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CONCEPTUAL DESIGN AND FABRICATION OF 400 N-CLASS MULTI-HOLE PINTLE GCH4/LOX INJECTOR

Abstract

The development of rocket propulsion systems using gaseous methane and liquid oxygen as propellants is of great interest for various aerospace applications, due to their high performance, low cost, and environmental benefits. However, the design and fabrication of such systems pose significant challenges, especially in terms of achieving efficient and stable combustion. One of the key components that affects the combustion performance is the injector, which delivers and mixes the propellants in the combustion chamber. Among various types of injectors, the pintle injector has been proven to be an effective and robust solution, as it can provide good mixing, high thrust-to-weight ratio, and wide throttling range. The pintle injector consists of a central pintle surrounded by an annular orifice, creating a radial jet of one propellant and an axial jet of the other. The geometry and configuration of the pintle injector can be adjusted to optimize the mixing and combustion characteristics for different operating conditions and propellant combinations. In this paper, we present the conceptual design and fabrication of a 400 N-class multi-hole pintle injector for a methane-oxygen rocket engine. The design methodology is based on empirical correlations, and analytical models, taking into account the thermodynamic, fluid dynamic, and structural aspects of the injector. The design parameters include the number, size, and arrangement of the orifices, the recess length of the pintle tip, the injection angle, and the injection pressure. The fabrication process involves various machining techniques, such as wiring, drilling, and tapping, as well as quality inspections, such as dimensional measurement, surface roughness measurement, and leak test. This work contributes to the ongoing research and development of efficient and reliable propulsion systems using methane and oxygen as propellants. The pintle injector designed and fabricated in this study has potential applications in various aerospace contexts, such as reusable launch vehicles, upper stage engines, and lunar landers. Future work will focus on optimizing the pintle injector design for specific mission requirements and validating its performance through cold-flow and combustion tests