HOT-FIRE TESTING RESULTS OF ADDITIVELY MANUFACTURED NASA HR-1 TOWARDS LARGE SCALE IMPLEMENTATION OF CHANNEL WALL NOZZLES

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ABSTRACT

Additive manufacturing (AM) has provided new design and manufacturing opportunities to reduce cost and schedules, consolidate parts, and optimize performance. One technique being evaluated is Laser Powder Directed Energy Deposition (LP-DED), which provides a significant increase in scale compared to Laser Powder Bed Fusion (L-PBF). NASA along with industry partners have been developing the LP-DED process to demonstrate internal channel geometry and development components for use in liquid rocket engine channel cooled nozzles. One material that has been the focus of this development is NASA HR-1, an Iron-Nickel based superalloy optimized for use in high pressure hydrogen environments. Material properties and process characterization has been completed on the high density thin-wall material in addition to advancements of the supply chain. NASA has also completed fabrication of several subscale and full scale channel wall nozzles in LP-DED NASA HR-1 and completed hot-fire testing. This includes refinement of the process to produce thin-walls and various channel geometries to meet the requirements for channel wall nozzle applications. This paper will provide an overview of the LP-DED process development, material characterization and properties, component manufacturing, and hot-fire testing. Hot-fire testing was completed for a lander-class 7K-lbf thrust chamber using Liquid Oxygen (LOX)/Methane. The design overview and results from hot-fire testing will be presented in addition to hardware development for future testing on 2K-lbf and 35k-lbf thrust chambers and large-scale manufacturing technology demonstrators.