Flow Sensor Integration for Precision Dispensing of Visco-Elastic Biomaterials

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Background

At the Center For Micro and Nano Technology, we use an Aerotech motion controller system modified for bioprinting to construct microfluidic devices using hydrogels that change phase and mechanical properties during the print process. These hydrogels have varying viscosities when printed, so dispensing of these gels lacks consistent deposition precision. With the goal of enhancing and optimizing the patterning of visco-elastic materials, we have modified the printer to incorporate a flow sensor that provides feedback to the system to fine-tune the pressure output of the printing pumps during patterning.

Problem

The lab has microfluidic flow sensors currently used for non-printing applications. We aim to utilize these sensors to develop a pressure feedback system for the printing tool. These sensors have accurately recorded flowrates for fluids with water-like viscosities; however, they have not been used with high viscosity phase-changing materials such as gels or silicones. To use the sensors in the pressure feedback system, it is necessary to first verify their function and calibrate them to accurately record flow rate data for visco-elastic and non-newtonian materials.

Methods

- Using a pneumatic pump, push molten visco-elastic gelatin solution through the sensor under constant pressure from the printer as it solidifies into a gel at room temperature.
- Deposit the gelatin onto a mass balance that plots and records mass accumulation as a function of time.
- Convert the measurements to volume/min using the measured density of the gelatin (1.034g/mL).
- Plot the flowrate as a function of time using the sensor.
- Compare the plots to verify that the sensor is recording the actual flow rate and use any differences to calibrate the flow sensor.

Figure 1: The Aerotech motion controller used for bioprinting applications

Figure 2: The flowsensors used come from Elveflow and have varied flowrate ranges.

