JANNAF Conference Abstract

Liquid Propulsion Systems (LPS) Session

Characterization of Machine Variability and Progressive Heat Treatment in Selective Laser Melting of Inconel 718

The absence of an economy of scale in spaceflight hardware makes additive manufacturing an immensely attractive option for propulsion components. As additive manufacturing techniques are increasingly adopted by government and industry to produce propulsion hardware in human-rated systems, significant development efforts are needed to establish these methods as reliable alternatives to conventional subtractive manufacturing. One of the critical challenges facing powder bed fusion techniques in this application is variability between machines used to perform builds. Even with implementation of robust process controls, it is possible for two machines operating at identical parameters with equivalent base materials to produce specimens with slightly different material properties. The machine variability study presented here evaluates 60 specimens of identical geometry built using the same parameters. 30 samples were produced on machine 1 (M1) and the other 30 samples were built on machine 2 (M2). Each of the 30-sample sets were further subdivided into three subsets (with 10 specimens in each subset) to assess the effect of progressive heat treatment on machine variability. The three categories for post-processing were: stress relief, stress relief followed by hot isostatic press (HIP), and stress relief followed by HIP followed by heat treatment per AMS 5664. Each specimen (a round, smooth tensile) was mechanically tested per ASTM E8. Two formal statistical techniques, hypothesis testing for equivalency of means and one-way analysis of variance (ANOVA), were applied to characterize the impact of machine variability and heat treatment on six material properties: tensile stress, yield stress, modulus of elasticity, fracture elongation, and reduction of area. This work represents the type of development effort that is critical as NASA, academia, and the industrial base work collaboratively to establish a path to certification for additively manufactured parts. For future flight programs, NASA and its commercial partners will procure parts from vendors who will use a diverse range of machines to produce parts and, as such, it is essential that the AM community develop a sound understanding of the degree to which machine variability impacts material properties.