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Comparative study of particle behavior in aqueous and ethanol-based suspensions in suspension plasma spraying and the influence of powder chemistry from micrometric to nanometric scales

Abstract:

YSZ thermal barrier coatings (TBCs), elaborated through suspension plasma spraying (SPS), are widely used in industry. This process presents many advantages, such as the versatility of the materials and microstructures, and its ability to process complex parts in large quantities. While numerous studies on TBCs have been conducted using ethanol-based suspensions due to their favorable spraying behavior, increasing attention is now being paid to water-based suspensions from an environmental perspective, as they reduce the use of volatile organic solvents (Ref 1,2). This implies a further understanding and a precise control of the thermokinetic behavior of the particles in the plasma plume, providing deeper insight into the factors that govern suspension formulation — a critical aspect for ensuring industrial reproducibility and for defining the intrinsic properties of the resulting deposit (Ref 3,4).
In thermal spraying, the solvent used in ceramic suspensions is a key parameter that strongly influences viscosity, colloidal stability, and surface tension, all of which govern jet behavior during spraying. In particular, water, which exhibits a higher surface tension and vaporization enthalpy than ethanol, shows a distinct evaporation behavior within the plasma plume, thereby significantly affecting particle fragmentation, heating, and acceleration, and ultimately the resulting coating characteristics (Ref 1,5,6).
In this work, coatings produced from ethanol and water-based suspensions are compared using on-line plasma measurements to better understand how suspension behavior within the plasma plume influences coating properties and performance. Special attention was also given to the role of formulation, from micrometric to nanometric powders, in modifying particle–plasma interactions, residence time, and in-flight evolution, and consequently the development of the coating microstructure. Resulting coatings and in-flight sampled particles were characterized by scanning electron microscopy and particle size analysis, allowing a detailed correlation between suspension properties, in-flight behavior, and final deposit morphology.

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