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REDUCING PLANT DYNAMICS CHANGE FOR THRUST MODULATION IN HYBRID ROCKET COMBUSTION USING PID GAIN SCHEDULING

Abstract

Many studies have reported that hybrid rocket engine (HRE) system can be quite adequate for a variety of propulsion system such as space launcher, space propulsion for landing or ascending. In addition, a recent study has shown that HRE is quite comparable or in some way shows better thrust modulation capability than conventional LRE and airbreathing engine. However, despite the various advantages of HREs, there are very limited research and application cases for using the HRE system as the main propulsion system. The design of the upper loop for controlling the altitude and speed of a spacecraft should consider the delay time in thrust response. But, in the design of the upper level control loop of VTVL (Vertical Take Off Landing), the response delay in engine thrust of LRE was assumed to have a linear characteristic because thrust delay is not significant. Nonetheless, if the response characteristics of engine subsystem are not maintained constant in a situation where the thrust is continuously controlled, the accuracy of the upper control loop, such as altitude/speed, can be greatly affected. Note that a nonlinear characteristic was observed of which the response delay is determined depending on the direction of thrust control in the combustion of the hybrid rocket. From a control point of view, the characteristic that the thrust response delay changes over time or controlling direction is called the change in thrust dynamics plant (PDC). Many studies suggested that supply system volume, actuator, supply pressure, oxidizer gasification and thermal inertia of solid fuels are important factors that determine thrust response delay. In this study, a variety of factors are identified that affect to determine PDC through open loop thrust modulation tests, and particularly found that feed system delay is the most critical factor. In addition, it was confirmed that the use of constant gains in the closed loop tests with PID technique aggravated the PDC, resulting in more deviations from input command. Therefore, the main purpose of this study is to experimentally confirm how much improvement of PDC can be achieved in the thrust control process through gain scheduling where different PID gains are used depending on controlling direction. In the test results, it was observed that PDC is substantially improved by applying gain scheduling. Also, it is expected that a simple linear system assumption can be used in the design of the upper control loop for altitude/speed control without PDC occurrence.