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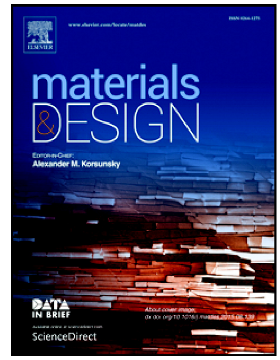

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The effect of laser focus shift on microstructural variation of Inconel 718 produced by selective laser melting

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Abstract

Selective laser melting is gaining interest in the aerospace industry as a candidate for manufacturing flight hardware. With increasing popularity comes the need for rigorous qualification standards and a thorough understanding of how processing parameters can affect part quality. One such parameter is the laser focal shift, which moves the building plane relative to the focal plane of the laser. Changing the focal shift alters the power density while keeping the laser parameters constant, a novel method for tailoring the microstructures of parts made by SLM. In this study, samples were manufactured at different focal positions and their microstructures were characterized. Samples built at the focal plane had a finer microstructure than samples built away from it, a result of higher power density and a smaller spot size. Furthermore, samples in the heat-treated condition produced at the shifted locations exhibited coarser grains aligned parallel to the build direction, while those at the focal plane had a finer and more equiaxed microstructure. Differences originating from the as-built condition that remain through post processing may influence the final mechanical performance of SLM parts. Utilizing the focus shift to produce these changes presents a unique opportunity for microstructural tailoring and improved mechanical performance.

Keywords: Additive manufacturing, selective laser melting, Inconel 718, laser focus shift, EBSD

1. Introduction

Additive manufacturing (AM) techniques utilize 3D models to create functional parts through the layer-by-layer addition of material [1]. Among the common metallic AM techniques is selective laser melting (SLM), a powder-bed fusion process that can produce fully-dense metal components using a high intensity laser [2, 3].

The layer-by-layer nature of SLM allows for the manufacturing of complex metallic parts with geometries and features that are not attainable through traditional machining [4, 5]. Furthermore, it has been commonly used with alloys that face machining challenges such as Ti-6Al-4V [6, 7] and nickel superalloys [8, 9]. The combination of these factors makes SLM extremely desirable in the aerospace industry where parts like injectors, impellers, and nozzles often require difficult to machine materials in complex geometries [10, 11].

Nickel-based superalloys are used in applications within the aerospace industry due to their outstanding mechanical properties at elevated temperatures [12, 13]. Inconel 718 (IN718), a precipitation-hardened alloy, is considered the workhorse of these superalloys because of its superior mechanical properties and