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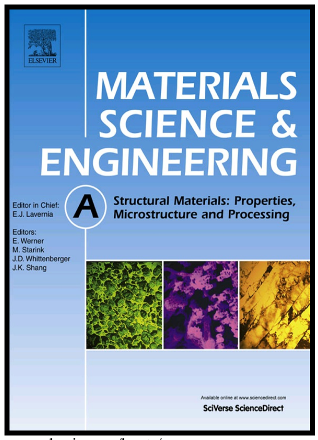

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Effect of microstructure on the fatigue crack growth behavior of laser solid formed 300M steel

Fenggang Liu[a,b], Xin Lin[a,b*], Haiou Yang[a,b], Xiaoli Wen[a,b], Qiuge Li[a,b], Fencheng Liu[c], Weidong Huang[a,b]

[a]State Key Laboratory of Solidification Processing, Northwestern Polytechnical University, Xi'an Shaanxi 710072, PR China

[b]Key Laboratory of Metal High Performance Additive Manufacturing and Innovative Design, MIIT China, Northwestern Polytechnical University, Xi'an, Shaanxi 710072, P. R. China

[c]National Defence Key Discipline Laboratory of Light Alloy Processing Science and Technology, Nanchang Hangkong University, Nanchang 330063, PR China

[*]Corresponding authors. Tel.: +86 29 88460510; fax: +86 29 88495106. xlin@nwpu.edu.cn

Abstract

In this research, the effect of microstructure on the fatigue crack growth rate (FCGR) of laser solid formed (LSFed) 300M steel was investigated. The results showed that the as-deposited microstructure of LSFed 300M steel consisted of martensite and coarse bainite. After heat treatment, the microstructure became homogeneous and was primarily composed of tempered martensite, bainite and a small amount of retained austenite. The FCGR of LSFed 300M steel gradually increases with increasing stress ratio (for a given stress intensity factor range and stress ratios between 0.1 and 0.5). The refined austenite grain of heat-treated LSFed 300M steel reduced the fatigue crack growth threshold (FCGT) and the FCGR. The fractography of as-deposited LSFed 300M steel was different from that of heat-treated LSFed 300M steel.

Keywords: laser solid forming; additive manufacturing; 300M steel; microstructure; stress ratio; fatigue crack growth behavior

1. Introduction

High-strength steels, such as HSLA-80 steel, SE702 steel, 4340 steel, and 300M steel, are widely used in the aerospace industry for improved fatigue resistance and reduced weight due to their excellent anti-fatigue properties [1-8]. Fatigue failure is a major threat to the safe use of the components, which are subjected to repeated alternating and cyclic stresses. Statistically, fatigue failure accounts for 80% of the all aviation component failures [9]. Therefore, determination of fatigue properties of high-strength steels is essential to guide their usage. The failure of components subjected to fatigue loading is a major challenge in engineering applications of high-strength steels. Generally, fatigue failure happens by means of progressive brittle cracking under repeated alternating or cyclic stresses considerably below the normal static strength. In the past, much research has been conducted on avoiding sudden fatigue failure. As a result, the fatigue crack growth rate (FCGR, da/dN, where a is crack length and N is the number of fatigue cycles), as an important index to reflect anti fatigue-fracture of the components, has been considered an indispensable parameter in estimating the residual life of components [10].

In recent years, there have been many studies describing the fatigue crack growth (FCG) behavior of high-strength steels [11-16]. Paykani found that the size of the austenite grains, the volume fraction, and the size and morphology of M_2B are primary factors in retarding crack propagation in the Paris region for FeCrNiBSi advanced high-strength steel [11]. In laser-clad AISI4340 steel, the coarse grains of the heat affected zone (HAZ) enable a lower fatigue life when compared with the substrate [12]. Spies found that the threshold levels and the FCGR for the HAZ are higher than those for the base