QUALIFYING MANUFACTURING VARIABILITY USING ANALYTICAL COMPUTED TOMOGRAPHY OF DIRECT METAL LASER SINTERED TEST STRUCTURES

David B. Saint John1, Griffin T. Jones2, Edward W. Reutzel2, Andrew H. Coward3, Sanjay B. Joshi1, Karen A. Thole3, and Timothy W. Simpson1

1Department of Industrial Engineering
2Applied Research Laboratory
3Department of Mechanical and Nuclear Engineering
Penn State University
University Park, Pa, USA

ABSTRACT

Additive manufacturing (AM) of metal parts using direct metal laser sintering (DMLS) or selective laser melting (SLM) processes remains an enticing prospect for a variety of industries, but as with many other AM processes, concerns about the reliability, reproducibility, and dimensional accuracy of the process linger [1, 2]. It is widely suspected that the choice of part orientation, support structures (placement, shape, and number), and fine tuning of machine parameters applied during a build are critical to the quality of the final result. Because of these opportunities for user-defined build variations, the decisions of the tool user(s) are not trivial, and may even be implicated in some build failures. While an experienced user or OEM using tuned tool parameters may produce ideal builds, little is known about the range of variability encountered among different shops using such processes independently. This is particularly true for ‘one-off’ parts which may not have the time or funding to permit extensive testing to achieve the best final product possible. Because of this variability, there appears to be a degree of art required for successful use of the DMLS process, and the implied learning curve should be accounted for when considering adoption. This study seeks to illustrate the variability encountered among lead users, by asking several of them to perform the same build and comparing their results.

A test block (Figure 1) was designed to evaluate the fidelity of a typical product produced by job shops using EOS DMLS systems, who were then asked to build the test part from the same supplied CAD model with no dimensional requirements given (no pass/fail), to simulate the typical interaction with an AM job shop, where a final part is returned to the user.

FIGURE 1. The test block CAD Model (ideal).

FIGURE 2. Surface comparison of a DMLS test block, with residual support structure remaining. Deviations beyond >+0.1mm from the expected surface are in pink, deviations >-0.1mm are in purple.
Three job shops with AM capabilities were selected from a list obtained from EOS based on the number of DMLS systems in shop, in an effort to select from an experienced set of users. All parts were made from GP1 (EOS 17-4 SS) using orientations and supports chosen by the tool users. Significant defects were observed visually in each printed part, including rough surfaces and distorted or misshapen regions, though the character and location of these defects varies from sample to sample. To further quantify variability these parts were scanned using a GE v|tome|x computed tomography (CT) system, for analysis of part fidelity [3]. This work attempts to quantify the dimensional variability observed while giving possible explanations for both the particular defects of each test block and the defects which are shared among the set, as well as recommendations regarding design methods for optimizing build supports to maximize final part fidelity.

REFERENCES