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SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Future Space Transportation Systems Verification and In-Flight Experimentation (6)

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FLIGHT DEMONSTRATION OF A PULSE DETONATION ROCKET SYSTEM TODOROKI II

Abstract

A detonation wave is a hypersonic combustion wave that is sustained by the interaction between the leading shock wave and a heat of reaction. A pulse detonation engine (PDE) can obtain nearly constant thrust and perform mechanical work by the generation of a high-frequency detonation wave. The challenge in making practical use of a PDE is to increase the thrust-to-weight ratio. Moreover, the flight validation in six-degree-of-freedom using total system is also important because there are many problems specific to intermittent combustion engine such as the valve motion, the thrust balance of multi-cylinder engine and the vibration due to the intermittent detonation. We constructed a rotary-valved four-cylinder PDR system (Todoroki II) for the flight demonstration. Total length and weight of the vehicle were 1910mm and approximately 32.5 kg with propellant and purge gas, respectively. From the results of the thrust measurement experiment (ground test) using liquid ethylene-nitrous oxide propellant, the average operation frequency of 96 Hz/tube (384 Hz/all tubes), the propellant-based specific impulse of 131 s, the time-averaged thrust of 256 N and the thrust-to-weight ratio of 0.8 were achieved. Moreover, the newly launch-recovery technique was developed for the flight demonstration. The maximum vertical flight distance was 15 m in present study. Last process was recovery of the PDR. Two wires with spring (recovery wire) were attached to the PDR to recover the PDR in the air. After the PDE operation in real flight condition, the two wires were rewound and tension was generated by recovery device. The PDR was held in the air by recovery wires and it descended gradually. The newly-developed launch-recovery system operated perfectly, and we successfully recovered the PDR without damage. The rolling by rotation of the rotary valve and the significant vibration by intermittent detonation was not confirmed and we validated the detonation engine thrust in real flight condition (6-degree-of-freedom condition). In addition, the time-averaged thrust between launch time $t = 1051$ ms and $t = 2000$ ms was estimated at $F = 254$ N, and the experimental propellant-based specific impulse was estimated at 113 s (86% of the ground test).