IAF SPACE EXPLORATION SYMPOSIUM (A3)
Small Bodies Missions and Technologies (Part 2) (4B)

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NUMERICAL MODELLING OF THE INTERNAL BALLISTICS OF A PYRO-DRIVEN LAUNCHER FOR HARPOON-BASED COMET SAMPLE ACQUISITION

Abstract

Comets are invaluable time capsules preserving materials from the origin of the Solar System. Ultimately, a returned sample will permit the necessary elemental, isotopic, organic and mineralogical measurements to be performed for a deeper understanding of the primordial Solar System. Past and current studies on comet sample return missions cover a wide technological range of sample acquisition methods. From these approaches, harpoon-based systems minimize risks regarding near object operations and anchoring which is not necessary here. Furthermore, harpoon-based sampling allows for acquiring multiple samples from different locations on the comet. The considered sample acquisition system consists of a pyro-driven Launcher, a Sample Acquisition and Retrieval Projectile and a retraction system using a deployable composite boom structure. The pyro-driven Launcher provides the required kinetic energy to the projectile and retraction portions. Due to high energy densities, pyrotechnically actuated devices ultimately minimize the overall system mass and dimensions reducing launch costs. Numerical models of the internal ballistics support the development of this pyrotechnical device. By modeling key ballistic parameters such as combustion chamber volume and propellant charge, the overall design process is more efficient and the number of required hardware tests can be reduced drastically. Moreover, a deeper insight into physical processes is gained and trajectories of the piston motion can be predicted for future tests. The models reproduce the following reaction chain: propellant combustion → gas dynamics → piston motion. A special feature of the pyro-driven Launcher is the high-low-pressure system providing optimized piston acceleration and nearly ideal conditions for propellant combustion.