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Title

Spray Behavior of Bi-swirl Injector in a LOx/LNG Small Rocket Engine

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Abstract

The injector, which is one of the key components of a combustion system, is a crucial factor in achieving the high levels of reliability, performance, and efficiency required for liquid rocket engines (LRE's) in space launch vehicles (SLV's) [1]. In particular, fine atomization, uniform mass distribution, and appropriate propellant mixing are necessary to minimize the ignition delay of propellant and increase combustion stability and efficiency. Bi-swirl injectors accelerate the atomization of propellant by spraying it into the combustion chamber with a thin film of conical shape and induce a more uniform propellant distribution in the chamber than shear-coaxial injectors. They also increase the flow residence time of the propellant in the chamber, which improves combustion completeness. For these reasons, bi-swirl injectors composed of inner and outer injectors are widely used in LRE's [2,3].

Swirl injectors are divided into two types based on the diameter of the swirl chamber: open-type and closed-type. For open-type injectors, the diameter of the injector orifice is the same as the one of the swirl chamber. In contrast, for closed-type injectors, the diameter of the swirl chamber is larger than that of the injector orifice, which creates a stronger swirl leading to a positive effect on propellant atomization. Accordingly, a bi-swirl injector with a closed-type design for both inner and outer components was adopted for a small rocket engine (SRE).

In this study, cold-flow tests are conducted to investigate the spray behavior of bi-swirl injectors to be used in a LOx/LNG (a substitute for LCH_4) SRE. In order to visualize the flow field inside the outer injector and observe the effect of the inner injector's post on the flow field, the injector with identical dimensions was fabricated using acrylic prior to processing the actual parts. The spray behavior is scrutinized using various apparatus, such as a high-speed camera (HC) and laser visualization system. Furthermore, the spray characteristics are supposed to be analyzed by combining the results with those from cold-flow tests conducted on injectors intended for use in SRE.

References

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