
The role of laser scan rotation on the microstructure and texture evolution in a Inconel 718 alloy processed through laser powder bed fusion additive manufacturing

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Abstract

In the laser powder bed fusion additive manufacturing process, the rotation angle of the laser scan direction between two adjacent layers is a critical controlling parameter. By carefully manipulating the scan rotation angle, the melt pool's thermal gradients and cooling rates can be altered. In this work, the tensile properties of Inconel 718 along the building direction (Z) and perpendicular to the building direction (X) with and without laser scan rotation were analysed. X-ray diffraction and Electron back-scattered diffraction (EBSD) were used to analyse the texture of the specimens along the transversal (XZ) and longitudinal (XY) planes. The inverse pole figure (IPF) map obtained from EBSD in the XZ plane for the as-printed sample without scan rotation showed long columnar grains and a few finer grains oriented toward {110} orientation. In contrast, the specimens printed with scan rotation exhibit columnar grains of comparatively smaller size. This behaviour is primarily due to the competitive grain growth between the maximum cooling direction (opposite to the building direction) and easy growth directions. The IPF map for the without-rotation specimens in the XY plane showed the presence of {100} oriented finer grains formed due to the fragmentation of coarser grains in the heat-affected zone along the easy growth direction. The XY plane for the with-rotation specimens also had a bimodal grain structure. Moreover, a comparatively smaller number of {100} finer grains ($\sim 12 \mu\text{m}$) were present in the with-rotation specimens than in the without-rotation specimens. The geometrically necessary dislocation map showed that a high number of dislocations was present in {100} oriented grains, enhancing the strengthening by increasing dislocation – dislocation interaction. The strength due to grain boundary, texture and dislocation-dislocation interaction was quantified using the Hall-Petch, Taylor, and Bailey-Hesh theories.

Keywords: laser powder bed fusion, additive manufacturing, texture

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