IAF SPACE PROPULSION SYMPOSIUM (C4)
Propulsion Technology (1) (3)

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PROGRESS IN ADDITIVELY MANUFACTURED COPPER-ALLOY GRCOP-84, GRCOP-42, AND BIMETALLIC COMBUSTION CHAMBERS FOR LIQUID ROCKET ENGINES

Abstract

Additive Manufacturing (AM) is an emerging fabrication technology being demonstrated at the United States (U.S.) National Aeronautics and Space Administration (NASA) along with US industry partners. Regeneratively-cooled combustion chambers are an ideal application of the AM technology due to the complexities of the design and an inability of traditional manufacturing to meet desired geometries. AM is also an excellent candidate to apply the structural jacket instead of using traditional brazing. These AM processes have been shown to significantly reduce the lead time for thrust chamber fabrication and reduce production costs.

High performance liquid rocket engine combustion chambers that operate in a high heat flux environment are fabricated using a copper-alloy liner with a series of integral coolant channels. Copper-alloys provide the necessary conductivity and material strength for adequate design margins without the need for film coolant. Copper-alloys present unique challenges to properly melt the powder in laser-based AM processes due to their high reflectivity and conductivity. Starting in 2014 NASA Marshall Space Flight Center (MSFC) and NASA Glenn Research Center (GRC) have developed a process for additive manufacturing of GRCop (Copper-Chrome-Niobium) alloys using Powder Bed Fusion (PBF). GRCop is high conductivity, high-strength dispersion strengthened copper-alloy for use in high-temperature, high heat flux applications originally developed at GRC.

NASA has completed significant material characterization and testing along with hot-fire testing to demonstrate GRCop-42 and GRCop-84 alloys are suitable for use in combustion chambers. Additional development and testing has been completed on additively manufactured bimetallic chambers using GRCop-84 liners with Inconel 625 jackets fabricated using two Directed Energy Deposition (DED), Electron Beam Freeform Fabrication (EBF) and Blown Powder DED. NASA completed hot-fire testing on various AM chambers using GRCop-84 and bimetallic chambers in Liquid Oxygen (LOX)/Hydrogen, LOX/Methane, and LOX/Kerosene propellants. The team is working towards hot-fire testing of a combustion chamber using GRCop-42 in the Summer of 2019.

This paper will provide an overview of the PBF process for the GRCop-42 and GRCop-84 alloys and the bimetallic DED process. Results from the hot-fire testing will be presented, and the current and future developments of these combustion chamber technologies discussed.