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The Effectiveness of Shielding Gas Setup in Cold Spray Additive Manufacturing to Minimize Oxygen Exposure

Cold spray is a solid-state additive manufacturing process in which particles are accelerated through a supersonic de Laval nozzle using high-pressure gases and bond to a substrate via plastic deformation without melting. Although inert gases are used, oxidation can still occur due to elevated gas temperatures and the presence of ambient oxygen, leading to degraded adhesion, reduced strength, and increased porosity in oxygen-sensitive materials such as copper and titanium. In this study, the radial distribution of oxygen concentration near the substrate surface was quantified using computational fluid dynamics (CFD) for a high-pressure cold spray process. The effectiveness of an annular shielding gas configuration was evaluated by varying the gas type, flow rate, and nozzle size. Results show that increasing the shielding gas flow rate and nozzle radius both lead to reductions in oxygen concentration at the substrate surface. Argon shielding was found to be highly effective, reducing oxygen mass fractions to as low as 3% under certain conditions. These findings provide guidance for the design of effective shielding strategies in cold spray systems.