Elastoplastic Response of As-built SLM and Wrought Ti-6Al-4V under Symmetric and Asymmetric Strain-controlled Cyclic Loading

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Abstract

Purpose - Using as-built SLM Ti-6Al-4V in engineering applications requires a detailed understanding of its elastoplastic behaviour. This preliminary study intends to create a better understanding on the cyclic plasticity phenomena exhibited by this material under symmetric and asymmetric strain-controlled cyclic loading.

Design/methodology/approach – This paper investigates experimentally the cyclic elastoplastic behaviour of as-built SLM Ti-6Al-4V under symmetric and asymmetric strain-controlled loading histories and compare it to that of wrought Ti-6Al-4V. Moreover, a plasticity model has been customised to simulate effectively the mechanical behaviour of the as-built SLM Ti-6Al-4V. This model is formulated to account for the SLM Ti-6Al-4V specific characteristics, under the strain-controlled experiments.

Findings - The elastoplastic behaviour of the as-built SLM Ti-6Al-4V has been compared to that of the wrought material, enabling characterisation of the cyclic transient phenomena under symmetric and asymmetric strain-controlled loadings. The test results have identified a difference in the strain-controlled cyclic phenomena in the as-build SLM Ti-6Al-4V when compared to its wrought counterpart, due to a difference in their microstructure. The plasticity model offers accurate simulation of the observed experimental behaviour in the SLM material.

Research limitations/implications – Further investigation through a more extensive test campaign involving a wider set of strain-controlled loading cases, including multiaxial (biaxial) histories, is required for a more complete characterisation of the material performance.

Originality/value – The present investigation offers an advancement in the knowledge of cyclic transient effects exhibited by a typical α' martensite SLM Ti-6Al-4V under symmetric and asymmetric strain-controlled tests. The research data and findings reported are among the very few reported so far in the literature.

Key words: Plasticity; Cyclic loading; Mean stress relaxation; Titanium alloys; Selective laser melting.

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