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Comparison of suspension plasma sprayed coatings fabricated with two torch configurations (conventional and cascade) and two injection methods (mechanical and atomizer)

Abstract:

This study investigates the effect of Suspension Plasma Spraying (SPS) yttria-stabilized zirconia (YSZ) thermal barrier coatings on the microstructure, porosity, and thermal performance. Two types of plasma torches were used: the ProPlasma torch and the cascade-type torch, each combined with two different injection methods: a mechanical injector and a twin-fluid atomizer. The objective of this research is to systematically analyze the combined influence of torch type and injection method on droplet behavior in the plasma jet, the structural characteristics of the deposited coatings, and their service performance.

A comprehensive experimental program was carried out, incorporating in-situ diagnostic techniques (SprayCam and Accuraspray) to observe and measure the characteristics of the suspension droplets within the plasma. These measurements helped define optimal injection pressures for each Torch/Injector combination. Significant differences were found in the morphology, microstructure, and properties of the YSZ coatings depending on the operating conditions.

Furthermore, the influence of five key process parameters on coating porosity was systematically investigated: suspension mass load, spray distance, plasma power, torch scanning step, and substrate roughness. Based on the experimental data, predictive models of coating porosity were developed using Response Surface Methodology (RSM) and Artificial Neural Networks (ANN).

Finally, thermal cycling tests (at 1150℃) revealed that the microstructure plays a crucial role in high-temperature performance: through-thickness vertical cracks promote oxygen diffusion into the substrate, leading to the formation of spinel phases at the edge of the thermally grown oxide (TGO), which tends to accelerate coating failure.

This work proposes a generalizable method for optimizing the SPS process, relying on numerical analysis to establish relationships between process parameters, coating microstructure, and porosity. The development of predictive models provides theoretical support and a useful database for the design of TBC-type coatings.