POSTER SESSION

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15:40 – 17:30

Consolidation of Al/Al_2O_3 Nanocomposite Powder by Cold Spray

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While the improvement in mechanical properties of nanocomposites makes them attractive materials for structural applications, their processing still present significant challenges. In this paper, cold spray was used to consolidate Al_2O_3/Al nanocomposite powder obtained from mechanical milling. The microstructure and nanohardness of the feedstock powders as well as of the resulting coatings were analysed. The results show that the large increase in hardness of the Al powder after mechanical milling is preserved after cold spraying. Good quality coating with low porosity is obtained from milled Al. However, the addition of Al_2O_3 to the Al powder during milling decreases the powder nanohardness. This lower hardness, attributed to non-optimised milling parameters for proper Al_2O_3 embedding and dispersion in Al, results in a lower coating hardness compared with the milled Al coating. The coating produced from the milled Al_2O_3/Al mixture also shows lower particle cohesion and higher amount of porosity. The overall results are promising and it is believed that an optimization of Al milling with Al_2O_3 will allow production of sound coatings with improved hardness.

Liquid Feedstock in Cold Spray Nozzle: A Numerical Investigation

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This study investigates the effect of water injection in the high pressure chamber of a cold spray nozzle. A De Laval nozzle geometry with constant back pressure and temperature is modeled numerically using Reynolds Stress Model coupled equations. Water spray with a droplet size of 10-100 μm is modeled using both uniform and Rosin-Rammler size distributions. The two-phase flow of gas-liquid is modeled using an unsteady discrete phase mass source with two-way coupling with the main gas flow. Upon injection, the droplets in the water spray evaporate while travelling through the nozzle due to momentum and energy exchange with the gas flow. The evaporation behavior in presence of water content is modeled and a correlation between the initial diameter and the diameter just before the throat is obtained. As a result, the proper droplet size distribution with a fully evaporative spray can be used as a carrier of nano-particles in cold spray nozzles. Having the results, guide us to substitute the un-evaporated part of the droplet with an equal diameter agglomerate of nano particles and find a minimum fraction of nano particles suspended in the liquid which guarantees fully evaporative liquid spray injection.

Optimization of Cold Sprayed Titanium Coatings Deposited Using Nitrogen as Propelling Gas

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Cold gas dynamic spray is a process which uses high pressured compressed gas to thrust micron-sized particles onto a substrate under atmospheric conditions. The cold sprayability of a powder on a given substrate can be characterized based on critical velocity, deposition efficiency, porosity, and mechanical properties of the cold sprayed coating. In this study, we seek to determine the effects of metallurgical variables on the functionality of cold sprayability of pure titanium. Commercially pure titanium coatings were cold sprayed using different powder morphologies and particle size distribution and at process conditions resulting in a large range of particle impact velocity and substrate surface temperature. An in-depth characterization was performed on coatings, including mechanical, microstructural, and chemical analyzes. Results showed that higher inlet gas temperature, spherically-shaped powder, broader particle size distribution, and specific substrate surface roughness are required for enhanced cold sprayability of titanium coatings deposited using nitrogen as propelling gas.

Keywords:
Nitrogen, Cold Spray, Titanium, Deposition Efficiency, Porosity, Particle Size Distribution, Bond Strength

Effect of the Deposition Conditions on the Adhesion Strength of Cold Sprayed Ti and Ti6Al4V Splats

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Cold Spray particle adhesion is attributed to the formation of the conformal interfaces and an adiabatic shear instability region which arise from high impact shearing stresses and a localized temperature rise. In the literature, computer simulations of single splat events demonstrate clearly that strong particle bonding (i.e. metallurgical bonding) occurs under favorable deposition velocity conditions. However, evidence of metallurgical bonding and an accurate measurement of bond strength associated with a single splat are difficult to demonstrate experimentally. We report on a modified ball bond shear test that was used to measure the adhesion strength of cold sprayed splats of commercially pure Ti and Ti6Al4V splats to Grade 2 Ti and Grade 5 Ti substrates. The extent of bonding at the interface between the splats and the substrates was measured after sample etching with a Kroll's reagent and with help of a scanning electron microscope. Splats were deposited with nitrogen and helium as the propelling gases. By varying gas pressure and gas preheat temperature, in-flight particle velocities between 600 and 800 m/s for nitrogen and 600 and 1200 m/s for helium were obtained. The effect of the substrate temperature on the particle adhesion was also investigated. Substrate temperature, gas preheat temperature and particle velocity were all found to have an effect on the particle adhesion.

