Influence of Recycling and Process Parameters on Powder Characteristics of Direct Energy Deposition Ti-6Al-4V

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ABSTRACT

This study investigated the effects of powder characteristics and process parameters on the final properties of Ti-6Al-4V fabricated via laser engineered net shaping (LENS®). Recycling powder is a simple method to reduce waste and cost of the LENS process; however, the effects of repeated handling and laser exposure are not well documented in literature. Ti-6Al-4V powders with different size distributions and levels of were used to determine the effect of recycling on powder properties. Powder conditions were characterized by evaluating size distribution, flowability, surface morphology, chemical composition, phase, porosity content, and oxygen content. The results indicated changes in the powder characteristics need to be considered when recycling. Ongoing work is investigating the effect of these changes on final part quality.

INTRODUCTION

Laser additive manufacturing allows for complex geometries to be optimized and built from a bottom-up approach. This allows additional material and structures to be deposited inside a part. Laser engineered net-shaping (LENS®) is a common Direct Energy Deposition (DED) process in additive manufacturing developed by Sandia National Laboratories in 1997 [1]. This type of system generally has a large build space, allowing for monitoring systems to be retrofitted at different positions. The LENS® system used in this study is an Optomec LENS® 750 fitted with both a pyrometer in-line with the laser and an infrared camera to monitor and collect thermal history of each build at the platform [2].

Making additive manufacturing more beneficial to part life [3, 4] reducing emissions [5,6], and improving the environmental efficiency has been shown to be largely dependent on the recycling of materials from the process [7]. Literature has reported as little as 5% powder usage efficiency for blown powder AM systems [8], meaning there can be a significant quantity of powder remaining in the chamber. Ma, et al. (2017) proposed an analytical life-cycle assessment model for the manufacturing of feedstock powder in order to address the role of the powder and the actual material utilization factor on the environmental impact of laser metal deposition [9]. In Ma's assessment, subsequent reuse and recycling of unfused feedstock powders is proposed [9]. Carroll, et al. performed a study with a Waspaloy powder recycled 10 times and concluded that the initial results gave no indication that reuse and recycling is not viable, or that reuse leads to part contamination, reduced process efficiency, or major changes in microstructure [8].