Experimental investigation of fatigue behaviour and failure mechanism of SLM AlSi10Mg lattice structures

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ABSTRACT

Recent advances in Additive Manufacturing (AM) have led to the production of complex micro-lattice structures that combine a lightweight design with high strength and high stiffness and with other properties, such as an high thermal conductivity, the capability to propagate energy and to distribute an impact shock and the possibility of maximizing surface areas. Micro-lattice material are so suitable for several applications that requires multi-functional properties.

To integrate micro-lattices in structural components, it is important o investigate the fatigue behaviour and failure mechanism in different loading conditions. The fatigue strength of these structures is strongly affected by several parameters, including: mechanical properties of bulk materials, printing parameter, micro-structure, porosity and surface roughness resulting in geometrical irregularities and local stress concentrations.

In this study, an experimental characterization of AlSi10Mg of micro-lattice structures obtained by Selective Laser Melting (SLM) was carried out on two different topologies of lattice micro-structure based on two different unit cells: a Body Centered Cubic (BCC) cell and a Lightened Face-Centered Cubic (FCC-L) cell.

High-Cycle Fatigue (HCF) tests in compression and in tension at different stress ratios (R=0.1 and R=-1) were performed on specimen designed with a graded lattice relative density in order to guarantee the fatigue failure in the gage section of the specimen.

To investigate the failure mechanism different HCF tests in tension have been carried out under CT-scan and the results have been analysed by means of Digital Volume Correlation (DVC). This technique enables to monitor the strain field evolution during in situ experiments and to study the failure modes of specimen.

The experimental results have been compared with a numerical model for fatigue strength prediction developed starting from a Finite Element Model (FEM) of the as-printed geometry. The results show that geometrical irregularities and stress concentrations at micro-notches play a fundamental role in fatigue strength of lattice structures.

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