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OFF-DESIGN HYPERGOLIC COMBUSTION OF THE HIGH TEST PEROXIDE-BASED PROPELLANT

Abstract

The low-toxic or green bi-propellant configurations are growing in popularity for in-space propulsion. Among the alternatives for hydrazine derivatives and nitrogen tetroxide, high test peroxide-based propellant has been noted as one of the promising candidates. Nonetheless, for the high test peroxide-based propellant, the comprehensive investigation of the hypergolic impinging jets and their possible instability has not been carried out. Herein, this study addressed the hypergolic combustion phenomena of the low-toxic bipropellant at the off-design point, referred to as either fuel or oxidizer-rich condition. The pentad type impinging injector was designed based on the propellant combination of 95 wt. % high test peroxide and amine-based fuel. Either manipulation on the flow rate control of oxidizer or fuel directly resulted in the jet momentum variation as the dimension of the pentad injector orifices of the four oxidizer jets and one fuel jet was fixed. Therefore, each jet momentum of the propellant was intentionally regulated to off-design conditions using flow rate control devices. The injector was mounted on the optical access chamber with a nozzleless configuration. The combustion phenomena for the off-design conditions were qualitatively examined using reacting flow visualization, suppressing intense flame luminosity. The off-design combustion of the pentad injector has revealed distinct reacting flow regimes, leading to severely inefficient mixing and combustion. The fuel-rich condition or fuel momentum dominance indicated a kind of reactive stream separation that the rapid gasification and strong jet momentum of the fuel prohibited the efficient infiltration of the oxidizer jets into the fuel core. Meanwhile, for the oxidizer-rich condition or oxidizer momentum dominance, lack of fuel content led to highly incomplete combustion that a major fraction of the propellant jets was not consumed, thereby emanating from the chamber. The fuel-to-oxidizer momentum can significantly affect the hypergolic reacting flow, and the operation at the off-design of either fuel or oxidizer-rich condition induces severe combustion inefficiency.