Paper ID: 89410
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IAF MICROGRAVITY SCIENCES AND PROCESSES SYMPOSIUM (A2)
Science Results from Ground Based Research (4)

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THEORETICAL PERFORMANCE EVALUATION OF REBOUND MITIGATION OF A TARGET MARKER IN A MICROGRAVITY ENVIRONMENT

Abstract

Target Marker (TM) is an artificial landmark that Hayabusa2 used as a navigational aid to perform an autonomous touchdown. An asteroid's microgravity environment causes a rebound on its surface to result in a large jump. This makes it challenging to deploy and settle the TM close to the target site. The TM is composed of hundreds of tiny inner balls and a shell to reduce the rebound motion. The rebound motion is mitigated as the inner balls within collide with one another and dissipate most of the energy stored in TM.

The TM can be deployed and settled in microgravity, as demonstrated by Hayabusa2's TM deployment, however the process underlying the rebound mitigation is not entirely understood. To enhance the rebound mitigation capabilities of new payloads for upcoming small-body missions, it is imperative to comprehend the process of rebound reduction. Toward this goal, this research clarifies the rebound mitigation process by conducting analytical and numerical analysis and suggests an ideal design that takes the radius and quantity of inner balls into account. The TM's rebound is mitigated by energy dissipation caused by the collisions between inner balls. We use a mean free path theory to describe this energy dissipation and reduction of the rebound. The ideal radius and number of inner balls for efficient rebound mitigation are found using a mean free path theory.

Numerical simulations are also conducted. We use a discrete element method to verify the energy dissipation process and optimum design of the TM. Hertzian contact theory is used to represent the collisions of the inner particles, and the TM's rebound motion is simulated. The analysis based on a mean free path is consistent with the numerical simulation results. Lastly, we suggest a design principle to minimize the rebound of a payload on an asteroid.

The study's contribution is that we provide the design guidelines for a payload to deploy on the surface of an asteroid to avoid needless rebound motion. With the help of this study, payload deployment in microgravity circumstances may become more dependable, opening up more alternatives during the proximity phase of a small-body mission.