Low-Temperature Spray Process Creates Adherent and Continuous Coatings of Fine-Grained and Nano-Sized Metal Powders

A low-temperature metal spray coating technology has been developed from observations made by its inventors during particle impact studies conducted at the NASA White Sands Test Facility, Las Cruces, New Mexico. The patented process plus specifically designed spraying apparatus are being further developed and commercialized by the U.S. company, Inovati, in Santa Barbara, Calif. The spray apparatus has been improved over past versions with respect to accelerant gas formulation, powder feeding, spray nozzle design, and the spray parameters for optimal film quality and adhesion.

The process, called kinetic metallization (KM), entails the spraying of metal powders, polycrystalline, usually below 20 μm in particle size, into continuous and well-adhered coatings on various metal and ceramic substrates. The grain size of the coatings is typically less than that of the powder particles, that is, there is no grain growth beyond the particle boundaries.

Coatings produced by KM differ from those generated by flame spraying processes such as high-velocity oxygen flame spray and low-pressure plasma spray because the spraying is performed as much as several hundred degrees below the melting point of the metal powder. As a result, the thermal distortion of the part being coated is minimized. In addition to the fine-grain size of the coatings and the ability to spray nano- and nanostructured powders, further advantages of the KM spray coating process include the ability to co-deposit different materials that would adversely interact if sprayed at high temperatures (e.g., when aluminum is KM-sprayed with any of the transition metals, intermetallics such as aluminides are not formed) and the ability to form diffusion barriers (e.g., Nb on Cu) that would be difficult or impossible to form with a high-temperature spraying process.

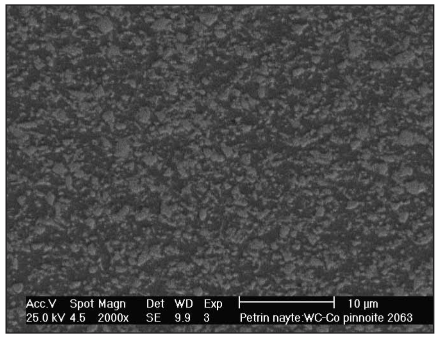

Figure 1. WC-15Co coating applied to 4340 steel (substrate not shown) deposited with the kinetic metallization process.

No combustible gases are used in the KM process. A two-phase deposition nozzle that directs a gas/particle suspension onto a substrate (metal or ceramic) is used to accelerate micrometer-size powder particles entrained in a carrier gas. The high-speed collisions (500–1000 m/s) of the micrometer-size powder particles cause very large strains (>100%) and strain rates (>10^4/s) in the particles, which produce depositions that have cold-worked properties (i.e., plastic deformation resulting from particle impacts produces cold-worked conditions in the coated materials). The formation of true metallurgical bonds occurs when active surfaces of the particles come into contact with the substrate surface or an already deposited material. Metallurgical bonding is achieved exclusively through solid-state reaction (bulk melting does not occur). Postdeposition heat treatment of the depositions can be used to control the microstructure of the deposited material. Pure chromium, nickel, copper, and aluminum have been deposited on both metallic and ceramic substrates. In addition, aluminum alloys and other metal alloys as well as composite mixtures, such as Al-SiC and WC-Co, have been deposited as continuous coatings. Figure 1 shows the submicron matrix (Co) grain size, micron-size reinforcement (WC) particle size, and uniform reinforcement phase distribution obtainable with the KM process. There are no surface area limitations.

Opportunities

Inovati welcomes inquiries about joint application development and custom coating.

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