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Effect of Intra-Build Design Parameters on the Fracture Toughness Properties of EBM Ti6Al4V

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Abstract

Metal Additive Manufacturing technologies provide new opportunities for manufacturing complex components. However, the limited and scattered data on damage tolerance behavior is hindering adoption in safe-critical applications. A design of experiments (DOE) is used in this study to provide an understanding of the Electron Beam Melted (EBM) Ti6Al4V fracture toughness properties. Three builds comprised of 150 compact tension samples were printed representative of the EBM build chamber, followed by surface machining, microstructural characterization, X-ray microcomputed tomography (μCT), and fracture toughness testing per ASTM E399. Analysis of Variance (ANOVA) statistics on the influence and interaction of intra-build design parameters on the As-Built and Machined samples showed orientation, build location, and geometry to contribute to property variation. EBM fracture toughness reported an average of 65 MPa[?]m, with an increase in build height and proximity to the center of the build envelope. The location- and size-dependent properties resulted from changes in microstructure and porosity throughout the build space. While intra-build design variation was present, the EBM Ti6Al4V fracture toughness properties reported a 10% overall variation comparable to wrought and cast alloys. The extensive experimental work in this study shows EBM Ti6Al4V to be a repeatable and reliable alloy for use in load-bearing applications.

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