Team #7: Soft Tissue Fatigue Testing Fixture

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Dr. Wei Sun, mechanical and biomedical engineering professor at University of Connecticut.

Research focused on stress and strain analysis of soft tissue.

This project is a continuation of his work on flexural/tensile durability testing of soft tissue specimens.
Devices capable of tensile and flexural testing already exist. The goal of this project is to improve on the existing designs. Data from this type of testing can be used to enhance the durability of bioprosthetic devices (heart valves, synthetic blood vessels). More people need bioprosthetic devices each year (heart disease, obesity, tissue replacement), so the designs of these devices must constantly be improved.
Most dealt w/ overall device.

Three tissue testing patents:

• #5902937: in vitro tissue testing; hemocompatibility.
• #20020012125: chamber that mimics body conditions; measurements of mechanical props. optically.
• #20020095994: Clamping mechanism, tensile/flexural(bending) testing, small gears and motors.
200 N Multi-chamber ElectroForce® BioDynamic® Test Instrument for Orthopaedic Specimens
The ElectroForce® 3200 Test Instrument (University of Pittsburgh, Bose).
Dr. Sun helped design this device.
Objectives

- Design a soft tissue fatigue testing fixture to meet specifications including:
  - 12 samples
  - Continuous data acquisition/monitoring
  - Flexural and/or tensile testing
  - Maximum 30 Hz, 200 million cycles
  - Bluetooth communication
  - Durable device
  - Simple setup, easy to run
Methods: Mechanical Design

- Proposed overall design
  - Compatible with Bose Testbench System currently in lab
  - Bose arm attached to bottom section; load cells and upper clamps remain stationary
  - Prevents data corruption by recording unwanted movement of load cells
Methods: Mechanical Design

- Clamp design
  - Hinged clamp allows for easy specimen setup
  - Pins prevent tissue movement during testing
Strain gauges: thin metallic coil
Sensitive to strain: resistance changes
GF: the most important parameter

\[ \varepsilon = \frac{dL}{L} \]

Gauge Factor (G.F.) = \( \frac{dR/R}{dL/L} = \frac{dR/R}{\varepsilon} \)
Methods: Strain Gauge Load Cells

- Wheatstone Bridge
- Quarter-Bridge circuit.
- Half-Bridge circuit.
- Additional considerations: amplification, filtering, offset nulling

\[
\frac{V_o}{V_{EX}} = \frac{R_3}{R_3 + R_4} - \frac{R_2}{R_1 + R_2}
\]

\[
\frac{V_o}{V_{EX}} = \frac{GF \cdot \varepsilon}{4} \left( \frac{1}{1 + GF \cdot \varepsilon} \right)
\]

\[
\frac{V_o}{V_{EX}} = -GF \cdot \varepsilon
\]
The Bose TestBench System is controlled using Bose software that came with the motor.
The data will be viewable via a Labview program that will display the data in real time.
The signal will be transmitted wirelessly using bluetooth.
Methods: Data Acquisition/Software

- Data Acquisition Board
  Used to input data to Labview from the strain gauges.
- PIC Microprocessor
  Used to transmit the data from the strain gauges.
The data will need to be filtered and amplified before being displayed in Labview. Filtering can occur within Labview or before the signal is transmitted. Experimentation will be necessary to determine the best option.
<table>
<thead>
<tr>
<th>Equipment</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plexiglass or Acrylic Raw Materials</td>
<td>$200</td>
</tr>
<tr>
<td>Silicone Sealant</td>
<td>$10</td>
</tr>
<tr>
<td>Titanium alloy hinges, screws, washers, nuts, pins</td>
<td>$30</td>
</tr>
<tr>
<td>Strain Gauges</td>
<td>$40</td>
</tr>
<tr>
<td>Amplifiers/Filters</td>
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<tr>
<td>Bluetooth Module</td>
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<tr>
<td>PIC Microprocessor</td>
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<tr>
<td>Insulated Wiring/Resistors</td>
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<tr>
<td><strong>Total Cost</strong></td>
<td><strong>$380</strong></td>
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</tbody>
</table>
Conclusions

- Device capable of cyclically loading multiple tissue specimens for tensile and/or flexural testing.
- Data can be examined in real time; no need to wait weeks for experiment to finish.
- Device can potentially help improve designs of bioprosthetic devices.
Acknowledgements

- Dr. Wei Sun
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Questions?