Improving the Time and Efficiency of Soft-Shell Gripper Operation

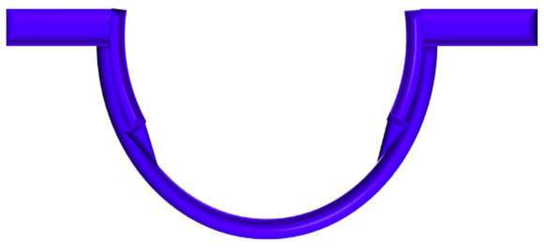
Project Description

TunaBotics is a soft-shell robotics startup dedicated to developing a tunable adhesive gripper designed for grasping and manipulating small, delicate, and curved objects in manufacturing environments. This semester, **our team's main objective is improving the existing gripper design to reduce the actuation time to less than one second and prevents premature buckling**. Achieving this milestone will make the product viable for manufacturing and distribution by the end of the academic year.

Design Options

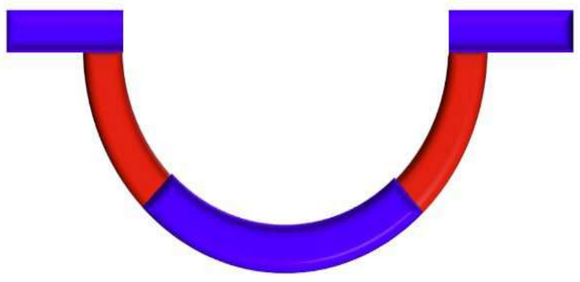
Option 1 – Increased Base Thickness

- **Chosen path for implementation**
- Increasing the base thickness will significantly increase the force required for buckling
- Using a wider base with a thinner contact surface could help reduce the activation time

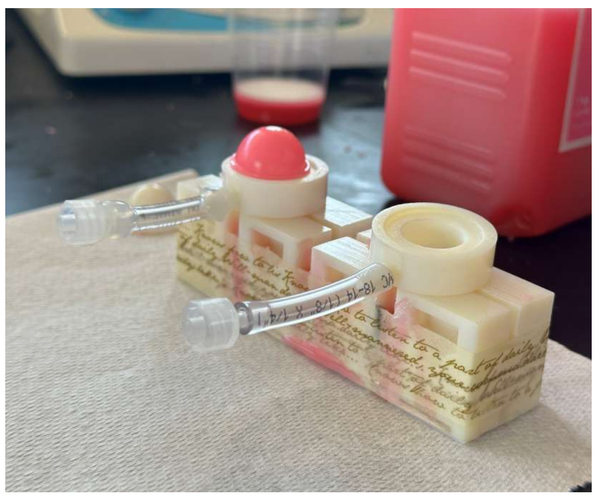


Option 2 – Alternate Material

- Changing the material will change the properties and required forces for buckling.
- Using a stronger material could help reduce the activation time

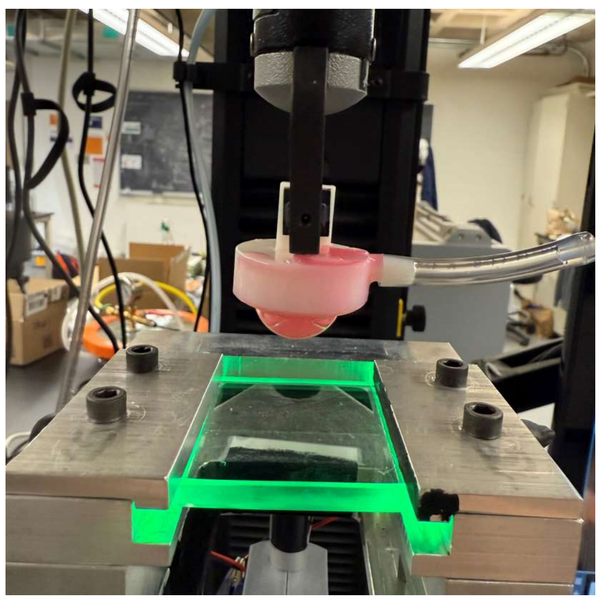


Testing Design and Methods



Fabrication:

- Shape and structure will be determined by 3D-printed mold
- SolidWorks will be used to generate CAD drawings
- Material is a two-part silicone elastomer material (VPS-6)



