LASER POWDER BED FUSION OF CEMENTED CARBIDE GEOMETRIES USING TUNGSTEN CARBIDE-NICKEL AGGLOMERATED POWDER

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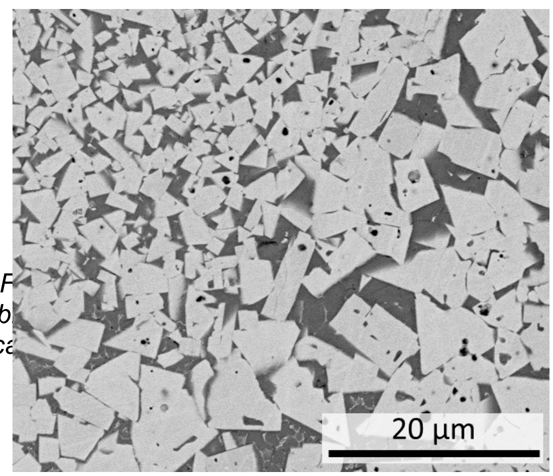
Cermets consist of ceramic crystals suspended in a metal binder, leading to high hardness, abrasion resistance, and fracture toughness, which are desirable for machining and tooling parts. However, the fabrication and achievable geometries of cermet parts are limited by the material's mechanical properties. Laser powder bed fusion (LPBF) is a novel fabrication pathway for more complex cermet part geometries through the layer-wise melting of metal binder. LPBF cermet fabrication has produced high-density (>98%) near net shape parts without post-processing, but lack-of-fusion porosity, microstructure alteration, and part deflection create process limitations resulting in part failure during fabrication. The objective of this study was to investigate process parameter selection to achieve larger and more complex cermet geometries needed for functional part fabrication using an agglomerated tungsten carbide (WC) -17 wt% nickel (Ni) powder.
SEM backscatter micrographs were taken at varying part heights to evaluate the effects of thermal accumulation on microstructure. A commercially available thermomechanical simulation software, Netfabb, was leveraged to predict the effects of laser power, scanning velocity, interlayer timing, and geometry selection on part deflection. Simulations were validated using cermet single bead widths and known build failure heights. The results from the micrograph and thermomechanical analysis were used to develop builds with 25 mm geometries, sharp corners, and internal channels to evaluate achievable geometries.

Clusters of WC crystals larger than those in the unprocessed powder (~1 µm diameter) introduced heterogeneity to the microstructure, as shown in Figure 1. The presence of heterogeneity at all heights and all samples analyzed indicated that microstructure alteration would be present with process parameters necessary to achieve high density. In the thermomechanical simulations, higher ratios of laser power to velocity and greater interlayer timing increased in part deflection of 3-5%, and the use of square geometries increased part deflection an additional 15% compared to cylindrical geometries. A 25 mm tall build consisted of cylinders printed to completion without catastrophic failure, which was consistent with a simulated recoater clearance of 40%. A build with internal geometries, sharp corners, and a long rectangular geometry saw the failure and removal of the long geometry at 4 mm in height, but the remaining parts were printed to completion. The failure of the long geometry highlights continuing limitations with achievable geometries, but the fabrication of more complex geometries opens the way for the fabrication of previously unobtainable cemented carbide parts.



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