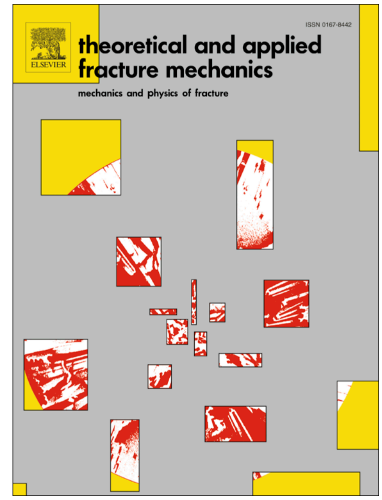
Accepted Manuscript



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PII: S0167-8442(18)30317-3
DOI: https://doi.org/10.1016/j.tafmec.2018.09.011
Reference: TAFMEC 2105

To appear in: *Theoretical and Applied Fracture Mechanics*

Received Date: 29 June 2018
Revised Date: 18 September 2018
Accepted Date: 18 September 2018

Please cite this article as: N.O. Larrosa, W. Wang, N. Read, M.H. Loretto, C. Evans, J. Carr, U. Tradowsky, M.M Attallah, P.J. Withers, Linking microstructure and processing defects to mechanical properties of selectively laser melted AlSi10Mg alloy, *Theoretical and Applied Fracture Mechanics* (2018), doi: https://doi.org/10.1016/j.tafmec.2018.09.011

LINKING MICROSTRUCTURE AND PROCESSING DEFECTS TO MECHANICAL PROPERTIES OF SELECTIVELY LASER MELTED ALSI10MG ALLOY

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Abstract

Here we analyse the relationship between the monotonic and cyclic behaviour of cylindrical AlSi10Mg (CL31 AL) samples fabricated by Selective Laser Melting (SLM) to the presence of manufacturing defects (pores, voids, oxides, etc.) and the beneficial effect of post-processing - T6 and hot isostatic pressing (HIP)- treatments. Correlative Computed Tomography (X-ray tomography, optical microscopy, electron backscatter diffraction, SEM and TEM) is used to characterise the microstructure and the three-dimensional (3D) structure of fatigue samples and to shed light on the role of defects on the experimental fatigue behaviour. Pancake-shaped pores are observed in the plane of the deposited layers having a 130% higher volume fraction for the vertical layering depostion (VL) than for horizontal layered (HL) orientations, and being larger and flatter. Further, while T6 treatment had relatively little effect on reducing porosity, the HIPping reduced the pore fraction by 44% and 65% for VL and HL samples, respectively. T6 and Hipping decreased the yield stress and the ultimate tensile strength considerably while increasing elongation and reduction of area accordingly. Although results are not conclusive and further work is required, our results suggest that the fatigue life seems to be dominated by the presence of these crack-like (pancake-like) defects perpendicular to the loading direction such that it is better to build samples transverse to the highest fatigue loads. Both T6 heat treatment and HIPping appear to reduce the fatigue streng of the material regardless of the AM deposition scheme as they tend to enlarge and collapse pores/voids to flat crack-like defects.

Keywords: Selective Laser Melting, Aluminium alloys, Porosity, Microstructure, Mechanical properties

INTRODUCTION

Unlike conventional material removal (subtractive) manufacturing techniques, additive manufacturing (AM) technologies allow the production of near-net shape components by building up the material layer by layer as powder or wire is melted locally by a computer-controlled energy source.