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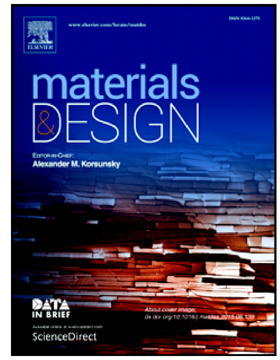

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Influence of Successive Thermal Cycling on Microstructure Evolution of EBM-Manufactured Alloy 718 in Track-by-Track and Layer-by-Layer Design

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Abstract

Successive thermal cycling (STC) during multi-track and multi-layer manufacturing of Alloy 718 using electron beam melting (EBM) process leads to a microstructure with a high degree of complexity. In the present study, a detailed microstructural study of EBM-manufactured Alloy 718 was conducted by producing samples in shapes from one single track and single wall to 3D samples with maximum 10 longitudinal tracks and 50 vertical layers. The relationship between STC, solidification microstructure, interdendritic segregation, phase precipitation (MC, δ-phase), and hardness was investigated. Cooling rates (liquid-to-solid and solid-to-solid state) was estimated by measuring primary dendrite arm spacing (PDAS) and showed an increased cooling rate at the bottom compared to the top of the multi-layer samples. Thus, microstructure gradient was identified along the build direction. Moreover, extensive formation of solidification micro-constituents including MC-type carbides, induced by micro-segregation, was observed in all the samples. The electron backscatter diffraction (EBSD) technique showed a high textured structure in <001> direction with a few grains misoriented at the surface of all samples. Finer microstructure and possibility of more γ″ phase precipitation at the bottom of the samples resulted in slightly higher (~ 11%) hardness values compared to top of the samples.

Keywords: Electron Beam Melting, Alloy 718, Track by Track, Layer by Layer, Successive Thermal Cycling, Microstructure evolution

1. Introduction

Electron beam melting, as a powder-bed fusion (PBF-EB) technique in the field of additive manufacturing (AM), is capable of directly manufacturing three dimensional (3D) parts from a computer aided design (CAD) file [1–3]. EBM is aimed to manufacture lightweight, and geometrically complex parts as well as rapidly produce small series required by aerospace and automotive sectors [4].

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