

Objective: To develop programmable “Smart Nozzles” for coolant distribution in machining processes.

Why Soft Robots?

- Naturally compliant, “safe interaction with humans, manipulating and grasping fragile objects” [1]
- Actuators with high strength-weight ratio

Applications in various industries:

- Health care: Exosuits, artificial organs
- Space exploration: Biologically-inspired actuators
- Automation: Product manufacturing & assembly

Project Objective

- Pneumatic “Smart Nozzles”, capable of directing coolant flow on machining tools



Figure 1: (a.) Loc-line Hose Assembly [2],
(b.) Metallic Coolant Line Platform [3]

Theoretical Background

- Finite Element Analysis of Smart Nozzle variations
- Performance predicting based on design geometry, material properties, and supplied air pressure

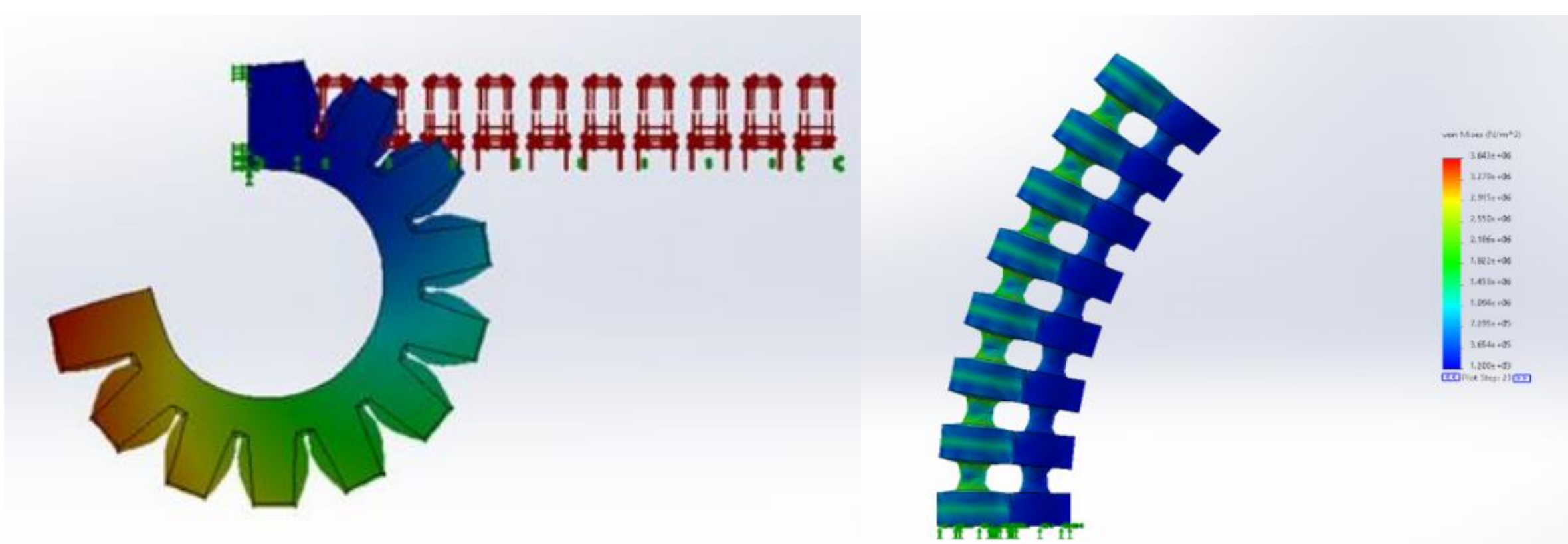


Figure 2: SolidWorks Finite Element Analysis of ABAQUS and 3-Chamber Actuators

Smart Nozzle Anatomy

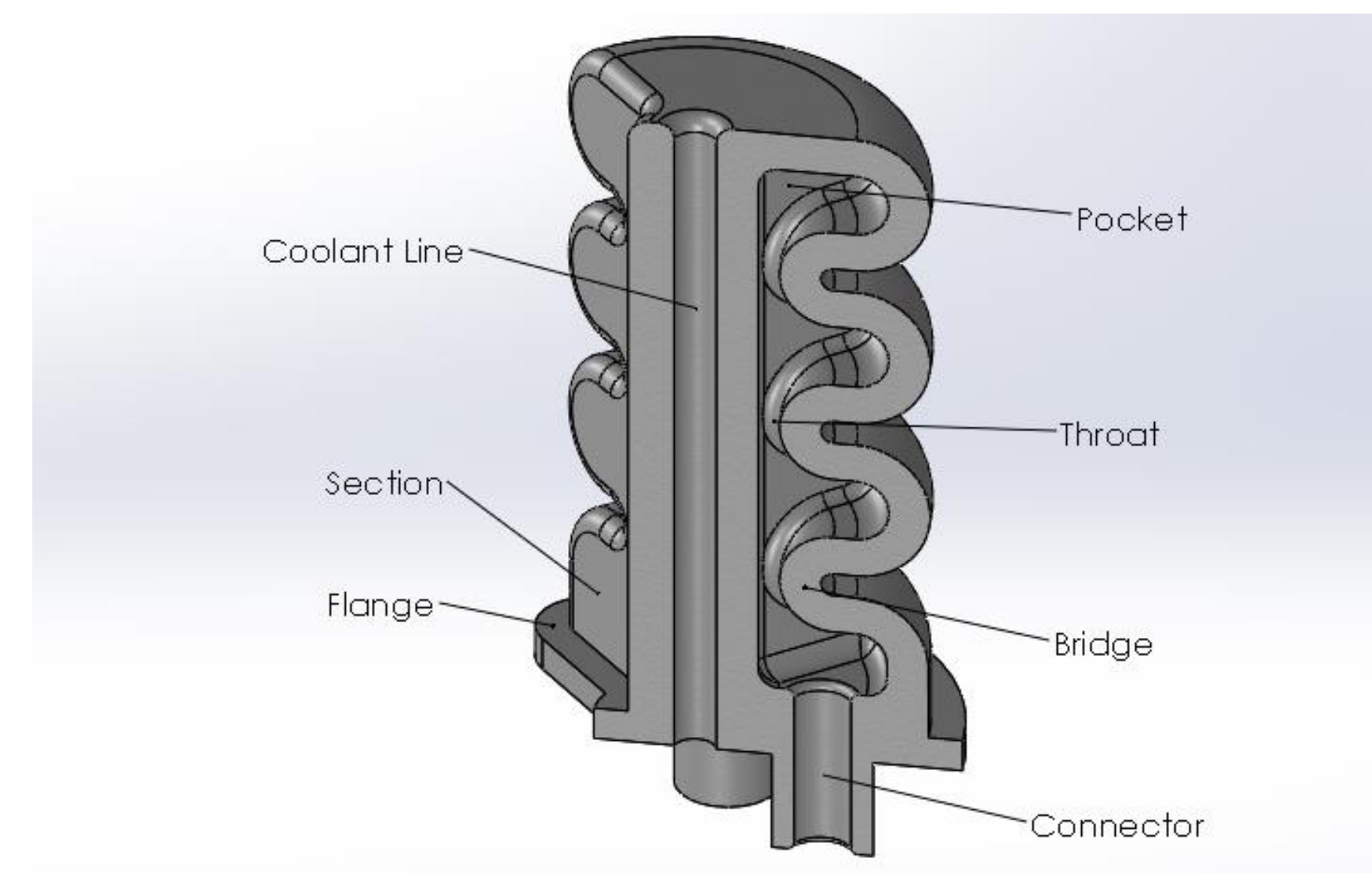


Figure 3: Section View of 2-Chamber “Taurus”
Smart Nozzle

DLP Print Quality Concerns:

