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Advanced modelling of Suspension Plasma Spraying: First Steps Toward Developing a Digital Twin

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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 depend on a large number of operating parameters (torch, injector and suspension, substrate, kinematics) and are highly sensitive to these parameters, making it difficult to control these microstructures, particularly when parts are coated with complex geometries. Furthermore, understanding the process is complex because it involves numerous interdependent phenomena (magneto hydro-dynamic, turbulence, suspension fragmentation, etc.) across a wide range of time 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, University of Limoges) 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 presents an overview of the various sub-models (systems) that constitute the overall predictive model of the process: i) plasma formation by the electric arc, ii) development of the turbulent plasma jet and fragmentation of the suspension, iii) physical treatment of suspension droplets, and iv) coating formation by the impact of molten particles on the substrate. Emphasis is placed on the phenomena to be represented, the approaches used, the assumptions and principles of the models, and significant results.

Biography:

Vincent Rat is currently a senior research scientist of the French National Centre for Scientific Research (CNRS) and leads his activity at the Institute of Research for Ceramics (IRCER), University of Limoges, France. He heads the Plasmas and Laser processes group of IRCER that includes coatings by thermal

spraying, nanostructures and thin films teams. The group research covers some topics of the joint laboratory PROTHEIS, dedicated to aerospace and hosted at IRCER, between SAFRAN, OERLIKON, and IRCER. After his Ph.D. in 2001 at the University of Limoges regarding the transport properties in non-equilibrium thermal plasmas, and a postdoctoral position in 2002 at the German Aerospace Center (DLR) in Stuttgart, Germany, he joined the CNRS at the end of 2002 to study suspension plasma spraying. His research activities are devoted to thermal plasmas processes, especially the electric arc dynamics in non-transferred plasma torches, but also plasma/liquid feedstocks interaction by developing models and diagnostics.