Paper ID: 68706
student

IAF SPACE PROPULSION SYMPOSIUM (C4)
Interactive Presentations - IAF SPACE PROPULSION SYMPOSIUM (IP)

Author: Mr. Kyu-Seop Kim
Korea Advanced Institute of Science and Technology (KAIST), Korea, Republic of, kswind@kaist.ac.kr

Mr. Sangwoo Jung
Korea Advanced Institute of Science and Technology (KAIST), Korea, Republic of, jsw747@kaist.ac.kr
Prof. Sejin Kwon
Korea Advanced Institute of Science and Technology (KAIST), Korea, Republic of, trumpet@kaist.ac.kr

WAVE STEEPENING INSTABILITY CAUSED BY HYPERGOLIC DETONATION OF HIGH TEST PEROXIDE-BASED HYPERGOL

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, the comprehensive investigation of the hypergolic instability possibly triggered during thruster operation has not been carried out for the high test peroxide-based propellant. Herein, this study addressed the hypergolic combustion instability noted as a nonlinear wave steepening effect. The conventional design of the bi-propellant thruster was carried out based on the propellant combination of 95 wt.% high test peroxide and amine-based fuel. A pentad injector, composed of four outer-oxidizer jets and a core fuel jet, was used to generate reactive mixing spray. The propellant flow rate and oxidizer-to-fuel ratio were manipulated to inject mass flow corresponding to 350 N scale thruster and produce maximum specific impulse, respectively. Interestingly, hypergolic combustion under conventional constant pressure was not exhibited, and the chamber pressure longitudinally fluctuated, shaping a classical "N" shape with approximately 100 Hz accompanying pulse-like surge. The periodic pulse-like fluctuation was based on the shock-involving wave steepening effect, in which the energy cascades from the fundamental frequency to its harmonics. The cause of periodic wave steepening is suspected as the interaction between the finite-amplitude pressure perturbation (incident and reflection wave within the chamber) and the hypergolic reacting flow. This interaction triggers the hypergolic detonation phenomena. The fundamental oscillation frequency is presumed to be highly related to the hydrodynamic interaction of the injector and detonation. We believe that this study enhances understanding of the hypergolic combustion characteristics and hypergolically-driven wave steepening effect. Furthermore, this study may demonstrate the concept feasibility of detonative-propulsion using high test peroxide-based liquid propellant in the sense that pulse-like surge is characterized by pressure-gain operation.