MODELLING OF DC PLASMA SPRAYING OPERATION INCLUDING PARTICLE IMPACTION AND SOLIDIFICATION

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ABSTRACT. In this paper a complete model of a DC Plasma Spraying system is presented. The model consists of three parts: a) Calculation of the flow and the temperature field in the plasma. The plasma system uses a shrouding gas. A boundary fitted coordinate (BFC) system is used to accurately predict the turbulent flow within the shrouding gas attachment nozzle; b) particle heating and trajectory model; and c) particle deformation and solidification after its impact on the substrate. The numerical solution for this part is based on the modified SOLA-VOF algorithm. A model similar to Stefan problem is used for the solidification part of the problem.

1. INTRODUCTION

Atmospheric pressure (APS) DC Plasma Spraying has a broad range of industrial applications A major problem of APS is the mixing of plasma gas with the surrounding air resulting in a sharp decay of the gas enthalpy, temperature and velocity, the most important parameters in accelerating and heating the injected particles. In addition, diffusion of oxygen from the surrounding air decreases the quality of the sprayed coatings by oxidizing the molten particles and creating impurities embedded in the coated layer. To delay this undesirable mixing a shrouding gas could be employed.

The objective of the present work is to model the APS system, shown schematically in Figure 1. First, we predict the flow and temperature field for the plasma. The predictions include the flow inside the shrouding gas attachment. The predicted flow and temperature fields are then used to calculate particle trajectories and heating. Finally, the flattening of molten powder is studied numerically. While mathematical models of free plasma jets and particle heating have been previously reported [1,2], these models do not consider flow in the shrouding attachment. As we will show later, this is important because of the entrainment of gases inside the attachment.

Flattening and solidification of the particles impinging onto the substrate surface involve very rapid changes in the shape and thermal state of the molten particles. The principle difficulty of