High Cycle Fatigue of Electroactive Membranes

Team 20:

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Abstract

Currently electroactive membranes are being studied for implementation onto robot legs to provide more efficient mobility. Little research has been performed on the fatigue of electroactive membranes [1]. The goal of this project is to develop a high cycle test mechanism to quantify the fatigue of these membranes so the design can be optimized. The mechanism will provide varying frequencies and stroke distances and will measure the associated load by implementing with the MTS machine. The chosen design is a crank slider mechanism that operates using a DC motor and will be controlled using LabVIEW. A prototype has been constructed and successfully operated and produced the expected sinusoidal motion.

Background

Need Statement: There is a lack of information on the fatigue of electroactive membranes.

- Electroactive membranes are being studied for application onto robots.
- There is insufficient data on the fatigue behavior for electroactive membranes [1]
- The purpose of this project is the design and implementation of a fatigue mechanism for electroactive membranes

Goal Statement: Design and build a device that produces high cycle sinusoidal mechanical fatigue of electroactive membranes.

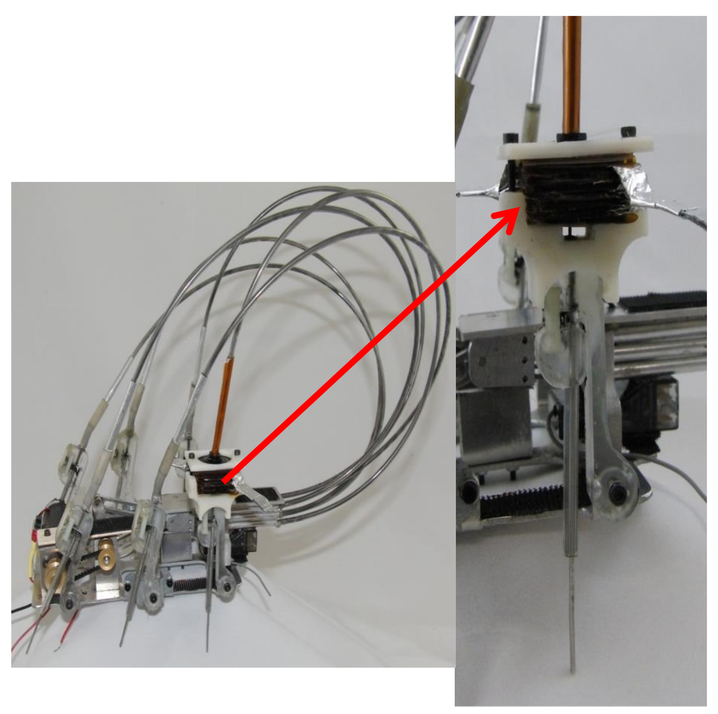
Figure 1. iSprawl Robot with VHB membrane stack[2]

Objectives:

- Accurately measure the fatigue placed on the specimen
- Produce various frequencies and displacements during cycling
- Allow for tracking of the displacements controlled by the fatigue machine
- Measure the load associated with the stroke by implementing with the MTS machine

