Hybrid Additive Manufacturing Deposition and Selective Laser Melting Techniques Applied to Copper-Alloy Liquid Rocket Engine Combustion Chambers

Kevin Zagorski, Andrew Duggleby, Vishal Doshi
Virgin Orbit
Long Beach, CA

Paul Gradl
NASA Marshall Space Flight Center
Huntsville, AL

Virgin Orbit and the NASA Marshall Space Flight Center have partnered to fabricate a small, multi-metallic, regeneratively cooled thrust chamber by leveraging the strengths of two different types of additive manufacturing: Direct Metal Laser Sintering (DMLS) for the copper alloy liner and blown powder Directed Energy Deposition (DED) for the Inconel structural jacket. The DED is being developed using Virgin Orbit's DMG Mori Seiki hybrid additive/subtractive machining center to further enable unique processing and further cost savings. The materials chosen are preferred for high performance thrust chamber applications, representing a significant advancement from the compromises typically made in the production of metal 3D printed thrust chambers for rocket engines. The 1.2K-lbf thrust article is a 16" tall, 3" diameter design modified for this effort to be regeneratively cooled with water and hot fired using a RP-1/LOX pintle-style development injector from Virgin Orbit's NewtonFour upper stage engine. The thrust chamber was tested at Virgin Orbit's Necker test site in Mojave, California. Results from this test campaign are reported in addition to information characterizing the liner, jacket, and bimetallic diffusion layer materials. This paper will also highlight some of the future bimetallic thrust chamber developments that MSFC and Virgin Orbit will complete under a recently awarded NASA contract.

Abstract for 65th JANNAF Propulsion Meeting (JPM) / 10th Liquid Propulsion Subcommittee
May 21 – 24, 2018 Long Beach, CA