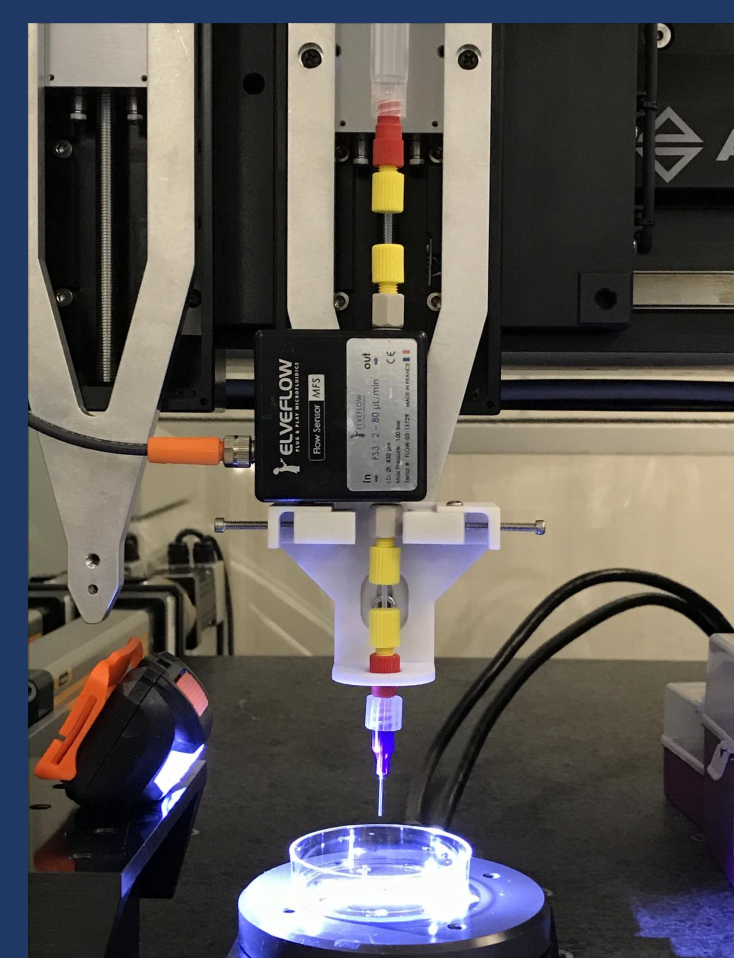

Figure 3: Experimental setup with flow sensor integrated with the pump

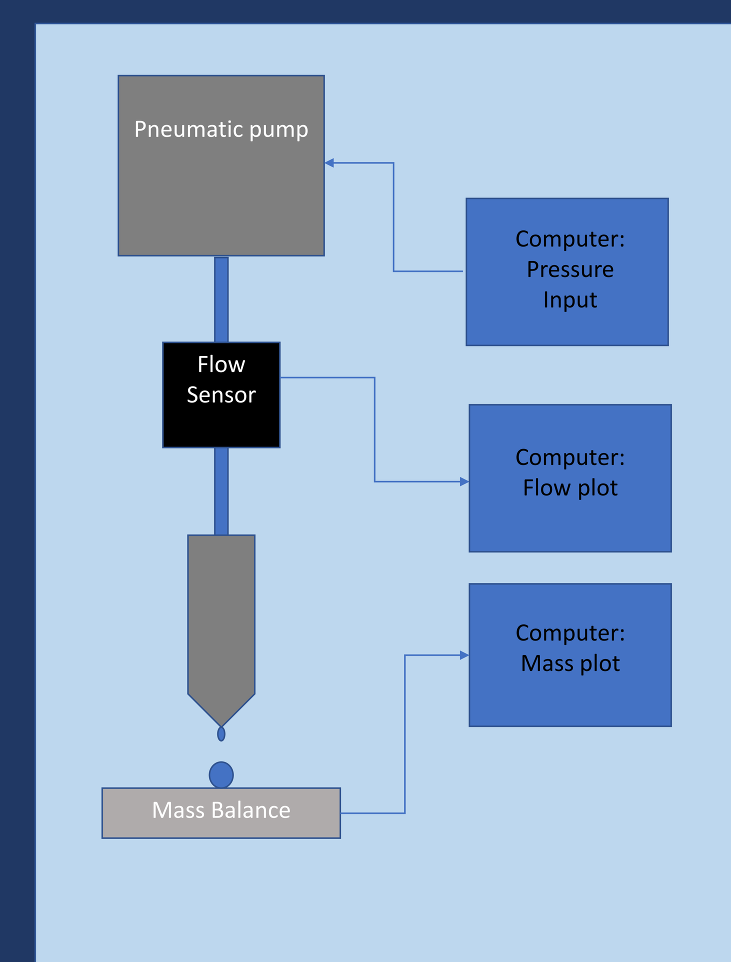

Figure 4: Diagram of the experimental test setup. The syringe containing the gelatin is above the sensor.

Results

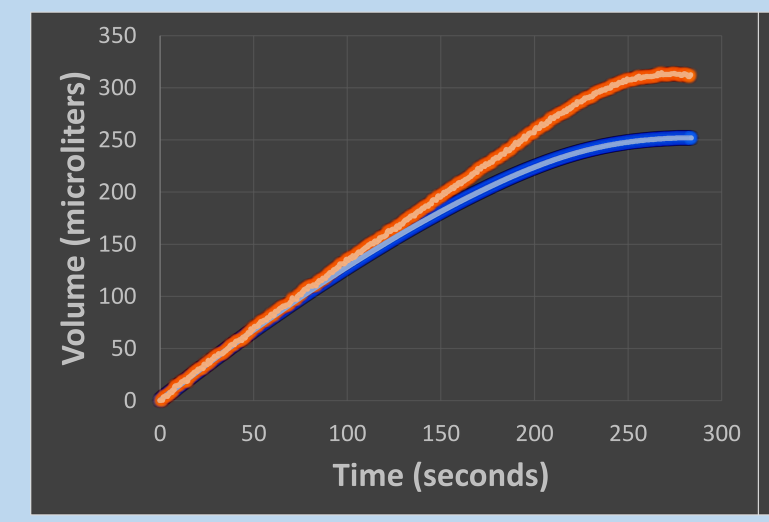

Chart 1: Comparison of the volume from the sensor (blue) and from the mass balance (orange).

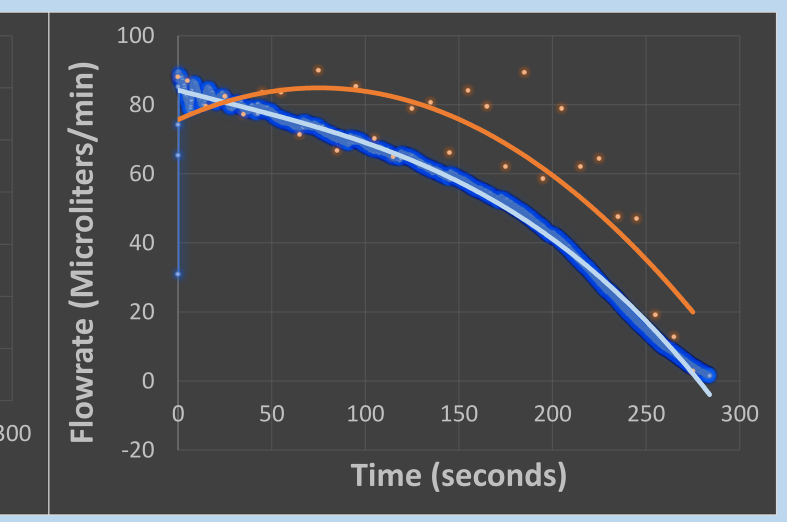

Chart 2: Comparison of the flowrate from the sensor (blue) and from the mass balance (orange).

Discussion

The results demonstrate an inconsistency between the flow sensor data and the actual flow rate as measured by the mass balance. While the flow sensor follows the general trend of the actual flowrate, the actual rate is greater. These discrepancies could be due to the phase change of the material altering the flow profile. The next step will be to run this test with a different visco-elastic solution, one that does not undergo a phase change during the printing process. Alternatively, other off-the-shelf sensors may offer greater accuracy for these types of materials without requiring calibration. Once a sensor’s data is verified as accurate, code will be written that allows the flowrate feedback to control the pressure output from the pump.

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