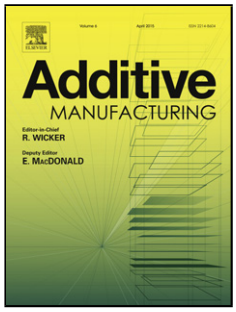

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PII: S2214-8604(18)30179-9
DOI: https://doi.org/10.1016/j.addma.2018.06.002
Reference: ADDMA 416

To appear in:

Received date: 17-3-2018
Revised date: 23-5-2018
Accepted date: 6-6-2018

Please cite this article as: Ahmad B, der Veen SOv, Fitzpatrick ME, Guo H, Residual Stress Evaluation in Selective-Laser-Melting Additively Manufactured Titanium (Ti-6Al-4V) and Inconel 718 using the Contour Method and Numerical Simulation, *Additive Manufacturing* (2018), https://doi.org/10.1016/j.addma.2018.06.002

Residual Stress Evaluation in Selective-Laser-Melting Additively Manufactured Titanium (Ti-6Al-4V) and Inconel 718 using the Contour Method and Numerical Simulation

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Abstract

Residual stresses play an important role for the structural integrity of engineering components. In this study residual stresses were determined in titanium alloy (Ti-6Al-4V) and Inconel 718 samples produced using selective-laser-melting (SLM) additive manufacturing. The contour method and a numerical simulation approach (inherent-strain-based method) were used to determine the residual stress distributions. The inherent-strain-based method reduces the computational time compared to weakly-coupled thermo-mechanical simulations. Results showed the presence of high tensile residual stresses at and near the surface of both titanium and Inconel alloys samples, whereas compressive residual stresses were seen at the center region. A good agreement was seen between the results obtained from contour method and the numerical simulation, particularly 1 mm below the surface of the samples.

Keywords: Selective laser melting, additive manufacturing, residual stress, inherent strain-based method, contour method.

1. Introduction

Selective laser melting (SLM) is a form of powder-bed fusion additive manufacturing [1]. It works by melting and bonding successive layers of powder metal to produce three-dimensional shapes with the use of a high-power laser [2]. The process usually takes place under an inert gas. Computer-Aided Design (CAD) software is used in the SLM process, which converts the full three-dimensional geometry to a series of layers for each laser pass. The thickness of each layer and a tool path are also defined [1]. A variety of complex and small shapes can be produced with SLM. The surface finish of parts built with SLM is generally better than other additive manufacturing processes [3].

Titanium (Ti-6Al-4V) and Inconel 718 alloys both find applications with the aerospace industry. The cost of these materials is high, and conventional machining of parts can have high rates of scrap