Towards understanding the fatigue behaviour of Alloy 718 manufactured by Powder Bed Fusion processes

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Abstract

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Additive Manufacturing (AM) is a disruptive modern manufacturing process in which parts are manufactured in a layer-wise fashion. Among the metal AM processes, Powder Bed Fusion (PBF) technology — comprised of Electron Beam Powder Bed Fusion (EB-PBF) and Laser Beam Powder Bed Fusion (LB-PBF) — has opened up a design space that was formerly unavailable with conventional manufacturing processes. PBF processes offer several advantages; however, the suitability of these processes to replace the conventional processes must be investigated in detail. Therefore, understanding the AM process – post-processing – microstructure – property relationships is crucial for the manufacturing of high-performance components. In this regard, only limited work has been done towards understanding the fatigue behaviour of PBF Alloy 718. The aim of this work, therefore, is to understand how the fatigue behaviour of PBF Alloy 718 is affected by its microstructure. Besides, the influence of the rough as-built surface is also investigated.

In general, the <100> texture along the build direction that resulted from PBF processing of Alloy 718 led to anisotropy in Young’s modulus. Consequently, the fatigue performance under controlled amplitudes of strain was anisotropic such that the low-modulus direction had longer fatigue life and vice versa. This texture-induced elasticity-dependent anisotropic strain-life behaviour could be normalized by the pseudo-elastic stress vs fatigue life approach.

Inclusions and defects had a detrimental effect on fatigue performance. Numerous factors, such as their geometry, volume fraction, and distribution, determined the effect on fatigue behaviour. Hot Isostatic Pressing (HIP) eliminated most defects and led to an improvement in fatigue performance. However, HIP did not alter the inclusions, which acted as crack initiation sites and reduced fatigue life. The rough as-built surface, which had numerous notch-like crack initiation sites, deteriorated fatigue performance; however, it lowered the scatter in fatigue life. Machining off the as-built surface improved fatigue life but increased the scatter.