Available online at www.sciencedirect.com

ScienceDirect

Procedia Structural Integrity 5 (2017) 393–400

Structural Integrity Procedia

www.elsevier.com/locate/procedia

2nd International Conference on Structural Integrity, ICSI 2017, 4-7 September 2017, Funchal, Madeira, Portugal

Fatigue Behaviour Evaluation of Additively and Conventionally Produced Materials by Acoustic Emission Method

Vendula Kratochvilova[1], Frantisek Vlasic[1], Pavel Mazal[1], David Palousek[1]*

[1]*Brno University of Technology, Technicka 2896/2, 616 69 Brno, Czech Republic*

Abstract

Additive manufacturing of metals is today one of the most growing fields in materials research. Selective laser melting (SLM) allows to produce metal parts with complicated shapes, but the quality of produced material is relatively low (in compare with conventionally produced materials). The main aims of latest studies is to improve materials properties and reach the same or better quality.

Presented paper shows the comparison of fatigue behaviour of SLM and conventional material using copper (Cu7.2Ni1.8Si1Cr) and aluminium (AlCu2Mg1.5Ni and AlSi10Mg) alloys. SLM and standard material samples were subjected to bending fatigue tests which were supplemented by acoustic emission (AE) measurement and fractography analysis. The results from AE measurement allows to analyse fatigue process, determine different fatigue stages and compare the results from SLM and standard material in more detail.

The results show that the main difference between fatigue behaviour of SLM and standard material is not only in total fatigue life (the SLM material has significantly worse fatigue resistance), but mainly in the length of fatigue stages and in mechanism of crack development. As we expected, the fatigue resistance of SLM is strongly affected by amount of production defects.

Peer-review under responsibility of the Scientific Committee of ICSI 2017

Keywords: Selective laser melting; additive manufacturing; acoustic emission; fatigue

* Corresponding author. Tel.: +420-54114-3240.
E-mail address: xkrato04@vutbr.cz

2452-3216
Peer-review under responsibility of the Scientific Committee of ICSI 2017
10.1016/j.prostr.2017.07.187

1. Introduction

Generally, the additive manufacturing (AM) or 3D printing technologies enable to produce complicated shaped part in short time and without big material waste. In recent decades, these technologies were subjected to intensive studies. They were mainly aimed to expand the portfolio of produced materials while preserving their mechanical characteristics. Selective laser melting (SLM) is one of the AM technologies which is able to produce metal parts with relatively good quality, nevertheless the range of those materials is small. SLM technology principle is based on adding of thin layers of metal powder and their connecting by a focused laser beam, see Fig. 1, Lober et al. (2014).

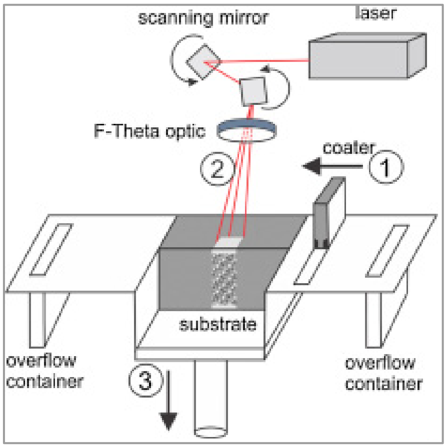

Fig. 1. Selective laser melting principle, Lober et al. (2014)

At the beginning of any new material production is needed to determine an optimal process parameters in order to get the best quality. The most important parameters are laser power, scanning speed, hatch spacing, layer thickness, power beam diameter and building (scanning) strategy.

1.1. Mechanical characteristics of SLM materials

Brandl et al. (2012) tested mechanical characterization, including high cycle fatigue, of aluminium alloy AlSi10Mg. The main topic of the paper is an investigation of influence of heat treatment (T6), position of samples axes to building platform and building platform temperature. Results showed that the heat treatment has the most significant influence on the fatigue resistance, higher building platform temperature increase the resistance slightly and position of the sample on the building platform has insignificant influence. The crack origins are always located on the surface or subsurface defects.

Work of Quanchu at al. (2014) was aimed to the fatigue behaviour of titanium (Ti) alloy Ti6Al4V. Achieved fatigue life of the SLM specimens was better than that of cast part and equivalent to that of cast specimens after heat treatment. The fatigue life was significantly affected by internal production defects and the crack origins was located in them.

The copper (Cu) alloys were investigated in papers by Zhang et al. (2014) – alloy K220 and Scundino at al. (2015) – Cu10Sn alloy. The relative density was over 99% in both cases. The Cu10Sn alloy had significantly better yield and tensile strength (220 and 420 MPa) than compared cast material (120 and 180 MPa).

1.2. Acoustic emission and fatigue behavior

Acoustic emission (AE) is one of the standard non-destructive method. This method is based on physical phenomenon in which a transient elastic waves are generated from local internal micro-changes in material structure. The AE method allows to continuously monitor a process of plastic deformation and crack development.