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EMCH 316
Lab #6

Biomechanical Testing

OBJECTIVE: The objective of this lab assignment is to test a sample with sinusoidal loading from the Bose machine. The sample is an agarose gel cylinder which mimics human tissue properties. This experiment will help us study the degradation of this material under repetitive stress which simulates what happens to human cartilages.

PROCEDURE

1. Start the Bose machine and follow the instructions to setup the machine. Cycle count 1500, 10Hz frequency, sinusoidal shape and 2mm compression. Auto tare the sample.
2. Then load the sample in the machine and click run. The experiment will begin, and the machine will vibrate the sample.
3. After the experiment the machine will give out a csv file.
4. Load the csv file into your computer and start data analysis.
5. The lower peaks of the two waves will have an offset.

DATA AND RESULTS

Table 1. Hydrogel plug specimen dimensions

Quantity	Dimension
Original Length lo (mm)	**13.4**
Original Diameter D (mm)	**13.1**
Original Area Ao (mm^2)	**134.78**

ANALYSIS OF DATA

- Calculation of specimen area, Ao

$$A_0 = \frac{\pi}{4}D^2 = \left(\frac{\pi}{4}\right)13.1^2 mm = 134.78218 mm^2$$

- Sample Calculation of stress and strain σ and ε
  - Stress = P/A = 7.7N/134.78218 mm^2=0.05713 MPa
  - Strain = ΔL/Lo = disp/l =1.76/13.4=0.13134
- Determination of the amplitudes of the sinusoidal stress and strain curves σ_o and ε_o
  - σ_o = 3932 Pa
  - ε_o = 0.0056 mm/mm

    by taking the avg of the peaks from the rdr graph.
- Determination of the phase angle, δ
  - Looking at the graph delta t is 0.004 sec

$$\delta = \Delta t * 20 * \pi = 0.004 * 20 * \pi = 0.25\, rad$$

- Determination of the angular frequency, ω

$$\omega = 2\pi f = 2\pi * 10Hz = 62.832 rad/s$$

- Determination of the strain function, (t)
  - ε(t)= $\varepsilon_o$sin(ωt+ δ)
- Determination of the stress function, (t)
  - σ(t)= $\sigma_o$sin(ωt)
- Determination of the storage modulus, E'

$$E' = \frac{\sigma}{\varepsilon} * \cos(\delta) = \frac{3932}{0.0056} * \cos(0.25) = 680314 \text{ Pa}$$

- Determination of the loss modulus, E''

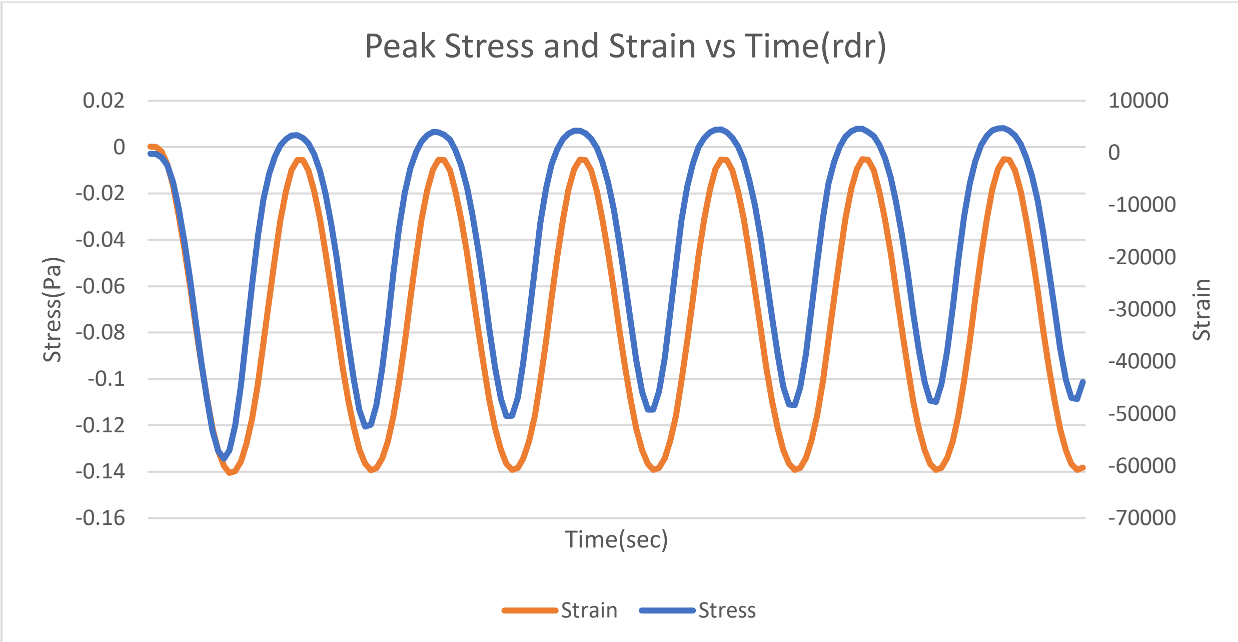
$$E'' = \frac{\sigma}{\varepsilon} * \sin(\delta) = \frac{3932}{0.0056} * \sin(0.25) = 173713\, Pa$$

