APP N10-1: Lab 03 - Chip Fabrication and Yeast Cell Adhesion

Engineering 1282.02H

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Y5 - Manotech
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This worksheet is a group assignment and is designed to help your team analyze the results of the Lab 03 and assess the procedure. This will require Excel **and** the fluid mechanics program you created. Questions 1-13 are about the data. Please submit both this worksheet and the spreadsheet to Carmen as a single PDF when complete.

1. Using the given spreadsheet, APP_N10_1_TABLE.xlsx, fill in the specific heights, change in volume, time of trial, number of cells after flow, percent of total cells and the experimental flow rate for each data point. These are all measured values or simple calculations. Place these columns from the spreadsheet in the box below.

Table 1: Collected data from yeast trials

Data Point	Trial	Height (cm)	Time (min)	Δ Volume (ml)	Cells	% of Cells Left	Volumetric Flow
	LPF	24.9	5	0.3	2106	100.00%	0.001
	1	35.5	2.15	0.1	1306	62.01%	0.000775
	2						
1	3						
	LPF	23.8	3.9333	0.4	1701	100.00%	0.001695
	1	31.9	2.7333	0.5	1607	94.47%	0.003049
	2	34.9	2.01666	0.1	669	39.33%	0.000826
2	3						
	LPF	24	4	1.3	1747	100.00%	0.005417
	1	30.7	2.0333	0.2	828	47.40%	0.001639
	2	32.8	2	0.6	389	22.27%	0.005000
3	3						
	LPF	24.23333333	4.3111	0.6666666667	1851.333333	100.00%	0.002577
	1	32.7	2.305533333	0.2666666667	1247	67.36%	0.001928
	2	33.85	2.00833	0.35	529	28.57%	0.002905
Average	3						

2. Next, using your heights, calculate the pressure and shear stress in the channel for each data point. Enter these cells from the spreadsheet in the box below.

Table 2: Pressure and Shear Stress data from height data

Pressure (H, dyne/cm^2)	τ (H, dyne/cm^2)
24426.9	148.9228807
34825.5	212.3197697
23347.8	142.3439583
31293.9	190.7887508
34236.9	208.7312665
23544	143.540126
30116.7	183.6117445
32176.8	196.1715055
23772.9	144.935655
32078.7	195.5734217
33206.85	202.451386

3. Using your above values, create a plot of Cell Percent vs. Shear Stress with trendlines and place it in the box below. Try different regressions to get a best fit for your data. Show the trendlines on the plot.

