. Coating repair techniques have also been evaluated. Current topics include wear-coating development, ceramic coatings, refractory metals and protective coatings for composite materials (C-C and C-Epoxy). HVOF spray process evaluations of the basic capabilities of this new, rapidly growing, field of thermal spray are also in progress.

Spray Forming: The deposition/fabrication of structures from metals and alloys which are difficult to form conventionally is another emphasis of the Center. Structural plasma deposits have included refractory metals, aluminides, other intermetallics, superalloys, beryllium, niobium alloys, rare-earth alloys and other transition element which are difficult to process conventionally. Current R&D topics include spray forming of refractory metal structures combined with "engineered" composites and laminated structures.

Composite Materials: The plasma deposition process has been used to co-deposit metals with other metals and/or ceramics to produce composite structures. Hardface coatings, long a mainstay of the plasma coating industry, were the original composite materials made by plasma processing. Recent advances in deposition technology and advances in design using composite structures have opened up a whole new field of composite structure processing which may uniquely fit plasma deposition processing. Currently, the Center is conducting exploratory work on the interaction of fibers with thermal spray processing.

Materials and Coating Synthesis: Reactors for the plasma synthesis of materials such as refractories, fine metal powders and/or ceramics are being developed by the CPPM. The aim is to measure and model the various reactions involved in synthesizing materials. The CPPM's goal is to provide the technical resources necessary to evaluate any of the plasma processing routes for synthesis. Research is proceeding on the study of the behavior of particulates in a thermal plasma with reactive gases. This work is being conducted to develop an understanding of the alloying of materials during reactive plasma spraying. Current research topics include the in-situ forming of wear-resistant coatings and advanced composite materials (MMC, CMC and IMC's).

Knowledge-Based Controllers: for deposition processes using "vision system" image processing.

Plasma Melting and Refining: using either transferred or non-transferred plasma arcs. The Center has the capability of carrying out both processes, and of conducting unique alloying evaluations with the plasma gases. Materials range from titanium and refractory metals to aluminum and its alloys.

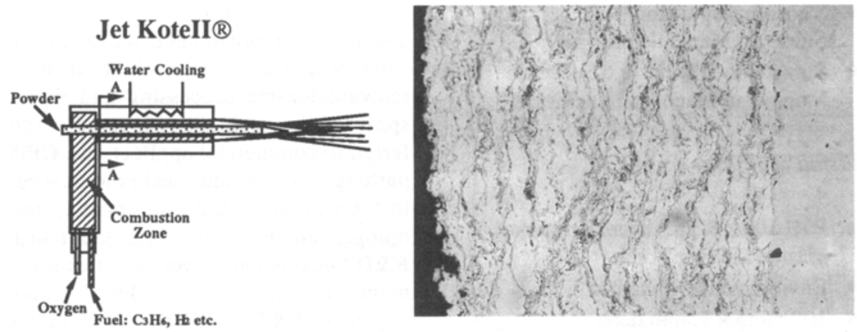
Plasma Waste Treatment: The applicability of plasma processes for the destruction, transformation or recycling of waste materials is being investigated by the CPPM.

Two basic research projects the CPPM has been conducting are i) Fundamental Studies of Thermal Spray Wear Coatings, and ii) High Velocity Oxy-Fuel (HVOF) Process Capability Studies. They are conducted under the auspices of the CPPM's Industrial Advisory Board.

Wear Coating Research: A Core Research program based on a fundamental study of thermal spray wear coatings, aimed at developing an understanding of their behavior, is being conducted. Current research is:

- Establishing structure/process/ performance relationships in thermal spray wear coatings
- Systematically analyzing test and characterization methods
- Establishing a documented thermal spray coating "Wear" database
- Developing materials/processing/wear relationships
- Developing analytical and physical models to describe wear phenomena
- Providing "design" criteria for selecting & improving thermally sprayed wear coatings.

Specifically, these studies include:



HVOF processing of a nickel-base alloy coating, propylene/oxygen jet, as polished (200 ×)

- The role of matrix strength, hardness and elastic modulus on wear performance
- The effect of second phase dispersions, size and spacing on wear
- The influence of coating defects (oxides , porosity, unmelted particles)
- The evaluation of matrix and second phase cohesive strength on wear resistance
- The influence of wear test parameters (load velocity, geometry, etc.).

