Effect of Substrate Properties on the Formation of Plasma Sprayed Alumina Splats

V. Pershin, M. Pasandideh-Fard, J. Mostaghimi, S. Chandra
Centre for Advanced Coating Technologies, Toronto, Ontario, Canada

Abstract

The effect of substrate characteristics on the formation of plasma-sprayed alumina splats was studied using both experiments and numerical simulation. Knowledge of the particle and substrate conditions is critical in understanding coating formation and in validating computational models. The size, velocity and temperature of the alumina particles prior to impact were measured using a particle in-flight diagnostic system. Experiments were performed on two substrate materials: stainless steel and glass. Substrate temperatures were varied in a range of 20-500°C and controlled with an electric heater. For each substrate material, a transition temperature was observed above which there was no fingering/splashing and the splats had a circular disk shape.

A 3D computational model of free surface flows with heat transfer and solidification was used to simulate the impact of alumina particles in conditions given by the experiments. The splat shapes from numerical model were comparable to those of the experiments for hot stainless steel substrate. For a cold substrate, the numerical model did not show any fingering/splashing. In the experiments, however, we observed two types of splat shapes: intensive splashing with no central core and circular disk splat. Substrate surface contamination, not considered in the numerical model, was the probable cause of droplet splashing on the cold substrate.

Introduction

Important properties of thermal spray coatings, such as adhesion and cohesion strength, thickness, porosity and roughness depend on the shape of individual splats and how they interact with the substrate and with each other.

The final splat shapes of powders of a given material sprayed onto a solid surface are a function not only of particle size, temperature, impact velocity and degree of solidification, but also the substrate conditions [1]. The temperature of the substrate has an important effect on splat formation. Previous studies [2-3] on the impact of nickel particles on substrates of different materials showed that there was a "transition temperature" above which splats had a circular disk shape, whereas they splashed and produced irregular splats when deposited on colder substrates. The transition temperature was found to be dependent on particle and substrate conditions.

Numerical simulations [4] showed that if a significant portion of the droplet froze during impact the solidified layer perturbed liquid flow and triggered splashing. Other studies [5] have shown that the presence of volatile contaminants on the surface, which vaporize when a splat lands on them, can also cause splashing. In this paper, we used experiments and numerical simulation to study the effect of substrate temperature on the impact of fused and crushed alumina