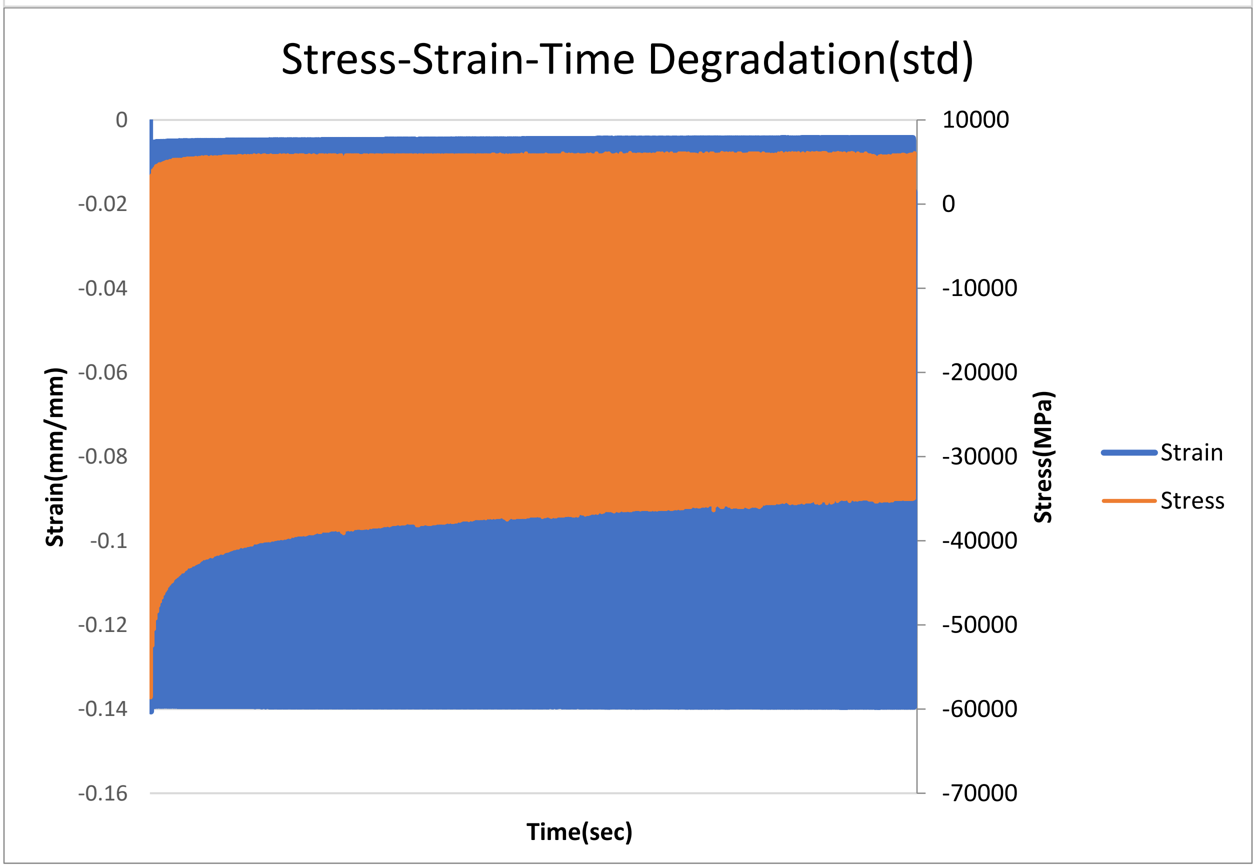
- Determination of the complex modulus, E*

$$E^* = E' + iE'' = 680314 + 173713i$$

$$|E^*| = \sqrt{E'^2 + E''^2} = 702141\, Pa$$

- Attach the plotted stress and strain curves.





DISCUSSION OF RESULTS

1. According to the obtained phase angle, discuss the viscoelastic properties of the sample.
   a. The phase angle was 0.25 radians. This value is closer to 0 than to $\pi/2$. This means that the material is more elastic.
2. Discuss the effect of an increase in tan δ on the physical properties of a viscoelastic material.
   a. Increase in tan δ will cause the loss modulus to increase and cause the storage modulus to decrease which will make the material more viscous and less elastic.
3. Comment on the decay on the plotted stress and strain curves. Was it expected for this kind of test?
   a. The decay was being caused because the material was fatiguing after repeated loading and unloading. This was expected for this test and that's why the stress strain curve showed decay.
4. If you increased the displacement range and the frequency to -4.0mm and 30 Hz, respectively, would you be able to obtain a similar wave function? What kind of difference would you experience?
   a. The wave would be again sinusoidal, but the frequency has been tripled and the displacement has been doubled, this will cause the wave function to be slightly different. The amplitude will be bigger, and the period will shorten. This will cause the fibers inside the material degrade faster.

CONCLUSIONS

The experiment shows how a material degrades under repeated loading. The sample tends to slip out of the machine so that needs to be held inside the jaws. The agar gel sample gets loaded repeatedly which causes it to degrade. The graphs show that the material is viscoelastic.