Effect of powder reuse on static mechanical properties of stainless steels produced through selective laser melting

Fernando Alamos, Jessica Schiltz, Kirsten Kozlovsky, & Steven Schmid

Dept. of Aerospace & Mechanical Engineering, University of Notre Dame, Notre Dame, IN 46556, USA

Ross Attardo, Pierre Ostiguy, & Joseph Budzinski

DePuy Synthes, Johnson & Johnson Co.
Raynham, MA, 02767, 46582, USA
Warsaw, IN 46582, USA

Bernice Aboud Gatrell & Charles Tomonto

3DPrinting Center of Excellence, Johnson & Johnson Co.,
Warsaw, IN 46582, USA
Coral Gables, FL, 33124, USA

Jim McGuffin-Cawley

Dept. of Mechanical Engineering, Case Western Reserve University, Cleveland, OH, 44106, USA

Tom Pelletiers

SCM Metal Products Inc., Research Triangle Park, North Carolina, 27709, USA

ABSTRACT

The major cost drivers in powder additive manufacturing include the high prices for consumables and poor material utilization. These associated expenses can be addressed with powder reuse, a practice that returns unfused material to the supply cylinder for use in subsequent builds, but since reuse has been shown to influence powder quality, reused ferritic alloy powder in selective laser melting (SLM) was investigated. 316L and 17-4PH stainless steel were cycled with a thermal dose and atmosphere representative of commercial machines a total of eight times. Powder properties were found consistent across reuse and mechanical behavior of sintered steel was evaluated using a design of experiments (DOE) approach. Analysis revealed that recycled 316L demonstrated consistent performance, while 17-4PH strength and ductility nominally decreased after one initial reuse before stabilizing. The DOE combinations found to maximize and optimize the mechanical response of reused feedstocks are reported and compared. The results demonstrate that a wide envelope of energy densities was critical to mapping parameters that mitigate reuse-dependent behavior. This strategy can be adapted to facilitate an understanding of how reuse effects the mechanical response of the library of SLM materials.

Keywords: powder reuse, powder recycling, additive manufacturing, selective laser melting, design of experiments, mechanical behavior, stainless steel

INTRODUCTION

Though additive manufacturing (AM) is being rapidly integrated into engineering practice, material cost persists as a significant obstacle. Previously, the price of raw material for AM has not been particularly important because of the overbearing tooling and labor costs associated with conventional methods, especially for prototyping or short production runs. Indeed, the reduced expense of custom or one-off components has been the main advantage of AM [1]. However, for laser powder-bed fusion, a subset of AM encompassing selective laser melting (SLM), a large feedstock volume is required to sufficiently supply commercial-sized build envelopes (0.055 m^3 – 0.154 m^3) [2]. Since only a fraction of the build