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DIAMETER RATIO EFFECTS ON GRANULAR JAMMING GRIPPER GRASPING FORCE

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Abstract

Granular jamming grippers are a versatile and adaptable alternative for object manipulation in soft robotics, especially due to their ability to conform to objects with different geometries and generate grasping forces through the variable stiffness of granular media when vacuum pressure is applied (Amend et al., 2012; Brown et al., 2010; Shintake et al., 2018). Their operating principle is based on the transition of the granular material from a loose to a jammed state, which allows the gripper to hold fragile, irregular, or complex-shaped objects without requiring complex sensing or active control strategies. Although previous studies have addressed the influence of

granular material, membrane behavior, particle morphology, and actuation conditions on gripper performance, the effect of the geometric relationship between the target body and the gripper remains insufficiently explored. In this work, a spherical target body is modeled to evaluate the influence of the object-to-gripper diameter ratio on the grasping force. Diameter ratios from 90% to 30% are considered to analyze different interaction conditions between the membrane, the granular material, and the target object. A coupled CFD–DEM numerical approach is adopted, where the CFD model represents the vacuum generation and airflow behavior inside the gripper, while the DEM model describes particle rearrangement, contact forces, and granular compaction during the grasping process. The results are expected to show that the diameter ratio significantly affects the contact area, membrane deformation, packing density, and force transmission mechanisms. This study contributes to understanding the role of geometric compatibility in granular jamming grippers and provides useful criteria for improving their design and performance in adaptive robotic manipulation.

Keywords:
Soft Robotics, Granular Jamming, DEM Simulations, Soft Gripper

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