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SPACE PROPULSION SYMPOSIUM (C4)
Propulsion Technology (3)

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EVALUATION AND CHARACTERIZATION OF LASER IGNITION CONDITIONS FOR GOX/GH2 PROPELLANTS

Abstract

Laser ignition characteristics of gaseous oxygen (GOX) / gaseous hydrogen (GH2) propellants were investigated for an application to the Reaction Control System (RCS). Efforts were focused on laser ablation ignition, which is achieved by using a pulsed laser beam to irradiate a solid target surface inside the combustion chamber. In this study, influence of laser power density, laser pulse width and repetition rate on the ignition characteristic was investigated by experiments. In the experiment, a fiber laser (SPI Lasers Ltd., G3.0 pulsed fiber laser) was used. The laser wavelength was 1065 nm. The laser pulse width (full width at half peak power) of the fiber laser was adjustable, i.e., 10, 19, 22 and 192 nsec. The frequency of the laser pulse was simultaneously varied with the pulse width, i.e., 500, 250, 125 and 25 kHz. The laser beam was transmitted to the focusing lens with a focal length of 75 mm and was focused on the target surface through a laser window of the combustion chamber using a quartz lens. The diameter of transmitted laser beam of the fiber laser was 3.1 mm and the spot diameter was about 33 μm. The inner diameter of the combustion chamber and the nozzle throat were 10 mm and 3 mm, respectively. An unlike-impinging-doublets-type injector was used. The ignition tests were conducted under atmospheric conditions. The ignition test conditions, such as combustion pressure, Pc, and mixture ratio, O/F, were Pc = 1.1 MPa and O/F =3, respectively. The ignition test results showed that the minimum ignition laser energy decreased as the pulse width was shortened, but that the power density increased. It is considered that irradiation by the laser beam having a short pulse width and a large power density effectively heats up the target surface with a small amount of laser energy. On the other hand, laser ablation process was analyzed by using the integrated simulation code REILA (Rocket Engine Ignition by Laser Ablation) developed in this study. This code can take into account of the all laser ablation process: irradiation of laser beam, absorption of laser energy in a target, changes of phase of a target material, fluid dynamics of ablated material, and heat transfer to a premixed gas. The tendency of the calculated results showed good agreement with the test results. Based on these results, optimal laser ablation conditions were investigated to realize a small and lightweight RCS ignition system.