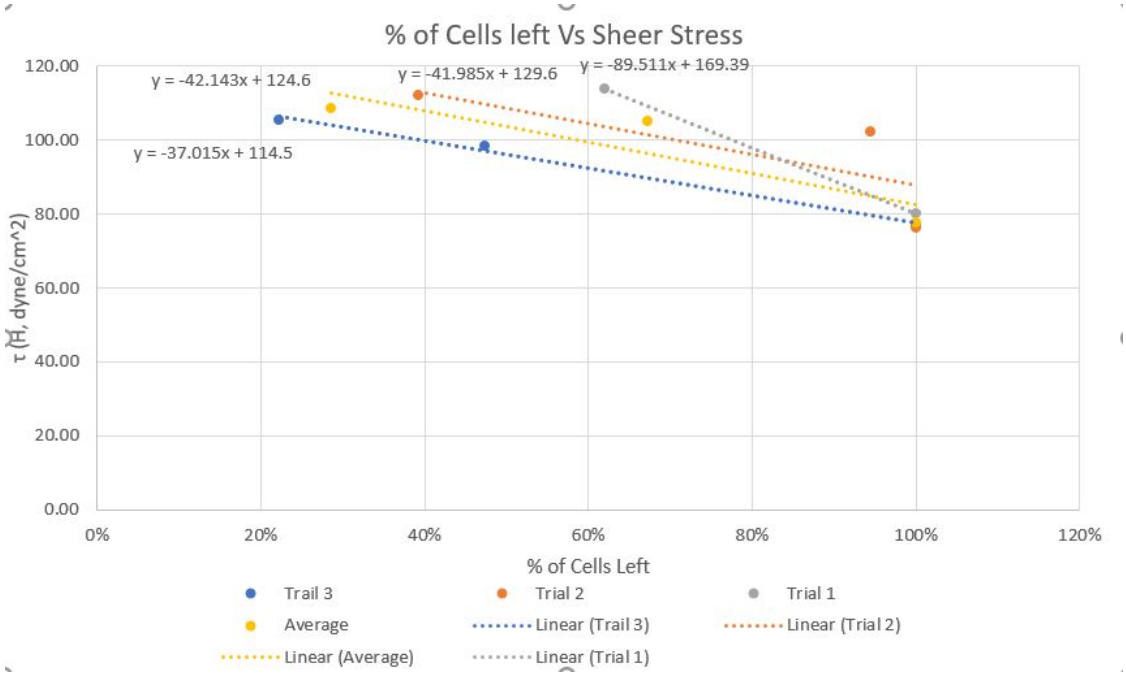

Figure 1: % of cells left VS Shear Stress using height data

4. What did your group define as “Threshold Yeast Shearing”? How did you come to this decision?

We decided that threshold yeast shearing was defined by 50% of the initial cells from the low pressure flush being sheared. We came to this decision because it was suggested in the Lab 3 documentation and we decided to use this again in our experimental procedure. We decided to use this value again because half of the cells being sheared seemed like a good indicator of threshold stress height.

5. Is this trendline method a valid way of determining threshold shear stress? If so, why? If not, how else could you collect data to get a better fitting trendline?

By plugging in % of cells left = 50 (0.5) into the trendline equation, a threshold shear stress based on the trendline can be determined. This is not an accurate way to determine the threshold shear stress because each trendline equation are very different from each other when they should be similar if the data is accurate. Collecting more data points during each trial would make a better fitting trendline.

6. Interpolate the threshold shear stress based on your team's defined threshold point and your trendlines. Fill the table with the results, and show a sample calculation.

Table 3: Threshold Shear Stress for each Trial Based on ΔP (Column Height)

Trial #:	Threshold Shear Stress (H, dyne/cm^2)
1	124.64
2	108.61
3	96.0
Average	103.53

Sample Calculation:
Trial 1
-89.511(.5)+163.39=124.64

7. Now, instead of using your height values, use the volumetric flow rate values to calculate . Calculate the pressure and shear stress in the channel during each trial. Enter these cells from the spreadsheet in the box below.

Table 4: Pressure and Shear Stress Data From Flow Rate Data

Pressure (Q, dyne/cm^2)	τ (Q, dyne/cm^2)
290947.64	954.55
225484.42	739.78
493156.25	1617.97
887099.36	2910.43
240322.75	788.46
1576063.37	5170.81
476863.18	1564.51
1454738.21	4772.76
786722.42	2581.11
529815.6533	1738.24
847530.48	2780.61

8. Now, using your shear stress values from the volumetric flow rates and your cell percentages, construct a plot similar to that in Step 3. Make sure to add the trendline equations.

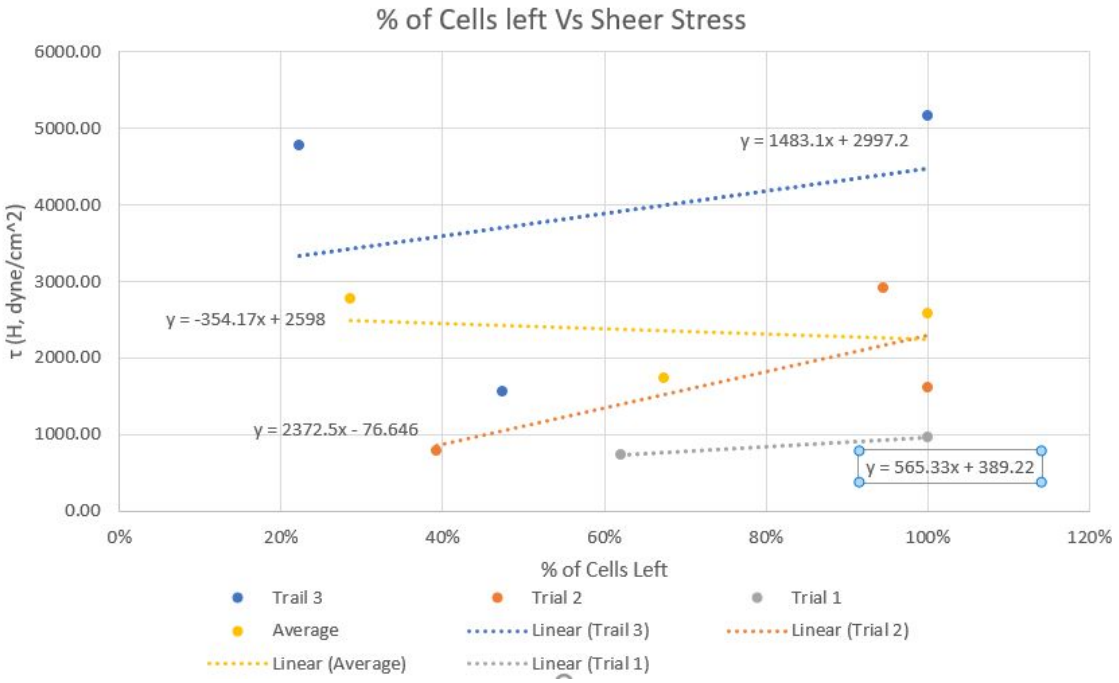

Figure 2: % of cells left VS Shear Stress using flow rate data

9. Calculate threshold shear stress based on your values and defined threshold level. Show the shear stresses in the table below as well as a sample calculation.

