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SPACE PROPULSION SYMPOSIUM (C4)
New Missions Enabled by New Propulsion Technology and Systems (6)

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CONCEPTUAL DESIGN OF SMALL SCALE HYBRID SOUNDING ROCKET AND ATTITUDE CONTROL WITH BANG-BANG METHOD

Abstract

This paper reports the results of conceptual design of sounding rocket with 2,500 N class hydrogen peroxide/polyethylene hybrid propulsion system and attitude control operations using 10 N class hydrogen peroxide monopropellant thruster for bang-bang method. Use of sounding rocket was started since the late of 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. Hybrid propellant propulsion is desirable for sounding rocket operation, in that it has higher specific impulse than solid propellant, and re-ignitable, throttleable. Also, although it has lower specific impulse than bipropellant, it has system simplicity with relatively low cost. 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 only catalyst. It has advantages in that it has higher ignition reliability, re-ignitability without additional spark system. For these reasons, sounding rocket was conceptually designed with catalyst ignition system based on the developed small scale hybrid thruster. Without enough space for attitude control system in small scale rocket, one monopropellant thruster was considered for bang-bang attitude control of spinning sounding rocket. Internal ballistics of scaled up hybrid propulsion system was conducted using regression rate of pre-developed thruster. Flight trajectory estimation code was developed considering six degree of freedom motion to see the effect of attitude control. Sounding rocket design point was iterated to meet the target altitude 15 km carrying payload 10 kg. As a results of design of sounding rocket, the rocket has approximately 80 kg at initial state and propellant mass is 34 kg. With 2,500 N thrust for 30 sec, designed sounding rocket was estimated to go up to 17 km height carrying 10 kg payload with maximum speed about 570 m/s, downrange 12 km, and flight time 140 sec, which was compared with results of other trajectory open code for validation and almost same with OpenRocket and RasAero. By several impulse of 10 N class thruster at the maximum altitude, precession motion occurred and flight direction was changed intentionally not to make the rocket keep direction of ascend at the beginning of descend, which brings more stable flight trajectory of sounding rocket. The results provide that bang-bang attitude control is greatly appropriate for attitude control of small scale spinning sounding rocket.