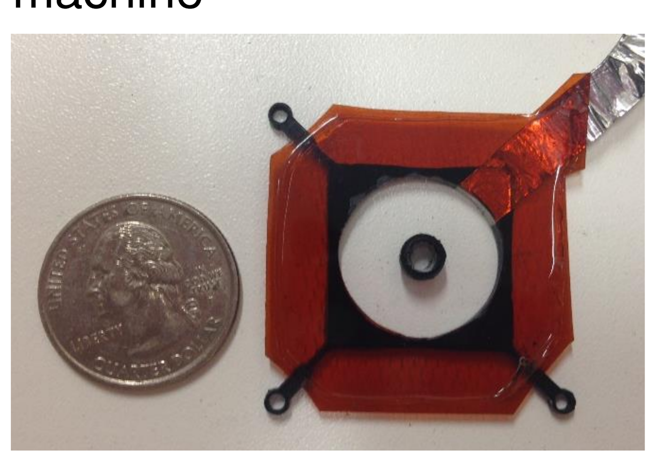
Figure 2. VHB membrane specimen

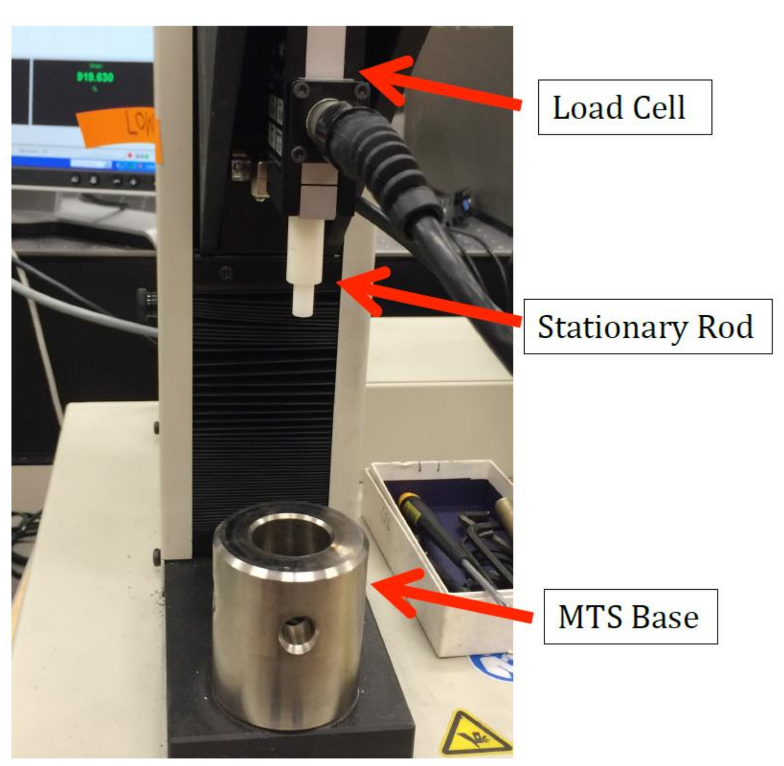

Figure 3. MTS machine

Final Selected Design

Constraints

- System should be a tabletop mechanism that is mounted to the MTS machine
- Vary stroke from 0 to 10mm
- Vary frequency from 0 to 25 Hz
- Produce consistent functionality for various specimens
- Test 1 to 5 specimens at a time
- Complete within $2000 budget

Crank Slider Mechanism

Concept: This design uses a crank slider, resembling that of a piston, powered by a DC motor to move a platform holding the electroactive membrane to produce a sinusoidal motion.

- Vary frequency through user interface
- Vary displacement using modified flywheel

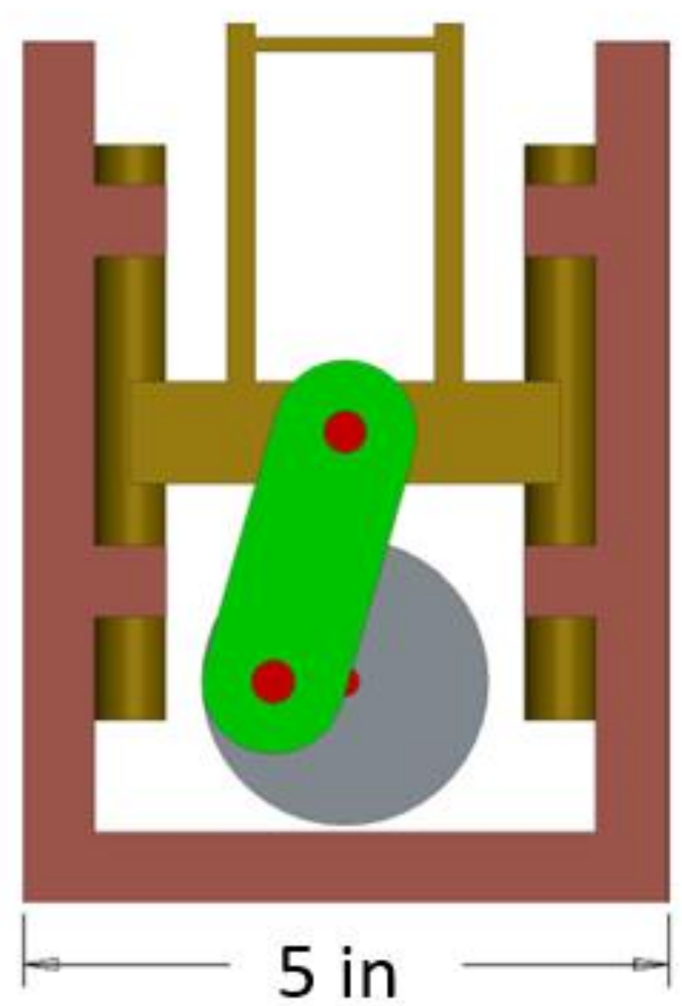

Figure 4. Crank Slider Design

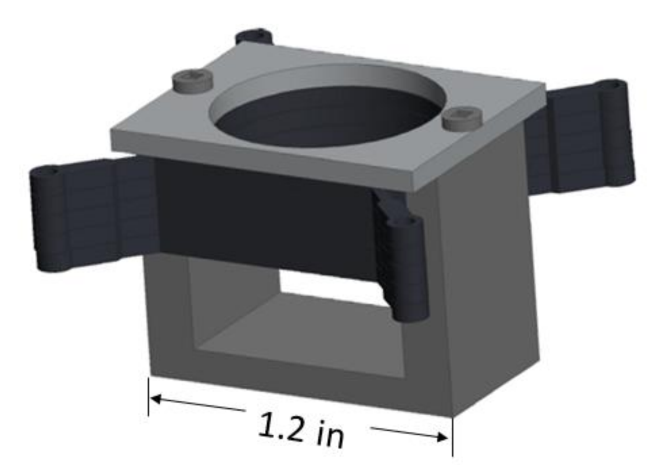

Figure 5. Platform rendering

The motor that rotates the crank to produce the sliding motion must provide sufficient torque to perform the desired motion and displacements. A torque will be induced from the force exerted by the specimen and the weight of the platform. The motor must have a torque larger than this torque.

