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CONCEPTUAL DESIGN OF A HYBRID SOUNDING ROCKET TO REACH A TARGET ALTITUDE

Abstract

This paper reports the results of the conceptual design of hybrid sounding rocket and its internal and external ballistics to reach the target altitude. Use of the sounding rocket was started since the late of the 1950s and it becomes more and more important not only for mandatory atmospheric inspection requirement of the UN, but also basic science experiment in micro gravity, supersonic combustion test, aerodynamic test and re-entry trajectory test. A system configuration of the solid propellant rocket is simple and has been commonly used as the main engine for sounding rockets but using hybrid rocket engine, better specific impulse and safer system configuration with separated oxidizer and fuel are possible. In addition, hybrid propellant propulsion is desirable for sounding rocket operation in terms of the ability of re-ignition and throttling, which is hard to achieve using the solid propellant rocket. Two types hybrid propellant ignitions are possible, spark ignition and catalyst ignition. Catalyst ignition type needs no additional ignition system like spark ignition type, but the only catalyst. It has advantages in that it has higher ignition reliability, re-ignitability without additional spark system. In this paper, a hybrid sounding rocket was conceptually designed with catalyst ignition system based on the developed small-scale hybrid thruster in previous work. Internal ballistics for the hybrid thruster performance estimation was conducted based on experimental regression rate, discharge coefficient of feeding line, and combustion properties estimated by chemical equilibrium assumption. To estimate the reachable altitude of the designed sounding rocket, external ballistics was also conducted considering six degrees of freedom motion and the trajectory estimation result was compared with other open source results and validated. Two ballistics were integrated to estimate trajectory variation depending on propulsion system configuration and shows not only the effect of each design parameter, such as oxidizer mass, feeding pressure, oxidizer to fuel ratio on the maximum height the rocket can reach but also optimum design condition for the propulsion system to reach the target altitude.