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MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Advancements in Materials Applications and Rapid Prototyping (9)

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SELECTIVE LASER MELTING FOR PRODUCTION OF A NOVEL HIGH TEMPERATURE ELECTROTHERMAL PROPULSION SYSTEM

Abstract

Electrothermal propulsion systems for spacecraft consist of an electrical heat exchanger that increases the enthalpy of a propellant, which is ultimately accelerated through a nozzle to produce thrust. The performance of this thruster, also known as resistojet, increases proportionally to the square root of the gas temperature. Increasing the propellant temperature of the thruster also decreases the amount of propellant required on board of the spacecraft to accomplish a specific mission.

Surrey Satellite Technology Limited (SSTL) has used a low power hot gas system since 2002, which uses either Butane or Xenon as propellant. This system has flown on 20 spacecraft including the European GPS Galileo Testbed GIOVE-A validation satellite. This low cost and relatively low temperature resistojet significantly improves the performance of traditional cold gas propulsion systems. Today, the main driver of the resistojet technology is the all-electric propulsion bus. Geostationary telecommunication satellites typically use chemical propulsion for attitude control as well as orbit–raising and station keeping. The benefit of using high performance resistojets is in propellant mass saving, cost savings in launch vehicle option for lighter spacecraft and further reduction of costs by eliminating the use of hazardous propellants.

A collaborative development programme between the University of Southampton and SSTL is currently proceeding to develop a Very High Temperature Resistojet (VHTR), which nearly doubles the current SSTL thruster performance, for all-electric spacecraft applications. This research programme includes design, electrothermal simulations, manufacturing, performance testing and ultimately the validation of a development model thruster. Selective Laser Melting (SLM) has been selected for the reason that enables to build a complex thin-wall Heat Exchanger (HE) as a single element. However, due to the novelty of the design and SLM manufacturing limits, a comprehensive and focused materials and manufacturing verification process study is necessary.

The paper presents the materials selection, design, manufacturing, analysis and preliminary testing of additively manufactured metal components suitable for the VHTR. The hardware list extends to different HE configurations with integrated nozzle and to other secondary components, which form the VHTR assembly. High resolution micro Computed Tomography (CT) is used as a tool for non-destructive inspection, since the complex geometry of the thruster is so small that visual inspection is not possible. The CT volume data are used to determine a surface mesh to perform coordinate measurement, nominal/actual comparison and wall thickness analysis. Test case components are tested in relevant laboratory environment for validation.