The CPPM is also conducting research on wear coatings to increase the use of aluminum and other lightweight materials which may be limited by their poor tribological properties. Special processing and materials studies are pursuing thermal spray coatings which will be compatible with the high production rate and low costs needed for automotive and industrial components. Iron-based coatings and others compatible with automobile engine tribosystems are currently under investigation.

HVOF Spray Process Studies: High Velocity Oxy-Fuel (HVOF) spray coating processes are relatively new to the thermal spray industry and are currently one of the most active development areas, yet little is known about the capabilities of, and differences between, different HVOF designs. Therefore, with the support of its industrial members, and in conjunction with HVOF equipment manufacturers, the CPPM is conducting research to provide its members with information on the capabilities of the various commercial systems. This study was initiated to provide a more scientific basis to the understanding of HVOF processes and to gain an understanding of the influence of the process on the structure and characteristics of HVOF coatings.

Research is being conducted across a broad range of materials: 80/20 NiCr, 88/12 WC/Co, Cr_3C_2/NiCr and Al_2O_3/TiO_2. Experiments are being carried out using the CPPM's Jet Kote® HVOF system and with other systems at cooperating HVOF Manufacturers sites. Coatings are evaluated for microstructure, hardness, oxide content & porosity (image analysis) and phase content (X-Ray Diffraction). Measurement of residual stress, heat input to the substrate and process calorimetry are also being conducted. The purpose of this research is to evaluate HVOF process capabilities, which will be achieved by investigating the sensitivity of the HVOF processes to variations in key process parameters: spray distance, gun/part speed and fuel:oxygen ratio. Results indicate strong correlation of coating properties with spray distance and fuel:oxygen ratio. The program includes:

- HVOF System Capability Evaluations
- Process/Structure/Property Relationship studies
- NiCr, WC/Co, Cr_3C_2/NiCr and Al_2O_3/TiO_2 materials
- Influence of Key Process Parameters
- Coating Characterization
- Coating Residual Stress Measurement
- HVOF Process Calorimetry
- Substrate Temperature Measurement
- Process/Particle Interaction Studies.

Supporting this research agenda the CPPM Research Facilities include:

Thermal Spray Deposition:

- Electro-Plasma, Inc. (120 kW DC Air/Vacuum Plasma Spray System)
- Metco Perkin-Elmer 9MB. (80 kW DC Plasma Spray System)
- Jet Kote II High Velocity Oxy-Fuel (HVOF) Combustion Spray Deposition System

- Vacuum Deposition Chamber with Substrate Manipulator
- Spray Booth/Torch and Substrate Manipulator/Acoustic Enclosure.

Plasma Melting:

- PMI 100 kW DC, Transferred-Arc, Plasma Melting Torch
- Environmental Chamber
- 100 mmϕ × 75mm deep hemispherical, water-cooled copper, melting hearth.

Process Characterization:

- Control Vision, Inc. high speed laser stroboscopy system
- Automatix Image Analyst" system
- GW Instruments/Lab Tech Notebook Macintosh IIx-based data acquisition system.

Materials Testing and Characterization:

- AMTI microprocessor controlled Pin-on-Disk tribometer (Sliding Wear Testing)
- Hommelwerke surface profile analyzer
- Scanning electron microscope
- Transmission electron microscope
- Complete metallography lab with automated polishing facilities
- Complete mechanical testing lab
- Thermal analysis equipment.

In Summary...

The CPPM is conducting research on:

- Thermally sprayed wear coatings
- HVOF process studies
- Lightweight coatings for lightweight structural materials
- Reactive spray coating development
- Reactive plasma synthesis of composite materials
- High velocity plasma spray
- High rate wear coatings for auto cylinders.

Other specialized coatings and forming projects are also under way, depending on requests from sponsors. The success of the CPPM to date demonstrates that basic and applied R&D coexists within the CPPM and with collaborating industrial partners. The sharing of precompetitive research results, people and facilities is ensuring that relevant plasma processing and thermal spray coating technology is rapidly transferred to commercial applications. CPPM participants maintain a technological edge in thermal spray and other coating technologies and in a time of limited industry R&D budgets and lower facilities investments, combined with reduced University-based R&D funding, such technology partnerships assure that science and applied research are continued. The basic research agenda of the CPPM, as presented in this article, demonstrates the commitment Drexel University and its research partners have given to thermal spray research for technological advances.

