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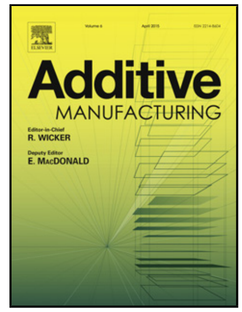

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Characterizing surface finish and fatigue behavior in binder-jet 3D-printed nickel-based superalloy 625

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Abstract

In this study, the fatigue properties of binder-jet 3D-printed nickel-base superalloy 625 were evaluated. Standard fatigue specimens were printed and sintered, then half of the samples were mechanically ground, while the other half were left in their as-sintered state. They were then characterized using micro-computed x-ray tomography, metallographic sample examination, and optical and stylus profilometry for surface topography. The micro-computed tomography observations showed that density of the as-printed sample was ~50%, while the sintered sample neared full densification (98.9 ± 0.3%) upon sintering at 1285 °C for 4 h in a vacuum atmosphere. The metallographic examination showed equiaxed grains. The roughness of the as-sintered samples was significant with an RMS roughness of R_q = 1.39 ± 0.20 µm as measured over a line-scan of 5 mm, but this was reduced to R_q = 0.47 ± 0.02 µm after mechanical grinding. All samples were tested to failure in fatigue, under fully-reversed tension-compression conditions. While the as-sintered samples showed poor fatigue properties compared to prior reports on cast and milled parts, the ground samples showed superior performance. Scanning electron microscopy observation was conducted on the fractured surfaces and showed that the samples underwent transgranular crack initiation, followed by intergranular crack growth and final failure. In the mechanically ground sample, hardness increased nearly two-fold up to 75 µm beneath the sample's surface and X-ray diffraction indicated an in-plane compressive stress, grain refinement, and micro-strain on the mechanically ground sample. The surface hardening and compressive stress resulted most likely in increasing fatigue life of the binder-jetted alloy 625.

Keywords: Additive manufacturing; Inconel 625; Fractography; Surface roughness; Hardness.

1. Introduction

Binder-jet 3D printing (BJ3DP) is a fast, low-cost process in which powder is deposited layer-by-layer, selectively joined in each layer with binder, and then sintered using a post-printing heat treatment to densify green parts [1,2]. Binder jetting uses inkjet printing technologies to bond the particles with the