

Mechanisms of Interfacial Mixing in the Blown Powder Deposition of Inconel 625 to Copper Alloy for Liquid Rocket Engine Applications

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There is an increasing need for functional materials to support high heat flux applications and optimize weight by using bimetallic additive manufacturing (AM). While one promising fabrication technology is the use of blown powder directed energy deposition (DED) AM, challenges remain with bi-metallic combinations. Prominent among these challenges is the need to understand mixing of materials at the bimetallic interface for forming stronger, more durable and reliable joints to extend the versatility of AM into critical applications. One application is the manufacturing of combustion chambers with copper-alloy liners and Superalloy structural jackets. In this application, material combinations are selected for effective heat dissipation, using copper, and retention of strength at high temperatures using Inconel 625. Currently, the dominant problem with this configuration is the highly variable strength of the interface and its correlation with deposition parameters. In this study, samples were fabricated at several vendors with Inconel 625 deposited onto wrought C-18150 (Cu-Cr-Zr) to form a bimetallic interface. Characterization of the interfaces were achieved through optical and electron microscopy, mechanical testing of mini tensile specimens, and electron dispersion spectroscopy to understand diffusion and bulk mixing behaviors at the joint. A theoretical framework was constructed in the context of solidification and mixing mechanisms to explain the resulting differences in the interface. This qualitative approach utilized a fluid dynamics perspective to sum the order of magnitudes of the various acting forces on the weld pool during deposition to predict convection trends based off known parameters. The predicted trends for each vendor are compared to obtain a better understanding of how mixing in the molten pool varied based on deposition parameters.

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