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EXPERIMENTAL AND ANALYTICAL CHARACTERIZATION OF SHEAR COAXIAL GO2/GCH4 INJECTOR COMBUSTION FLOWFIELD

Abstract

Oxygen-methane is viewed as one of the most promising propellant combinations for reusable rocket engines. Compared to kerosene, methane can provide higher specific impulse, better cooling ability, non-soot deposition and lower pressure loss in the cooling channel. It is also characterized with lower cost, better reliability, simpler ground operation and higher density specific impulse compared to hydrogen. The characteristics of combustion flowfield in high pressure GO2/GCH4 injector combustors are studied in this study. Optical diagnostics technology was utilized to capture the real-time instantaneous flame temperature distributions and the flame structures.

A total of thirteen single-element shear-coaxial injectors were designed and fabricated with different design parameters. The combustion flow fields of these injectors were examined in a windowed combustion chamber with two quartz windows allowing for optical access. The flame lengths of these injectors were obtained by examining the near-field temperature distributions with the infrared camera. The flame holding and development mechanisms were also captured by high speed photograph. The mixing of the propellants, the flame structure and instability were analyzed. And one injector was hot-tested in different pressures to investigate the influence of the chamber pressure. Additionally, the axial temperatures along the chamber wall and the temperature on injector faceplate were measured with thermocouples in all the tests. The effect of the injector design parameters on the combustor heat flux distribution was analyzed. Furthermore, the relationship between the chamber wall temperature distribution and the inner flame structure was analyzed, which can give insight into the heat transfer of Liquid Rocket Engines (LRPs).

The results show that the near-field flame is influenced significantly by the injector design parameters. The highly turbulent and unsteady natures of the gaseous oxygen/gaseous methane combustion flowfield were observed. The formation of shear layer instabilities in the region near the O2 post during the hot-fire tests was analyzed. The turbulence fluctuation and shear layer instability of the combustion flow increases as the methane-to-oxygen velocity ratio increases. The flame structures and the wall temperature distributions at different chamber pressures were similar when the chamber pressure just was changed through changing injection flowrate.