Mechanical Engineering Thesis Defense

Exploring the Optimal Design of Helical Structures for Space Explorations

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Abstract

As the explorations beyond the Earth's boundaries continue to evolve, researchers and engineers strive to develop versatile technologies capable of adapting to unknown space conditions. For instance, the utilization of Screw-Propelled Vehicles (SPVs) and robotics that utilize helical screws propulsion to transverse planetary bodies is a growing area of interest. An example of such technology is the Extant Exobiology Life Surveyor (EELS), a snake-like robot currently developed by the NASA Jet Propulsion Laboratory (JPL) to explore the surface of Saturn's moon, Enceladus. However, the utilization of such a mechanism requires a deep and thorough understanding of screw mobility in uncertain conditions. The main approach to exploring screw dynamics and optimal design involves the utilization of Discrete Element Method (DEM) simulations to assess interactions and behavior of screws when interacting with granular terrains. In this investigation, the Simplified Johnson-Kendall-Roberts Model (SJKR) model is implemented into the utilized simulation environment to account for cohesion effects similar to what is experienced on celestial bodies like Enceladus. The model is verified and validated through experimental and theoretical testing. Subsequently, the performance characteristics of screws are explored under varying parameters, such as thread depth, number of screw starts, and the material's cohesion level. The study has examined significant relationships between the parameters under investigation and their influence on the screw performance.

November 1, 2023; 10 AM; PSH 230;Zoom Link: https://asu.zoom.us/j/82088618317?pwd=OEZHMFJaT3hvNFJRSU4rU2YvQmd0dz09%20%20%20%20%20Password:%201234