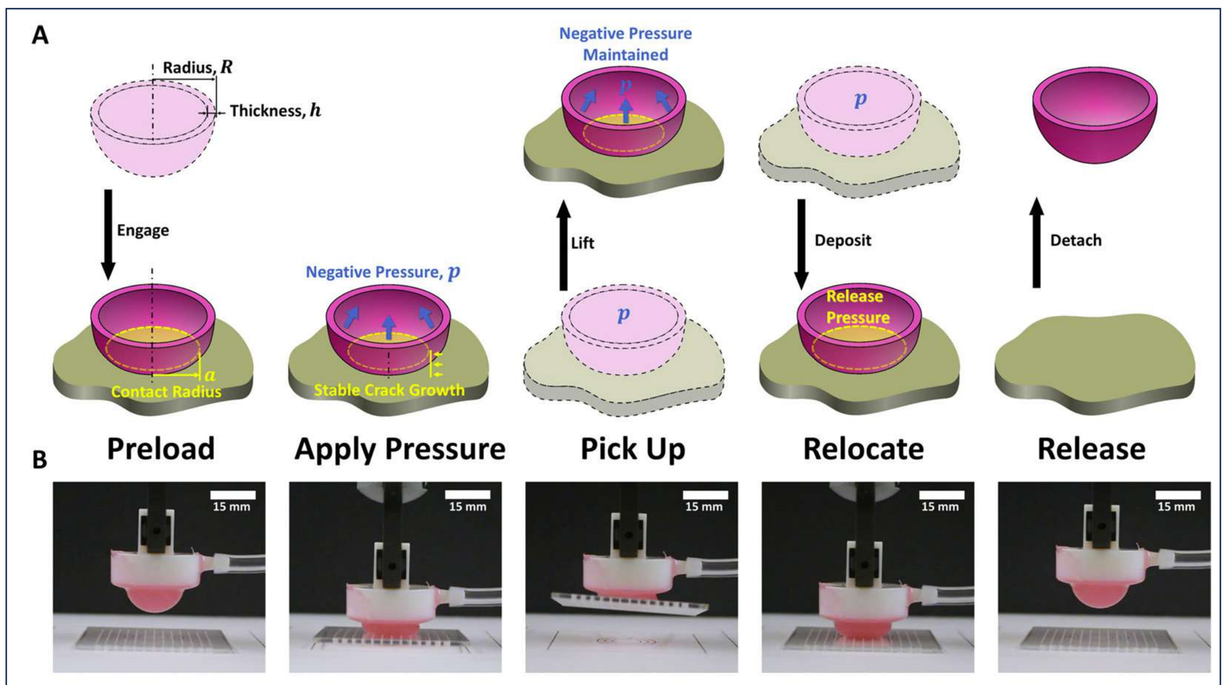
Testing:

- Gripper connected to a syringe-based system with Arduino pressure monitoring
- Instron measured force–displacement during actuation
- Buckling pressure and actuation time recorded

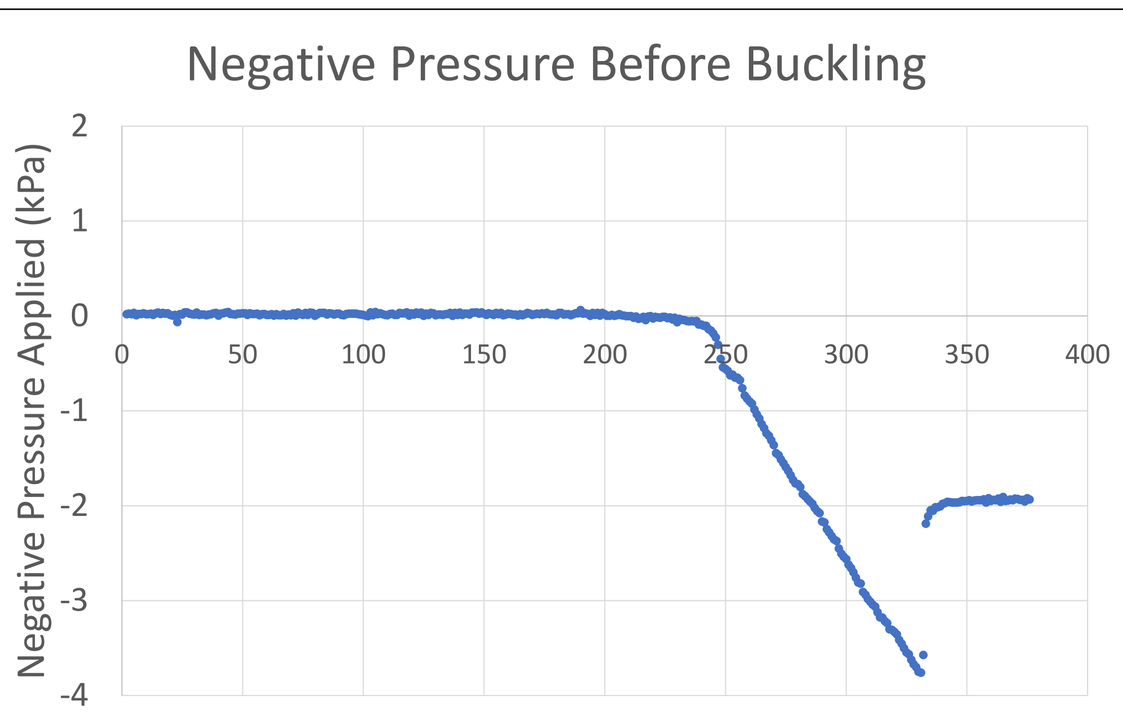
Gripper Design and Working Principle

The soft-shell gripper is made from a flexible rubber-like elastomer that can tune its adhesion strength by adjusting internal pressure. Its dome-shaped design allows uniform contact with the surface of an object. When a small negative pressure is applied inside the dome, it creates a partial vacuum that enhances the gripping force beyond the material's natural stickiness, allowing it to lift and hold objects securely.

Unlike conventional suction grippers, this design doesn't rely on a full vacuum or airtight seal. TunaBotics' gripper combines negative pressure with natural surface adhesion, allowing it to work on rough or perforated surfaces.



General Process of the Gripper on a Flat Plate with Holes [1]



1st Prototype - Testing Results of Negative Pressure of Gripper before Buckling (No Load)

Semester Deliverables:

1) Implement a design that:
   a) Reduces the actuation time of the gripper to less than a second
   b) Prevent premature buckling to occur during operation
2) Research and analyze
   a) Adhesive performance of the gripper in contamination tests
   b) Fatigue life of gripper

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[1] Zhao, Chenxu, et al. "Soft Shell Grippers with Highly Tunable Dry Adhesion through Low Negative Pressure for Universal Manipulation." *Advanced Functional Materials*, 21 Apr. 2025, https://doi.org/10.1002/adfm.202504871. Accessed 30 Sept. 2025.