PO2053

A CFD model of the APS process: from the arc to the particle spray

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Atmospheric Plasma Spray (APS) is used for a long time to elaborated coatings on work-pieces for several applications. Despite that, understanding of this process is still not fully achieved today. For example, it was long believed that the plasma jet velocity at the gun exit of a conventional plasma spray gun did not exceed 800 m/s, whereas both experiments and models have now shown that the plasma velocity could reach much higher values (up to 2000 m/s). Thus, our understanding of the APS process must still be improved, requiring a fine modeling of the process as well as fine experiments.
In the present study, a computational fluid dynamics model incorporating both the internal flow (including modeling of electromagnetic couplings) and the external domain (free plasma jet mixing with the surrounding air) was implemented and alumina particles were injected externally to consider the spray process. Whereas, the contribution of turbulence is low on the internal plasma flow, it becomes essential for the study of the external plasma jet. In order to overcome this difficulty, a low Reynolds turbulence model was selected to perform the computations. It is shown in the article that the computed results remain similar to those obtained with a laminar assumption concerning the internal flow. However, the model allows considering the turbulent mixing with the surrounding air which would not be valid with a laminar model.
The behavior of alumina particles injected in the free plasma jet was also studied with the model. A comparison of experimental and computed in-flight particle characteristics is provided, as well as the resulting SEM pictures of coating cross-sections.

Keywords
Direct Current Plasma Torch
Alumina thermal spray
CFD and electromagnetic couplings