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THE EFFECT OF SWIRL INJECTION PARAMETERS ON A VORTEX-COOLED THRUSTER FABRICATED USING THERMOPLASTICS AND METAL

Abstract

This paper reports on a vortex-cooled thruster experimentally investigated for its cooling performance with respect to the swirl effect. Compared to the conventional cooling systems for rocket propulsion, such as regenerative cooling, film cooling, ablative cooling, and radiative cooling, which potentially have higher system complexity with added system components for cooling of the combustion chamber and nozzle structures, vortex cooling can be employed by rather simply changing the injection direction of propellant, making a swirl flow of propellant following the inner surface of the chamber before combustion reaction and protecting the surface from the high temperature flame with almost no complications in terms of a manufacturing process as well as an operating procedure. The current study focuses on interpreting fluid motion and its characteristics in this type of propellant injection, determining the optimised oxidant swirl injection parameters for the highest cooling efficiency and thrust. For an experimental based study, a 10N class Propane/GOx bi-propellent vortex-cooled thruster was designed and tested with different types of fabrication materials such as thermoplastic and metal. The study investigates the injection-related parameters and their impacts on the safe range of engine temperature and the effect on the optimum specific impulse with operation parameters mainly including O/F ratio, injection position, and combination of fuel injection types and the oxidizer swirl injector. Based on the experimental test results, it has been found that the vortex-cooled thruster can operate with a chamber wall temperature and nozzle as low as approximately one hundred Celsius maintaining the combustion reaction at the core region of the combustion chamber and the nozzle. Further experimental tests will be analysed to evaluate whether this cooling technique can protect the fabricated thermoplastic engine from high combustion temperature by selecting the appropriate combination of fuel injection and emphasizing the basis of designing an ideal vortex thruster.