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Advanced modelling of Suspension Plasma Spraying: focus on the physical treatment of the suspension

Abstract:

Suspension Plasma Spraying (SPS) process is being adopted by cutting-edge industrial sectors due to wide range of microstructures produced at atmospheric pressure and its relatively high deposition rate. Nevertheless, the resulting microstructures are highly sensitive to a large number of operating parameters (torch, injector and suspension, substrate, kinematics) making their control particularly challenging, especially for components with complex geometries. Furthermore, understanding the process remains complex because it involves numerous interdependent phenomena (Magneto-Hydro-Dynamic, turbulence, suspension fragmentation, heat transfer, etc.) occurring over a wide range of temporal and spatial scales, and there are few diagnostic tools available to characterize the treatment of the material in-flight, given the small size and high velocity of the agglomerates formed in the harsh plasma environment. Consequently, the Institute of Research for Ceramics (IRCER) and the Bordeaux Engineering and Mechanics Institute (I2M), in partnership with Safran Group, are developing advanced modelling of SPS as the first steps for developing a SPS digital twin in order to 1) enhance their understanding of the process and 2) reduce the costs of process development and 3) optimize new coatings by establishing the link between operating parameters and microstructures. This study focuses on the physical treatment of an already fragmented droplet. Indeed, an initial analysis of the time constants associated with the various phenomena has shown that the fragmentation of the liquid by the plasma jet is the fastest process, followed by the evaporation of the liquid and its recirculation, while the diffusion of submicrometric particles being the slowest. This model, developed as a 2D-axysmetric in-house code depicts the initial evaporation stage, before the viscoelastic shell forms as a result of particle agglomeration on the spherical droplet surface from an initial particles distribution within the droplet. It includes, the liquid recirculation, droplet heating and shrinking, submicronic particles movement and agglomeration.