1. External leaking to atmosphere
2. Internal leaking between chambers

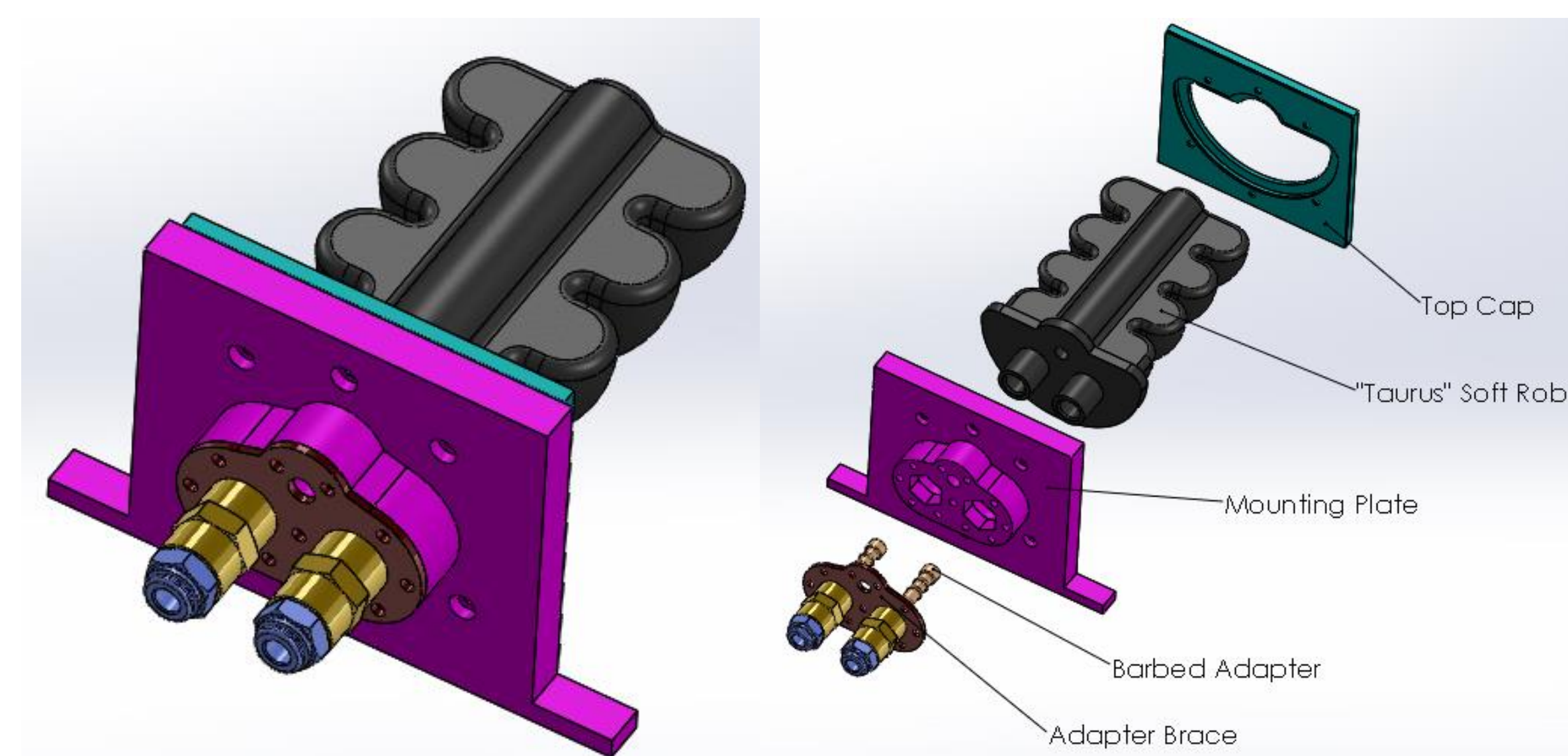


Figure 4: Exploded View of “Taurus” Mounting Assembly

Assembly Components

- Barbed adapters: Mesh with internal walls of connector tubes
- Mounting plate: Provides support and assists with pressure seal
- Adapter brace: Bolted to mounting plate, forces barbed fittings to stay wedged within soft robot
- Top Cap: Bolted to mounting plate, forced soft robot to remain in contact with barbed adapters

