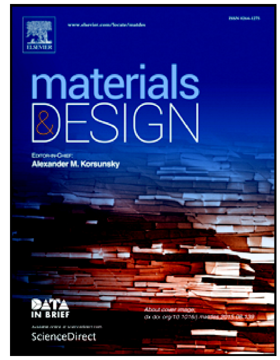

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3D Laser Shock Peening – a new method for the 3D control of residual stresses in Selective Laser Melting

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Abstract

This paper describes a hybrid additive manufacturing process – 3D Laser Shock Peening (3D LSP), based on the integration of Laser Shock Peening (LSP) with Selective Laser Melting (SLM). The well-known tensile residual stresses (TRS) in the as – built (AB) state of SLM parts in the subsurface region have a detrimental effect on their fatigue life. LSP is a relatively expensive surface post treatment method, known to generate deep CRS into the subsurface of the part, and used for high end applications (e.g. aerospace, nuclear) where fatigue life is crucial. The novel proposed 3D LSP process takes advantage of the possibility to repeatedly interrupt the part manufacturing, with cycles of a few SLM layers. This approach leads to higher and deeper CRS in the subsurface of the produced part, with expected improved fatigue properties. In this paper, 316L stainless steel samples were 3D LSP processed using a decoupled approach, i.e. by moving back and forth the baseplate from an SLM machine to an LSP station. A clear and significant increase in the magnitude and depth of CRS was observed, for all investigated process parameters, when compared to the AB SLM parts, or those traditionally LSP (surface) treated.

Keywords: 3D Laser shock peening; Selective laser melting; Laser shock peening; Residual stress profile; Fatigue life; 316L stainless steel

1. Introduction

Selective laser melting (SLM) is a part of a large family of Additive Manufacturing (also known as 3D printing) processes [1]–[3], and also the most studied over the past years. In the SLM process the part is built layer by layer out of a metallic, ceramic, polymer or composite powder. At each step, a powder bed is deposited on a substrate and selectively melted by a laser beam. Using a laser beam deflection system, each layer is scanned according to the corresponding part cross section, as calculated from the CAD (computer-aided design) model. After selective consolidation, a new powder layer is deposited, and the operation sequence is repeated until completion of the part. At the end, the unused powder is removed and can be reused in another building process. This manufacturing method leads to the ability to produce parts with high added value and very complex geometries, which would otherwise be difficult or impossible to produce. Typical examples concern lattice structures used for aerospace and medical applications, bionic design for weight reduction, conformal cooling channels in molds, etc.
Although the mechanical properties of parts made by SLM have become close to those produced by conventional processes [3]–[13], SLM still has several inherent limitations, one of them being the