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# Multiaxial high cycle fatigue (HCF) behavior of IN718 thin wall structures obtained by laser powder bed fusion (LPBF)

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## Abstract

In order to achieve the 2050 challenging goal of zero carbon emissions, the aeronautical industry research focus on the latest fabrication processes to produce new materials and reduced weight parts. Our aim is to show that metallic, LPBF manufactured, triply periodic minimal surface structures (TPMS) can be used to reduce the weight of critical mechanical aeronautical components and optimize their performance, achieving a better weight-to-resistance ratio. We present our results on HCF multiaxial behavior of IN718 thin-wall structures, the first step to master complex, TPMS behavior.

TPMS structures, made of thin walls are essential for achieving low densities, but have complex microstructures with few grains across their thickness. The LPBF process can add additional complexity, like porosities, lack of fusion, and oriented microstructures. The resulting complex geometry generates stress gradients under mechanical loading and influences surface topology, which is a key factor when considering fatigue strength.

Our study describes the microstructure and mechanical behavior of thin walls, down to 200 microns of width. Tubular thin-wall fatigue specimens, fabricated with different thicknesses and orientations to map the behavior at various locations within the TPMS geometry are thoroughly investigated.

Microstructural analysis aligns with findings reported in literature (Sanchez-Camargo et al., 2003). Columnar grains along the building direction are observed even after heat treatment. EBSD maps reveal elongated grains and a significant degree of texture. We show that surface topology in the as-built state is heavily dependent on the building orientation and

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remains a primary factor influencing fatigue life. Moreover, adhered powder on surfaces can create small notches in material and serves as potential crack initiation sites. Given that surface topology is a critical factor for fatigue behavior, optical and tomographic measurements were used to characterize it, before performing axial, torsional and combined cyclic loading. Furthermore, we show how factors like width, high-stress concentrations, coupled with adhered powder notches and gaseous process lead to a decrease in fatigue life.