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EXPERIMENTAL AND NUMERICAL STUDY ON FEASIBILITY OF 5KN THRUST LEVEL HYBRID ROCKET MOTOR USING THE LOW-MELTING-POINT THERMOPLASTIC FUEL

Abstract

A hybrid rocket system possesses several excellent benefits such as high safety, low cost, and green propellant characteristics. However, the conventional hybrid rocket system has a low thrust level because of its low fuel regression rate. Low-melting-point thermoplastic (LT) fuels for hybrid rockets provide a higher fuel regression rate than conventional fuels such as hydroxyl-terminated polybutadiene (HTPB). Additionally, LT fuels have excellent mechanical and adhesive properties. Therefore, LT fuel is expected to be applied to large hybrid rockets. The final goal of our study is to develop a small sounding hybrid rocket using LT fuel that is able to periodically sampling meteoroids small particles from an altitude of 100 km. As the first step, this study plans the development of the small hybrid rocket and launch to an altitude of 30 km in order to small particle sampling from the stratosphere in 2021. In this study, the feasibility of 5kN thrust level hybrid rocket using LT fuel is evaluated by finite element method (FEM) analysis considering viscoelasticity and combustion experiment. It is necessary to consider viscoelasticity in an investigation of the structural feasibility of the LT fuel. The FEM analysis considering viscoelasticity was conducted on eight conditions of 5kN class hybrid rocket LT fuel. Eight conditions were simulated to storage, static firing test, launch environment. In storage conditions for one-month, max deformation amount is under 0.33 mm. At static firing test and 10G flight conditions, the stress was highest. Max stress is 6810^{-3} MPa and strain is 0.11. However, the maximum stress and the maximum strain are as small as 1/10 order to the breaking stress and breaking strain. Failure envelope and FEM analysis results are shown in Fig. 1. From this result, it was shown that the possibility of fuel destruction is low in launch environment of 10G or less. Static firing tests were performed of 5kN class hybrid rocket motor using a nitrous oxide and LT fuel. Burning time is 30 sec or less. A baffle plate was inserted into the combustion chamber to improve characteristic velocity efficiency. Below results were obtained; max thrust is 6,689

N, average thrust is 5,154 N, average chamber pressure is 1.61 MPa, and average fuel regression rate is 2.31 mm/s. No fuel destruction and peeling from the motor case was observed. This study presents the results of FEM analysis and static firing tests, and reports a more detailed discussion.