Experimentation

- Quality air pressure control is the foundation for all soft robot projects

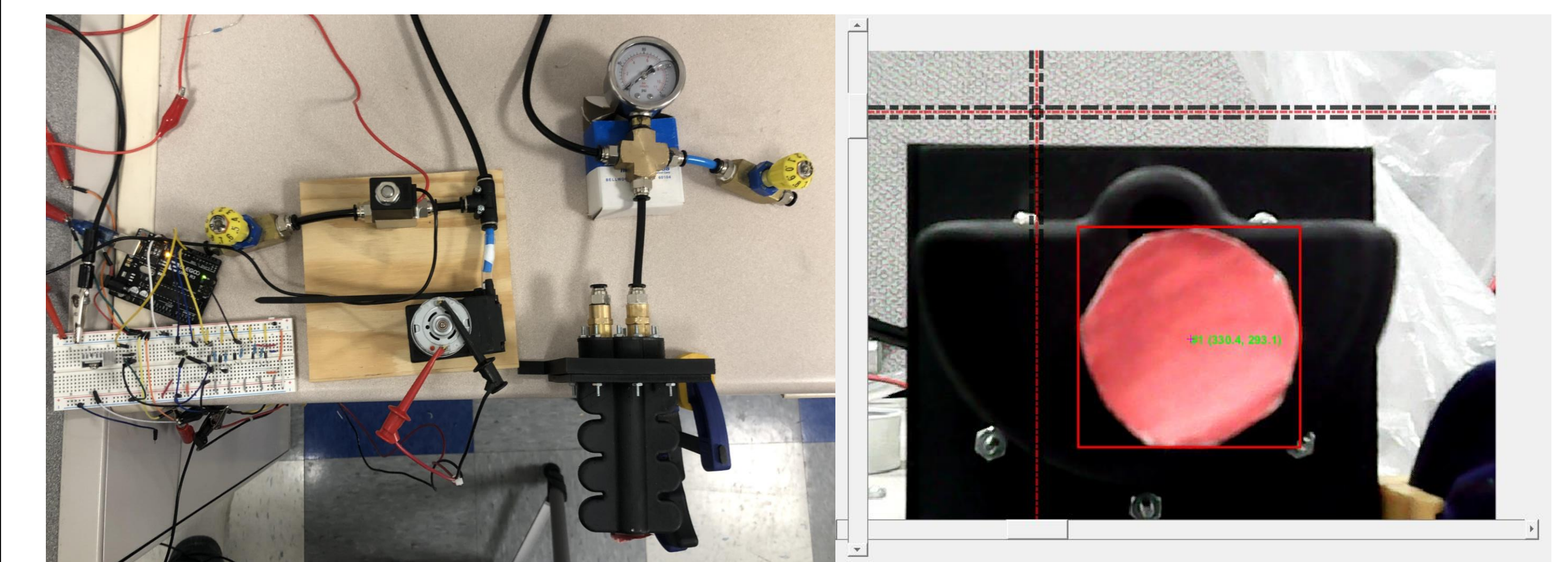


Figure 5: (a.) Pressure Mitigation Device –
Top View, (b.) MATLAB GUI Slider Control

MATLAB/Arduino

- USB webcam visual feedback, tracks marker centroid
- MATLAB GUI: user-controlled slider target
- Arduino computes: Error = Centroid - Slider values

Three States:

1. $Error < (-1) * Tolerance \rightarrow$ increase pressure
2. $Error > (+1) * Tolerance \rightarrow$ decrease pressure
3. $Error \leq abs(Tolerance) \rightarrow$ hold pressure constant

Future Work

- Continued SOLIDWORKS modeling of new prototypes
- Expanding MATLAB GUI research, multi-object detection and tracking

References

- [1] G. Alici, “Softer is harder: What differentiates soft robotics from hard robotics?,” *MRS Advances*, vol. 3, no. 28, pp. 1557–1568, 2018.
- [2] “Chip Rite General Purpose Coolants,” *KOOLRite*. [Online]. Available: <https://www.koolrite.com/machine-cutting-coolant/cnc-coolant/chip-rite/>. [Accessed: 12-Apr-2023].
- [3] Author Susan Woods Susan Woods served as a Contributing Editor for *Cutting Tool Engineering* magazine. and S. Woods, “Cool tool,” *Cutting Tool Engineering*. [Online]. Available: <https://www.ctemag.com/news/articles/cool-tool>. [Accessed: 12-Apr-2023].