Circle (25)

Caterpillar, University of Illinois Adopt Novel Approach in Testing Brittle Coatings

By Kevin Wesling and Darrell Socie
University of Illinois at Champaign-Urbana
and
Brad Beardsley
Caterpillar Inc.
Peoria, Illinois

In 1991 Caterpillar Inc. and the University of Illinois at Champaign-Urbana, under subcontract with the DOE Ceramic Technology Project, began working together on thick-thermal-barrier coatings (TTBCs) for low-heat-rejection engines. The material determination and processing are performed in cooperation with Metco Perkin-Elmer in Westbury, Long Island, New York and at Caterpillar's Technical Center in Peoria, Illinois. Reliability tests, failure analysis, and cyclic testing are performed in cooperation with the University of Illinois. Bond coat material development was carried out at State University of New York at Stony Brook.

The selection and characterization of powders was the first phase of the project. Several combinations of bond-coat and TTBC powders were characterized with respect to particle size distribution and crystallographic phases. In addition, chemical and surface area analyses were performed. Knowledge of these factors and state-of-the-art plasma spray technology allows Caterpillar control over the microstructure of the coatings.

A novel approach was then implemented to fabricate specimens that would allow

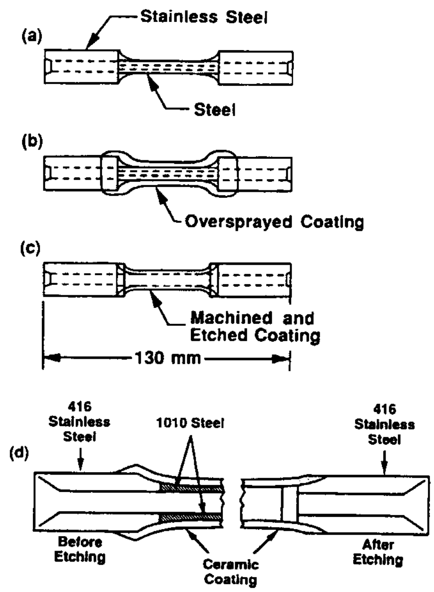


Fig. 1 Bulk coating specimen preparation. (a) Powders are plasma sprayed several millimeters thick onto a mild steel tube with thick stainless ends. (b) The coating is oversprayed and (c) machined down to the required thickness; the mild steel tube substrate is etched away with a solution of HNO_3 and water. (d) Cross-sectional view of axial test specimen [enlarged view of Fig. 1(b) (left side) and Fig(c) (right side)].

testing of the bulk coating material, independent of the coated substrate. The powders are first plasma sprayed several millimeters thick onto a mild steel tube with thick stainless steel ends [Fig. 1(a)]. The coating is oversprayed [Fig. 1(b)] and then machined down to the required thickness, resulting in a uniform, reduced gauge length. At this point, the mild steel tube substrate is etched away with a nitric acid (HNO_3) and water solution so that only a free-standing coating remains attached to the stainless steel ends, which are unaffected by the etching process [Fig. 1(c)].

Mechanical testing is then performed to determine bulk properties of the coating and to accumulate durability data. Traditional on-substrate coating testing involves bending tests, which allow for indirect evaluation of compressive and tensile loads. The absence of a substrate allows direct compressive, tensile, and possibly even torsion loads to be applied similarly to any tube specimen.

The testing performed at the University of Illinois is designed to accomplish several goals that include accumulation of fatigue-life data in compression and tension at ambient (25 °C) and maximum (800 °C) diesel operating temperatures, determina-

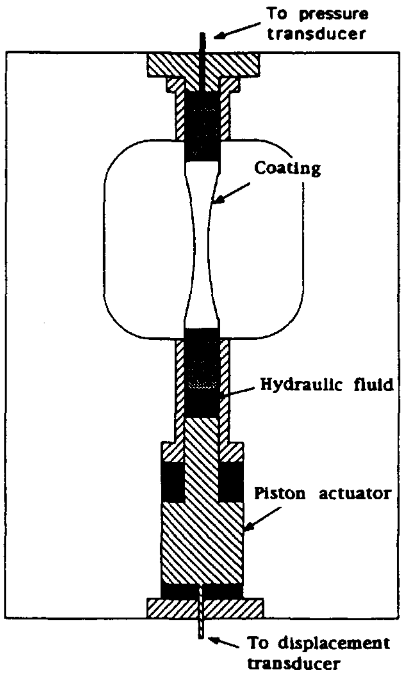


Fig. 2 Self-aligning TTBC compressive test fixture. Specimen (with ends plugged) is loaded into a test fixture designed to support each end with a hydraulic fluid. A compressive load is applied by increasing the pressure in the oil reservoirs through the actuator piston.

