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CHANNEL WALL NOZZLE MANUFACTURING TECHNOLOGY ADVANCEMENTS FOR LIQUID ROCKET ENGINES

Abstract

A regeneratively-cooled nozzle is a critical component for expansion of the hot gases to enable high temperature and performance liquid rocket engines systems. Channel wall nozzles are a design solution used across the propulsion industry as a simplified method to fabricate the nozzle structure with internal coolant passages. The scale and complexity of the channel wall nozzle (CWN) design is challenging to fabricate leading to extended lead times and higher costs. Some of these challenges include: 1) unique and high temperature materials, 2) Tight tolerances during manufacturing and assembly to contain high pressure propellants, 3) thin-walled features to maintain adequate wall temperatures, and 4) Unique manufacturing process operations and tooling. The United States (U.S.) National Aeronautics and Space Administration (NASA) along with US specialty manufacturing vendors are maturing modern fabrication techniques to reduce complexity and decrease costs associated with channel wall nozzle manufacturing technology.

Additive Manufacturing (AM) is one of the key technology advancements being evaluated for channel wall nozzles. Much of additive manufacturing for propulsion components has focused on powder bed fusion, but the scale is not yet feasible for application to large scale nozzles. NASA is evolving directed energy deposition (DED) techniques for nozzles including arc-based deposition, blown powder deposition, and Laser Wire Direct Closeout (LWDC). There are different approaches being considered for fabrication of the nozzle and each of these DED processes offer unique process steps for rapid fabrication. The arc-based and blown powder deposition techniques are being used for the forming of the CWN liner. A variety of materials are being demonstrated including Inconel 625, Haynes 230, JBK-75, and NASA HR-1. The blown powder DED process is also being demonstrated for forming an integral channel nozzle in a single operation in similar materials. The LWDC process is a method for closing out the channels within the liner and forming the structural jacket using a localized laser wire deposition technique. Identical materials mentioned above have been used for this process in addition to bimetallic closeout (C-18150–SS347, and C-18150–Inconel 625).

NASA has completed process development, material characterization, and hot-fire testing on a variety of these channel wall nozzle fabrication techniques. This paper will present an overview of the various processes and materials being evaluated and the results from the hot-fire testing. Future development and technology focus areas will also be discussed relative to channel wall nozzle manufacturing.