ASM Cleveland Chapter Symposium on Thermal Spray Technology

Presentations and Speakers

1) Thermal Spray - A Versatile Tool to Enhance Performance, Cut Cost, and Create New Design Possibilities

Thermal Spray is a generic term for a remarkably versatile family of process technologies that offer the materials engineer and component designer valuable opportunities to independently optimize surface and bulk material properties and also to create unique new materials with novel engineering properties. Although the basic technology has been in commercial use for several decades, technological and scientific advancements in recent years have dramatically improved the quality and performance of many spray deposited materials. This presentation provides an overview of traditional and emerging thermal spray process technologies, some potential advantages and limitations, and examples of how this technology has been used to solve challenging materials and design problems.

Dr. Mark Smith is Deputy Director of Sandia National Laboratories' Materials Science & Engineering Center, located in Albuquerque, New Mexico. This 250-person center annually conducts roughly $60 million of R&D to support various US national security programs. After receiving his Ph.D. in Metallurgy from Iowa State University in 1981, Mark joined Sandia as a technical staff member in the Materials and Process Sciences Center. Since 1993, he has also served as an Adjunct Professor in the Department of Materials and Metallurgical Engineering at New Mexico Tech University. Before moving into management at Sandia in 1999, Mark was best known for his pioneering work in thermal spray process diagnostics, modeling, and control, with more than 50 spray related journal publications. Mark was also a co-founder of the ASM Thermal Spray Technical Division (now the Thermal Spray Society - TSS) in the mid-1980s. He served nine years on the TSS Board and helped start the National Thermal Spray Conference (now the International Thermal Spray Conference - ITSC). He was also the founding Chairman of the Editorial Review Committee of the Journal of Thermal Spray Technology and served as Chair of the Chapter Committee on Thermal Spray and Cold Spray for the current edition of the AWS Welding Handbook. In 2006, Dr. Smith was inducted into the TSS Thermal Spray Hall of Fame. An ASM Fellow, Mark was 2011 President of the ASM International materials professional society.

2) Chrome Plate Replacement:

With all of the issues inherent with the use of Hexavalent Chromium plating over the last 20 years, St. Louis Metallizing has been working with various thermal spray coatings and processes as alternatives that can successfully replace and potentially enhance the life of parts through the use of thermal sprayed coatings. Some areas that have had great success time and again are in the commercial offset printing industry, hydraulic actuators that range from a small size of ¾" diameter, up to large struts for 500 ton trucks, and for landing gear used in the aircraft industry. This presentation centers around two materials that are presently being used extensively for chrome replacement; Tungsten Carbide/Cobalt Chrome and Chrome Carbide/Nickel Chrome. Methods of application, testing and quality control will be discussed as well as finishing techniques that can be employed to achieve the desired results.

Joe Stricker began his career at St. Louis Metallizing in 1974 as a Sales Engineer. He was promoted to Vice President – Thermal Spray Operations in 1985, Vice President of Operations in 1989 and President in 1999. Joe graduated from Southern Illinois University with a Bachelor of Science Degree in Business Management and completed a Master's degree in Business Administration from Fontbonne University.

Joe has been active with the International Thermal Spray Association since 1990 and has served as Vice Chairman (1995) and Chairman (1997). He presently serves on the Executive Board of the ITSA group.

St. Louis Metallizing (SLM) has worked with a variety of industries over the past 60 + years to effectively apply metal and ceramic coatings using thermal spray processes such as HVOF, Plasma, Electric Wire Arc, and Flame Spray. SLM recently added laser cladding to the list of surface engineering processes. These coatings are very dependable in minimizing wear and corrosion, and are excellent choices for chrome replacement. Industries such as aerospace, power generation, printing, oil & gas, mining, and pulp and paper have experienced increased component life as a result of our coatings. St. Louis Metallizing is a full service facility that offers complete coating, machining, grinding, and superfinishing capabilities. Our (17) six-axis robots give us the ability to fully automate the most complex OEM projects. We have a strong focus on quality as evidenced by our IS0 9001.2000 and AS9100 certifications. St. Louis Metallizing is also a NADCAP, FAA Part 145 and EASA certified company. These certifications assure you that we are dedicated to high quality and consistency in everything we do.

