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LCF behaviour and a comprehensive life prediction model for AlSi10Mg obtained by SLM

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Abstract

The full potential of additive manufacturing (AM) components is today yet to be reached. Space and aerospace industries are still conservative in the use of AM parts for safety-critical applications, mostly because of the uncertainties and low reproducibility that are often associated with the process. One of the most challenging issues is the fatigue resistance. The rough surface condition and the presence of manufacturing defects can cause significant scatter, leading to the adoption of large conservative safety factors. To robustly model the fatigue resistance of defected AM materials, there is a need to implement defect-tolerant designs and deal with these uncertainties. The present research activity aims at developing a model for fatigue life estimation in a large range of loading conditions, from high cycle fatigue to low cycle fatigue. This is achieved by adopting a fracture mechanics approach, through elastic-plastic fatigue crack growth calculations based on the known defect population inside the material. The model has been applied to AlSi10Mg produced by three slightly different selective laser melting processes, showing a robust estimation of fatigue life and scatter with limited experimental effort. The life predictions performed are then summarised in design maps where the allowable stress (or strain) depends on the defect size and on the HCF/LCF design upon the number of cycles selected.

Keywords: AlSi10Mg, additive manufacturing, low cycle fatigue, elastic-plastic driving force, defects

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