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CHARACTERIZATION OF BENDING VIBRATION FATIGUE OF SLM FABRICATED Ti-6Al-4V

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1. Abstract

Additive Manufacturing (AM) is a novel process that promises an increased efficiency in material use, while allowing the production of advanced topologies and the seamless integration of inner cavities and pathways without the use of complex tooling. As of now, little work has been done on the fatigue performance of these materials. Concurrently, an interest in understanding fatigue behaviour specific to turbine and compressor blades has been expressed by original equipment manufacturers. This type of fatigue loading is characterized by high frequency, short wavelength stress states as well as mixed mode loading. It has been found that conventional fatigue data are inadequate in representing this type of fatigue loading. In response, a vibration-based fatigue technique has presented itself as a viable alternative. In this work, the vibration-based fatigue behaviour of Ti-6Al-4V is studied in an effort to address the use of AM for the production of compressor parts. Samples produced by Selective Laser Melting (SLM) are cycled in the first bending mode to quantify the average stress amplitude at failure for 10^7 cycles using the Dixon-Mood staircase method. Subsequent fractography and statistical analysis are used to determine the dominant failure mechanisms and the effect of chosen variables, respectively. The effect of the build direction and post-build heat treatment are examined. Lastly, 3D laser vibrometry data are used to critically assess the vibration test method relative to AM materials. The study concludes that fatigue life can be greatly increased by a Hot Isostatic Pressing (HIP) treatment, even surpassing wrought alloy performance, and that build direction has a significant effect on fatigue performance. Also, the vibrometry data indicate that AM and conventional materials present similar modal behavior.

2. Introduction and Background

AM is gaining increasing attention within the aerospace community in light of efficiency and performance gains. Specifically, AM opens the way to ease of construction of superior parts with or without