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OPTIMIZED BUCKET WHEEL DESIGN FOR ASTEROID EXCAVATION

Abstract

Spacecraft currently need to launch with all of their required fuel for travel. This limits the system performance, payload capacity, and mission flexibility. One compelling alternative is to perform In-Situ Resource Utilization (ISRU) by extracting fuel from small bodies in local space such as asteroids or small satellites. Compared to the Moon or Mars, the microgravity on an asteroid demands a fraction of the energy for digging and accessing hydrated regolith just below the surface. Previous asteroid excavation efforts have focused on discrete capture events (an extension of sampling technology) or whole-asteroid capture and processing. This paper proposes an optimized bucketwheel wheel design for asteroid or small-body excavation. Asteroid regolith is excavated and water extracted for use as rocket propellant. Our initial study focuses on system design, bucket wheel mechanisms, and capture dynamics applied to ponded materials known to exist on asteroids like Itokawa and Eros and small satellites like Phobos and Deimos. For initial evaluation of material-spacecraft dynamics and mechanics, we assume lunar-like regolith for bulk density, particle size and cohesion. We shall present our estimates for the energy balance of excavation and processing versus fuel gained as well as the potential new flight trajectories introduced by the delta-v. Conventional electrolyzed liquid fuel is compared with steam and both show significant delta-v. Using this approach, we show that a trip from Deimos to Earth is possible for a 50 kg craft using ISRU processed fuel for the return trip.