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CHARACTERIZATION OF RESIDUAL INCONEL PARTICLES IN ADDITIVELY MANUFACTURED ROCKET ENGINES

Abstract

Additive manufacturing (AM) has achieved prominence in the Aerospace industry as the technology has matured. The use of Direct Metal Laser Sintering (DMLS) has enabled the industry to create more complex and efficient injectors. During the DMLS AM process there is often residual powder left within small features, specifically within printed regenerative cooling channels. Residual powder poses risks to engine performance in the form of blockages, combustion instabilities, and inhibiting steady flow through the engine. These unknowns in a rising technology motivated the USC Liquid Propulsion Lab (LPL) to seek collaboration with The Aerospace Corporation to characterize the residual particulate within an Inconel 718 DMLS rocket engine. The primary objectives of this investigation are to identify the residual particulate leftover during the printing process. A secondary objective is to identify a cleaning procedure to effectively remove the Inconel particulates from the system. These two motivations are currently not well characterized and will serve as invaluable insight into post-printing processes for additively manufactured rocket engines.

The test starts with flowing gaseous nitrogen using Hydra, LPL's High Pressure Feed System, through a 1/5th section of the engine nozzle into a collection container of water. Of the five total nozzle sections, three are used for primary testing of the three different flushing methods (N2, water, ethanol) and two will be contingency sections. The water collected is then flowed through a series of filters with a decreasing mesh size (200 um, 30 um, 10 um and .2 um). The filters are then imaged using a visible light microscope with a maximum magnification of 2000x as well as the FEI Nova NanoSEM 450 Electron Microscope and its Energy Dispersive X-Ray Analyzer (EDX) function from the USC's Core Center of Excellence in Nano Imagine lab.

The research is broken into two parts, a nozzle-side and full engine. The nozzle-side serves as pathfinder investigation before proceeding to full engine testing. Once a sufficient cleaning method has been established, the nozzle will be attached to the uncleaned chamber and a full flow of the most effective cleaning method will occur. This final cleaning fluid will be collected and filtered using the previous methodology. After imaging for composition and particulate density a final conclusion will be drawn about the ideal processes for cleaning additively manufactured rocket engines.