Effect of build orientation on the fatigue properties of as-built Electron Beam Melted Ti-6Al-4V alloy

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Effect of build orientation on the fatigue properties of as-built Electron Beam Melted Ti-6Al-4V alloy.

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Abstract

As-built Ti-6Al-4V thin parts were manufactured in three different orientations using EBM and characterized by laboratory X-ray tomography. Fatigue tests were performed. The comparison with results for machined samples from the literature showed a large reduction of fatigue strength. SEM observations of the fracture surfaces showed that surface defects which were identified as notch-like defects on tomographic images caused the failure. Their impact on fatigue results was rationalized by Kitagawa-Takahashi diagrams. A build orientation impact on the fatigue properties was observed and linked to its effect on defects distributions and crack growth. The limits of roughness measurements were also discussed.

Keywords: Electron Beam Melting, Titanium alloys, Fatigue behavior, X-ray microtomography, As-built properties, Manufacturing orientation

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1. Introduction

Combining good mechanical properties with interesting thermal or acoustic properties is of great interest and, to this end, architectured materials are good candidates to replace monolithic materials. In particular, for industries where weight saving is also considered such as aeronautics industry, lattice structures are extremely promising, see e.g. [1], [2], [3], [4], [5], [6], [7], [8]. However, until recently, it was very challenging to build such metallic lattice structures with conventional processes as multiple steps were required, see e.g. [9], [10]. With the emergence of powder-bed based additive manufacturing techniques such as selective laser melting (SLM) and electron beam melting (EBM), producing such structures is becoming easier.

If series production is to be considered, one needs to determine reliable mechanical properties for the manufactured lattices, see e.g. [11], [12], [13], [14], [15]. As damage caused by cyclic mechanical loading is the main cause of failure for industrial parts, determining the fatigue properties of additively manufactured samples is mandatory. It has been demonstrated that the fatigue properties of Ti-6Al-4V EBM samples can be equivalent to those of the wrought materials

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