Analysis

Minimum Required Torque

$$Torque = F_{max} \cdot r_{max} = 500N \cdot 5mm$$
$$Torque = 2.50\ N \cdot m$$

Minimum Required Angular Velocity

$$\omega = \ 2\pi \cdot f_{max} = 2\pi \cdot 25Hz \cdot \frac{60s}{1\ min} \cdot \frac{1\ rev}{2\pi}$$
$$\omega = 1500\ rpm$$

Possible Motor Choices

National Instruments model AKM22E

- 3500 rpm & 2.42 N·m, $797

National Instruments model AKM23D

- 1500 rpm & 3.89 N·m, $832

Conclusions

Dynamic analysis at maximum conditions:

- Max Force = 500 N

Minimum Motor Specifications:

- Angular Velocity: 1500 rpm
- Torque: 2.5 N·m

Prototype: Proof of concept assembly was constructed and yielded successful operation to provide the needed sinusoidal motion. The prototype showed that the dimensions used were feasible for the final design.

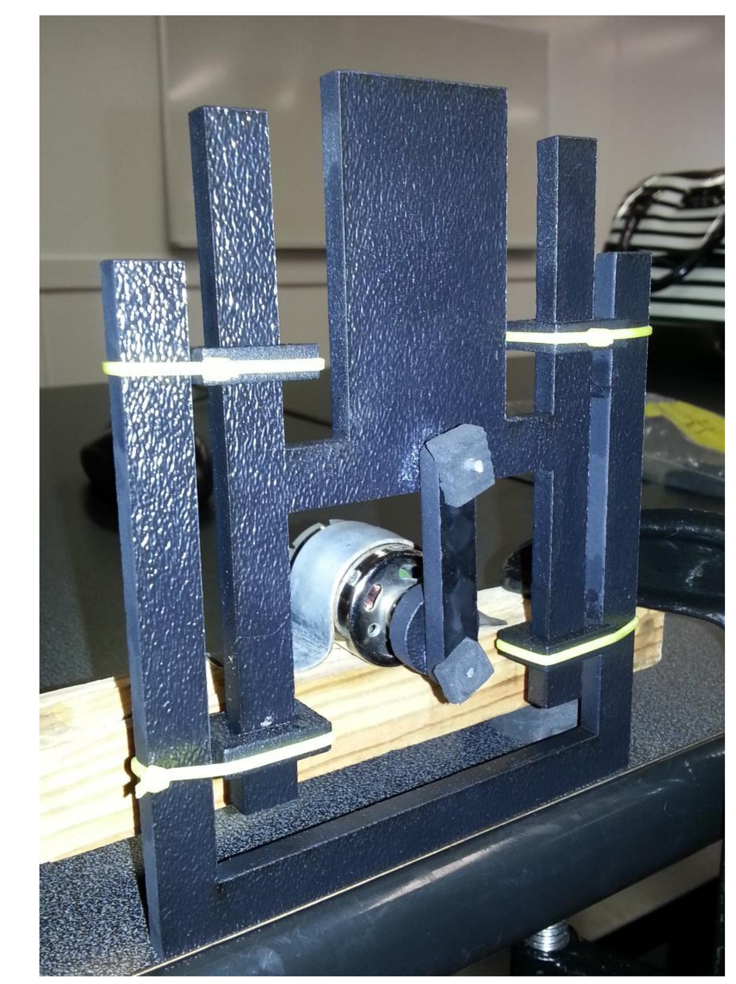
Figure 6. Mechanism prototype

Future Work

- Finalize dimensions of design components
- Material selection
- Purchase materials
- Fatigue/Failure analysis
- Additional prototyping
- Development of user interface
  - LabView
- Time syncing data from mechanism to MTS data
  - DAQ system

References
[1] Oates, William and Jonathan Clark. Personal Communication. Florida A&M/Florida State University, 2014.
[2] Newton, Jason. "Design And Characterization Of A Dielectric Elastomer Based Variable Stiffness Mechanism For Implementation Onto A Dynamic Running Robot." Thesis. Florida State University - College Of Engineering, 2014. Print