3) Thermal Spray Guns: Types, Sizes, Capabilities, and Designs:

After one-hundred years of thermal spray, much has changed and little has changed, with respect to thermal spray guns. Following the Pareto Principle, our forerunners achieved perhaps eighty percent of the design requirements and principles that we use today. That has left twenty percent for us to innovate and improve the devices we use every day. From the beginnings with electric-arc spray, through flame spray, D-gun, plasma-arc spray, HVOF, and now cold spray, we have had those who invented the guns, those who improve on designs, those who use the guns, and those who copy. This presentation will discuss the everyday issues that involve the selection of devices and processes, design limitations, third party knock-offs, and aging designs. The focus will be on established, commercially available technology.

Daryl E. Crawmer has been involved with thermal spray for 40 years, including research, equipment manufacturing, and production coating applications. He began his career at

Battelle Memorial Institute, in Columbus, Ohio where he worked in both the Engineering Mechanics and Materials Departments. Daryl was Group Leader and Principal Research Scientist for the Thermal Spray Lab at Battelle. He began work with Miller Thermal, Inc., in Appleton Wisconsin in 1990, which was later acquired by Praxair Surface Technologies, Inc. He served 10 years as Director of Engineering for that operation. Daryl became Thermal Spray Technologies (TST), Inc. Director of Technology in September of 2000, where he serves currently. He was co-founder of ASM's Thermal Spray Society and was an active Board member for several years. He also served for many years as Vice Chairman of the Journal of Thermal Spray Technology Editorial Committee, Chairman of the ASM TSS Recommended Practices Committee, Chairman of the TSS Training Committee, and a member of the TSS Safety Committee. Daryl was elected as an ASM Fellow, in 2004 "in recognition of distinguished contributions to the field of materials science and materials engineering." In 2009 he was elected to the TSS Thermal Spray Hall of Fame "For advancing thermal spray technology through numerous innovations in equipment and process design, and for being an invaluable source of information and advice to the thermal spray community."

4) Cold Spray Technology:

The cold spray process uses a supersonic particle jet to produce high quality coatings. Cold-sprayed coatings are formed by solid state plastic deformation of sprayed particles and hence these coatings have many unique characteristics. Since high temperature is not involved, it is ideally suitable for spray depositing temperature-sensitive materials such as nanophase and amorphous materials, oxygen-sensitive materials like aluminum, copper and titanium and phase-sensitive materials such as carbide composites. Due to the small size of the nozzle and spray distance, the spray beam is very small, which translates into precise control over the area of deposition over the substrate surface. The cold spray process works similar to a micro-shot peening device and hence the coatings are produced with compressive stresses. Thus, ultra thick (5-50 mm) coatings can be produced without adhesion failure. The high energy, low temperature formation of coatings leads to a wrought-like microstructure with near theoretical density values.

Many groups around the world have taken up various R&D programs and these studies have resulted in large advances in cold spray science and technology. Most metals, alloys and composites have been sprayed over almost any substrate material. Cold-sprayed coatings are being adapted in many high tech industries including aerospace, defense, etc.

Dr. J. Karthikeyan received his Ph.D. from Bombay University and specialized on thermal spraying and advanced material processing technology. Since 1972, he pursued research at the Atomic Energy Commission, India; Kernforschungsanlage, Germany; Monash University, Australia; and SUNY at Stony Brook, USA. He has been involved in industrial R&D since 1997, developing advanced coating techniques and engineered coatings. He has authored in excess of 100 publications, mostly in peer reviewed journals. During the last twelve years, he has been leading industrial cold spray R&D and has published over 40 papers in various aspects of cold spray technology. He has also authored many patents in cold spray technology and applications. He has organized the ASM sponsored "Cold Spray 2004", "Cold Spray 2007" and "Cold Spray 2011" meetings in Akron, and also has arranged special sessions on Cold Spray at various International Thermal Spray Conferences.

