The Role of Powder Characteristics on the Strength and Ductility of Cold Sprayed Refractory Metal Deposits

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Abstract

Feedstock powder characteristics such as composition (specific alloying elements and concentrations and impurity levels), microstructure, thickness and composition of surface oxide layers, and particle size distribution have a defining impact on the overall mechanical properties of cold sprayed deposits. Herein, we report on two deposits sprayed from differently-sourced batches of nominally identical elemental refractory powders under identical spraying conditions, which exhibit bending strength and ductility values that differ by more than a factor of two – and with the weakest sample displaying negligible ductility. Through microstructural and micromechanical characterization of both the feedstock powders and cold sprayed deposits, we conclude that the deposits formed from the two feedstock powders are indistinguishable and extremely ductile when characterized locally within the relatively undeformed bulk of a single particle or splat. However, the two sprayed deposits show extremely low ductility or brittle behavior when loaded in tension across inter-splat boundary domains comprising material that has undergone extensive deformation. This result, combined with the observed differences in the morphology of the inter-splat boundary network between the two deposits, explains the difference in macroscopic mechanical behavior. We attribute these differences to the difference in the particle size distributions between the feedstock powder batches – larger particles are accelerated below the critical impact velocity, resulting in imperfect metallurgical bonding and higher porosity at the inter-splat boundaries.