Material Transfer between Ni Particles and WC-Co Substrates at Shallow Impact Angles and Elevated Surface Temperatures

Akul Chaudhari, Tricia Schwartz, Ozan Özdemir, Sinan Müftü

In cold spray processes, nozzle fouling or clogging is a persistent issue primarily caused by the collision of powder particles with the nozzle walls, leading to the buildup of residual material. Despite efforts to combat fouling through nozzle cooling, it remains a formidable challenge, often requiring the use of suboptimal processing temperatures to prevent fouling. This study delves into a comprehensive analysis of the interaction between cold spray powder particles and nozzle walls. The focus lies on investigating the adhesion and erosion effects of nickel (Ni) powder particles on WC-Co material through experimental and simulation approaches. In controlled experiments, Ni powder was sprayed onto flat WC-Co substrates at varying angles, revealing residual Ni material on the substrate. Computational fluid dynamics (CFD) were utilized to ascertain the impact velocity and angle of the particles on the nozzle walls. Finite element method (FEM) was then applied using a coupled Eulerian-Lagrangian approach to simulate oblique particle impacts at the angles and velocities identified through CFD analyses. The findings indicate that, in certain scenarios, particle temperatures near the point of contact surpass the melting point of Ni, suggesting the potential for material residue deposition through smearing on the nozzle walls. Notably, it was observed that the mechanisms governing particle deformation and temperature rise during shallow-angle impacts differ from those in normal impacts. Friction dissipation emerges as crucial in temperature elevation during shallow-angle impacts, whereas plastic dissipation dominates normal impacts. These insights gleaned from the study contribute to a deeper understanding of the root causes of fouling in cold spray nozzles, essential for mitigating nozzle clogging and enhancing overall process efficiency.