Key Words: cold spray, titanium, titanium alloy, adhesion, ball bond shear test, adiabatic shear instability,

Grain Refinement in the Interfacial Region of Nickel Powder Particles Impacted at High Velocity

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Nickel powder particles were deposited on a steel substrate by means of cold spraying. Based on electron backscatter diffraction (EBSD) technique, the change in the microstructure of nickel particles and the mechanism of integration of particles into a dense coating in process of the impact of particles with high velocity were studied in detail. The results show that nanometer-size and misoriented grains form along the boundary between the particles. The local lattice distortion and the strain gradient in the individual grain were analyzed by observing the change in EBSD pattern qualities. A model of dynamic reycrystallization that occurs at low temperature due to deformation-enhanced atomic diffusion was proposed.

Keywords: Cold spraying; Plastic deformation; Recrystallization; Electron backscatter diffraction characterization; Metallic powder

Cold Spray Coatings for Gas Turbine Protection: Supersonic Science in Aerospace Applications

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Gas turbine engines are considered to be among the most hostile operating environments for conventional material systems. Increasing demands for higher engine performance, thermal efficiency and durability of components have led to the development of thermal barrier coating systems. Currently, the use of these coatings is limited because of premature failure of the ceramic top coat, which occurs due to oxidation of the underlying metallic bond coat. While the bond coat is typically deposited using thermal spray techniques such as air plasma spraying (APS) and high velocity oxy-fuel (HVOF) spraying, it has been demonstrated that the high temperatures inherent to these processes can be detrimental to the bond coat oxidation behaviour. To address this issue, it is proposed to deposit bond coats using Cold Spray (CS), a relatively new material deposition process that uses kinetic energy rather than thermal energy to produce coatings. In this process, a supersonic gas flow accelerates fine powder particles above a given critical velocity. Upon impact, the particles plastically deform and adhere to the substrate to form a coating. The objective of this study is to deposit bond coatings using different spraying techniques and investigate their microstructure and oxidation behaviour. Coatings with conventional and nanocrystalline microstructures were produced by means of APS, HVOF and CS, and then subjected to isothermal oxidation testing. Characterization of the coatings and their oxidation behaviour is achieved using Scanning Electron Microscopy (SEM), X-Ray Diffraction (XRD) and Transmission Electron Microscopy (TEM).

Quality Improvement of Cold Sprayed Ti6Al4V Coating

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Cold spray technology, using temperatures well below the melting point of the sprayed material, has the potential to quickly manufacture additive features with minimal waste. Even though it has more advantage in Ti and Ti alloy coatings as compared to conventional thermal spraying, it is still difficult to obtain dense Ti-6Al-4V coating by cold spraying owing to its high strength.

Ti-6Al-4V powder was cold sprayed on Ti6Al4V substrates in this work. Nitrogen and Helium as propellant gas were used at a pressure of 40 bars at 800 °C and 350 °C, respectively. In order to investigate the effect of surface temperature, gun traverse speed and substrate thickness were varied. In addition, continues wave laser was employed in order to preheat the substrate and deposited layer right before spraying. For all conditions, the surface temperature was evaluated using high speed infrared imaging. The ability to use the cold spray process to produce coatings on thin parts without noticeable substrate damage was demonstrated. The experimental results show that substrate temperature has significant effect on the quality of the cold spray coating. Using laser-assisted cold spray, the coating properties were improved when using N2, but was lower than coating produced using He as propelling gas.

Keywords:
Cold Spray, Ti6Al4V Alloy, Substrate Temperature, Porosity, Bonding Strength, Fractography