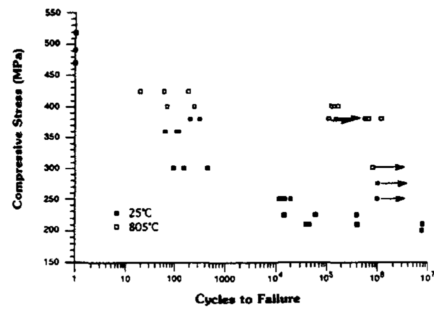


Fig. 3 Cyclic compressive fatigue of 8 wt.% YSZ coating.

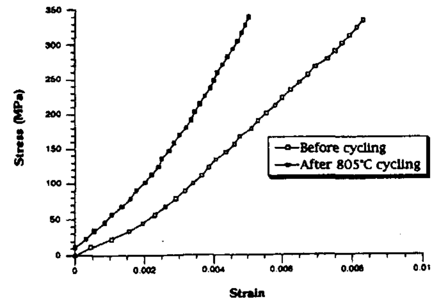


Fig. 4 Change in the bulk material's room temperature elastic modulus after cycling at high temperature.

tion of TTBC failure modes, and interaction between high-cycle and low-cycle fatigue.

The approach is as unconventional as is the specimen preparation because of the low ductility of the ceramic tube. Specimen ends are first plugged after the steel substrate is etched away. The sample is then loaded into a test fixture designed to support each end with hydraulic fluid. A compressive load is applied through the sample by increasing the pressure in the oil reservoirs through an actuator piston. The one-directional load transfer without any form of mechanical gripping allows the alignment in the load direction to occur automatically. The mass of this actuator is small enough to achieve test frequencies of 30 Hz (Fig. 2).

The gauge length of the specimen is heated to test temperatures with a quartz lamp furnace. The low thermal conductivity of the coating and the stainless steel ends of the specimen keep the temperatures at the end of the specimen below 200 °C when test temperatures reach as high as 805 °C. The heat that does reach the hydraulic fluid is diffused into the bulk of the test machine, which is then cooled by a copper cooling plate.

The results of compression fatigue for an 8% yttria-stabilized zirconia (YSZ) coating at both ambient (25 °C) and high temperature (805 °C) are shown in Fig. 3. Most notable is that at high temperatures the cyclic fatigue resistance of the material increases in compression. The material gains in fatigue resistance only after it has been stressed in compression at high temperatures and retains the resistance after the temperature has been returned to 25 °C. The bulk material's room-temperature elastic modulus is also increased permanently after cycling at 805 °C, as seen in Fig. 4. This indicates that some sort of creep is occurring in the coating at temperatures lower than normally seen in ceramics. The slope increase of the stress/strain curve may indicate a greater net section area caused by removal of porosity similar to a sintered material. However, a comparison of the porosities in high-temperature samples, both tested and nontested, with mercury intrusion porosimeters indicates no change in either the porosity distribution or the total porosity.

The change occurring in mechanical properties under testing designed to simulate operating conditions of the bulk coating poses some new questions.

- If the coating porosity necessary for thermal barrier behavior is unaffected, what is responsible for the slope increase of the stress/strain curve?
- If critical healing is occurring at the high-temperature loading, does the coating fail by a different mechanism than that occurring at room temperature?
- Is this behavior seen in tensile loads, and, if so, is it beneficial or detrimental?

The complex combination of tensile and compressive strains that a piston head coating receives demands that the coating's complete failure envelope be determined. For this reason, testing will continue to determine tensile fatigue limits for TTBCs and compare failure modes.

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Circle (26)

First Prizes for Metallography

The Thermal Spray Laboratory at SUNY Stony Brook recently won two first prizes for posters at the American Powder Metallurgy Institute P/M Metallography Competition. These prizes were awarded at the annual APMI conference in Nashville, Tennessee, May, 1993.

In the category of "Color Light Microscopy" the award was for a poster titled "Composite Powders with Shell Structure Formed by Mechanofusion". The authors were John Z. Chen, C.Perdikaris, H.Herman and C.C.Berndt of Stony Brook and C.C.Huang of Micron Powder Systems. The second award also went to John Z. Chen in the student category for a poster titled "The Structural Formation of Powders Produced by the Mechanofusion Process". Chen is at present a doctoral student at Stony Brook, nearing the completion of his thesis in the area of feedstock/powder formation and processing for thermal spray applications.