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Low cycle fatigue behavior of direct metal laser sintered Inconel alloy 718

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Abstract

In this work, we investigate strength and low cycle fatigue (LCF) life of direct metal laser sintered (DMLS) Inconel 718 superalloy at room temperature. To investigate effects of initial microstructure, the material was deposited in two directions. As a result, the axial loading direction was 45° and 90° with respect to the deposition direction. To further investigate effects of initial microstructure, a few samples of the printed material underwent hot isostatic pressing (HIP). As-printed samples as well as the HIP processed samples were further heat treated (HT) according to AMS 5663 after machining the LCF specimens. To have a reference for the LCF behavior of DMLS Inconel 718, a set of wrought Inconel 718 samples in the same HT condition was also made, and the results critically compared against the results for the DMLS materials. Strain controlled LCF tests were conducted under a mean engineering strain of 0.5% and several strain amplitudes ranging from 0.6% to 1.4%. LCF behavior of DMLS HT material was found to be better than that of wrought HT material at lower strain amplitudes. However, the wrought material had longer life at higher strain amplitudes. The results revealed that the role of porosity present in the DMLS specimens is not as significant at low strain amplitudes as it is at high strain amplitudes. Furthermore, we found that the HIP treatment deteriorated the LCF performance of the material, suggesting that a high content of annealing twins present in the HIPed material microstructure has a larger effect on shortening the life of the samples than porosity. Finally, the Coffin-Manson model was fit to extract the strain-life curves for the studied materials. At lower strain amplitudes, where plastic strain is small, the standard Coffin-Manson model deviated from the data. A bilinear Coffin-Manson model for LCF was found to better capture the data.

Keywords: Direct metal laser sintering; Inconel 718; Low cycle fatigue; Coffin-Manson model

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