Table 5: Threshold Shear Stress for each Trial Based on Volumetric Flow Rate

Trial #:	Threshold Shear Stress (H, dyne/cm^2)
Trial 1	671.89
Trial 2	1109.60
Trial 3	3738.75
Average	2420.92

Sample Calculation:
Average,
-354.17(.5)+2598=2420.92

10. Calculate the average of all values (excluding time) for each height. Now, calculate percent difference from average between each data point and its respective average. Do this for: volume, cell count, cell %, flow rate, pressure (Q), shear stress (Q), and threshold shear stress (H and Q)

11. Comparing τ_H and τ_Q, which is better to use when analyzing results? Support your answer by discussing both your interpolations from above and sources of error in the experiment.

The τ_H is better to analyze the results from this experiment. This is because there were a lot of sources of error when measuring the flow rate of the chip. If the inlet or outlet nozzles leaked at all during the trial, the amount of water in the cup and therefore the flowrate would be inaccurate. Also when we were performing the shearing trials, we did not wait to start the timer until the outlet tube started dripping. There were sometimes bubbles in the outlet tube that caused there to be no water being added to the cup while the timer was running. This caused a smaller amount of water and a lower calculated flow rate and a source of error. This can be seen from the interpolations of the data in which the trends of each trial based on the flowrates varied much more than the trends based on the flowrate.

12. Comment on these values. How repeatable is this experiment? How consistent are your results?

These values are not very consistent, and have a lot of variability due to error. This suggests that this experiment is not very repeatable, as the values varied greatly between different trials. Our results are not very consistent, lending to a decreased repeatability. This could be remedied in future trials through more careful data collection, and a more practiced technique for taking consistent pictures of the yeast cells in the channel after shearing.

13. If you were unable to collect sufficient data, discuss what challenges prevented you from gathering data.

We were able to collect sufficient data.

Questions 14 – 18 are about the experimental procedure.

14. Why might the use of a reverse flush step be useful prior to performing a shearing trial?

The reverse flush may be useful before performing a shearing trial because it might be able to dislodge any clumps of cells or irregular groups of cells that the forward flush could not. It would help ensure that the channel walls are properly seeded with an even coat of yeast cells.

15. What are the pros and cons of allowing the yeast to incubate for relatively longer periods of time before proceeding with the next steps?

Incubating the yeast in the channels for longer periods of time has the benefit of ensuring the channel is well seeded. In the experiment, the yeast incubated in the channels for 15 minutes which resulted in a well covered channel after the low pressure flush. However, if the yeast is incubated too long, it has the possibility of the yeast adhering too strongly and not detaching under high pressure. The longer incubation times also have the disadvantage of slowing down the experimental procedure. There is limited time in class and open labs to run all the trials, so if too much time is spent incubating, time could run out before we obtain all of our data.

16. What design features in your chip can help address issues with delivery, incubation, clogging, or clumping?

In our chip, our channels are symmetrical, meaning that the inlet and outlet ports have the same shape, including the fillet. This is helpful for addressing issues with clogging and clumping, as flow can be delivered equally well through either the inlet or outlet port, allowing us to attempt to clear clogs with either a forwards or reverse flow. Another feature that helps is the fillet in the inlet and outlet ports. This allows the flow to normalize more quickly within the channel, which can help prevent clumping that may be caused by an irregular flow regime.

17. Do you think the flow rates in the channel with yeast cells should be the same or different from a channel with no yeast cells in it? Why or why not?

The flow rates of the channels containing yeast should be slightly different than the flow rates of the empty channels. This can be concluded because the yeast adhered to the sides of the channel make its shape into a imperfect rectangle. This would cause the flow to not exhibit a perfect

no-slip condition and parabolic flow shape due to the irregularities on the sides of the channel. The water doesn't flow as smoothly over the yeast cells as it does over a flat channel wall.

18. Could it be possible (could you) and practical (should you) to run multiple shearing trials on a single chip? How would you modify your procedure? Could you demonstrate that conditions are the same?

Multiple shearing trials should not be run on a single chip. If possible, all of the shearing trials should be run through the same channel on the same chip. This would eliminate the variation of different channels in the experiment. Channels on the same chip can have different flow characteristics even if the dimensions are the same. So, while it would be possible to run multiple trials on a single chip, it should be avoided to eliminate a source of error. If, however, the channels were proved to have the same values from the flow calibration, then it would be reasonable to run multiple trials on the same chip.