Contribution ID: **246** Type: **Contributed Oral**

M3Or2F-03: Ultimate Tensile Strengths and Elastic Moduli of Additively Manufactured PA840-GSL, A6061-RAM2, and AlSi10Mg at 20K

Wednesday 12 July 2023 11:40 (15 minutes)

The additive manufacturing (AM) of polymer matrix composites (PMCs) presents a unique option for reducing the mass of aerospace vehicles and thereby the cost required for launch. Also, there are many AM metal matrix composite (MMC) systems that can increase part efficiency and performance. These solutions have the potential to reduce the cost of terrestrial applications where cryogenic temperatures are present. Thus, this paper explores the mechanical characterization of these materials at 20K and the effect material deviations have on part mass and performance. To assert accurate data obtainment in all material characterization, the mechanical load frame utilized for mechanical data acquisition, the Cryogenic Accelerated Fatigue Tester (CRAFT), is first detailed herein. Next, a mechanical characterization of the additively manufactured AlSi10Mg alloy and an MMC alternative are obtained. Third, the mechanical performance of an additively manufactured PMC liquid hydrogen tank constituent is collected in addition to an analysis on the effect the processing parameters have on the mechanical behavior. These developments permitted the recommendation for alternative material and processing parameter selections that have the potential to reduce launch vehicle dry mass and improve application performance. Beyond the observed improvements detailed within this paper, the data acquired encourages further cryogenic design optimization through modifications made to material selection and development.

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Session Classification: M3Or2F: Additive Manufacturing