5) Powder A ≠ Powder B ≠ Powder C: A Review of Thermal Spray Feedstock Manufacturing Methods:

The manufacturing methods for thermal spray materials are as varied as the chemistries. The end user is challenged by this since the material selection can affect quality, porosity, processing efficiency and cost. The producer is challenged by this in that the manufacturing method can affect yield, waste and cost. As the market demands increase efficiency, decrease waste and lower cost it is even more critical for the user and the producer to be knowledgeable of one another's requirements and challenges. Add to the mix the availability and fluctuating costs for raw materials and the challenges become greater. This presentation will review the various manufacturing methods; the material families produced by each; the differences; and the advantages. Additionally an overview of the major raw materials supply chain will be presented.

Jean Mozolic has over 35 years of technical sales, marketing, business development and senior management experience. In her career she has held positions of increasing responsibility with Praxair, Sulzer Metco, and H.C. Starck. She has extensive experience in PVD, CVD, VPS, Plasma and HVOF materials, coatings, equipment, systems and applications. Her expertise spans the energy, aerospace, automotive, gas and oil exploration, chemical processing, medical, printing, semiconductor and plastics industries.

In 2006 Ms. Mozolic formed a consulting company focused on surface technology and powder metallurgy applications; and as a marketing and business development contractor. In 2007 she formed a partnership with Mr. Ray Zatorski, VP and Managing Director of the Zatorski Coating Co. (ZCC), Inc. ZCC is focused on the development and commercialization of surface technology solutions for industry. Additionally she has a commercial partnership with Mr. Satish Raghunath of INTAG in Mumbai, India and is developing business relationships in India's expanding aerospace, alloy production, MIM and automotive industries.

Ms. Mozolic holds a BS and MS in Materials Science from MIT. She was recently awarded a patent for an advanced aeroturbine abradable, and has a patent pending for a nano-powder consolidation method. Ms. Mozolic has authored papers and made numerous presentations on surface technology and metals processing.

6) Monitoring and Controlling the Properties of Plasma Sprayed Thermal Barrier Coatings via Modification of Interfacial Defects:

Coating deposition using thermal spray has been widely used for protection of components from severe environments. This process involves a feedstock, generally in powder form, and a source of thermal energy that melts and accelerates molten droplets toward a substrate. Due to the successive impingement of droplets, also known as splats, sprayed coatings contain a myriad array of defects, such as intersplat interfaces and intrasplat cracks. These defect interfaces play a critical role in determining the mechanical and thermal properties of the coatings. With the knowledge of processing science, the architecture of defects in a coating can be tailored for specific applications by changing the spray parameters. These spray parameters can be categorized into particle-state-parameters (PSPs) and non-particle-state-parameters (NPSPs). PSPs define the melting and kinetic energy of spray particles and NPSPs include parameters such as powder feed rate, spray distance, spray raster speed, etc. In addition, other factors such as substrate material, deposition temperature, and ambient humidity can contribute to the coating microstructure which dictates properties and performance of the coatings. This presentation will focus on plasma sprayed thermal barrier coating systems. Firstly, the techniques practiced to monitor and control coating properties by controlling PSPs and NPSPs will be discussed. The next part of the presentation will focus on the relevant coating properties, such as thermal conductivity and coating compliance, which are governed by defect interface characteristics of coatings.

Dr. Gopal Dwivedi is a post-doctoral associate at the Center for Thermal Spray Research (CTSR) at Stony Brook University. In 2006, he completed his undergraduate degree in Materials and Metallurgical Engineering at the Indian Institute of Technology Kanpur, India. He earned his Ph.D. Degree in Materials Science from Stony Brook University in 2011. During his Ph.D. research he worked on the novel anelastic behavior of plasma sprayed thermal barrier coatings (TBCs) which was nominated for the distinguished dissertation award at Stony Brook University. Currently, Dr. Dwivedi is involved in a Department of Energy (DOE) sponsored project focused on the development of advanced multilayer TBCs for application in hot sections of integrated gasification combined cycle (IGCC) turbine engines.

Dr. Dwivedi has presented his research work at in various conferences including the International Thermal Spray and American Ceramic Society conferences. In October 2010, he was invited to be a speaker in the Provost Lecture Series at Stony Brook University. There he presented his National Science Foundation (NSF) sponsored work on the similarities between sprayed synthetic materials and natural composites such as nacre, or mother of pearl. Since 2009, he has been actively participating in the biannual industrial consortium meetings organized by CTSR which is comprised of more than 30 companies.