AUCKLAND BIOENGINEERING INSTITUTE
THE UNIVERSITY OF AUCKLAND NEW ZEALAND

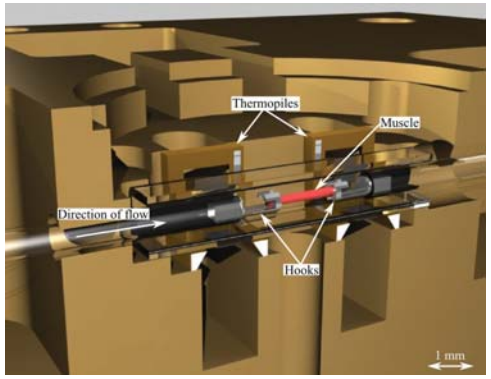
Micropumps and Mixing

Yuan Mai, Supervised by Andrew Taberner, Poul Nielsen and Bryan Ruddy

10 February 2015

Background

The ABI micro-calorimeter is an ultra-high resolution temperature sensor used to measure energy output from the muscle sample in its chamber. During the course of an experiment, fluids containing oxygen and nutrients must be constantly supplied in order to keep the sample alive. An illustration of the scale and internals of the micro-calorimeter is shown below; where a muscle sample is immersed in the continuous fluid flow.



Aim

The aim of this project is to create a subsystem which gives the user control over the fluid supplied to the micro-calorimeter.

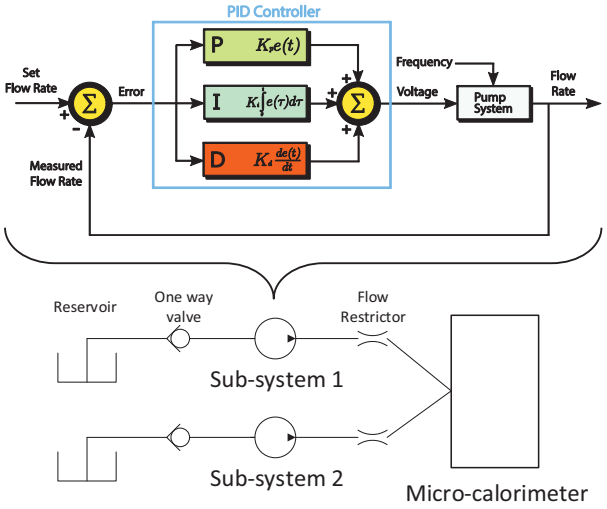
- Regulate flow rate at a constant 0.5 µL/s to maximise calorimeter sensitivity while limiting noise in the 0 Hz —10 Hz band.
- Allow the user to switch between different fluids or create a desired mixture.

System

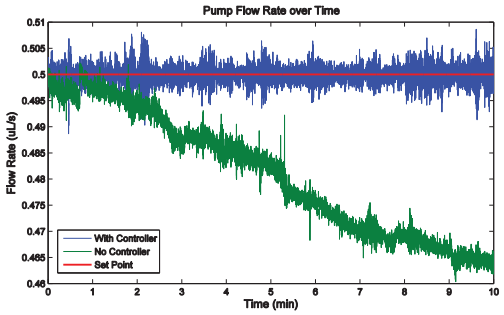
The system is set up as shown on the right. Each sub-system is made up of:

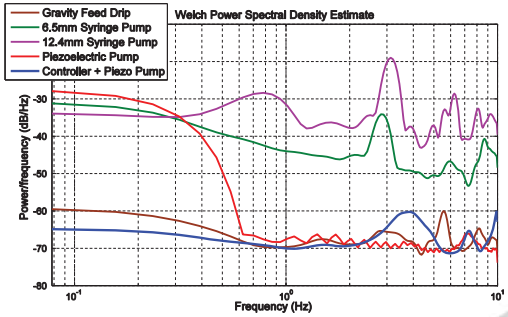
- Fluid reservoir
- One way flow valve
- Sensirion SLI-0430 flow rate sensor
- Bartels MP6 piezoelectric pump
- 75 µm diameter flow restrictor
- PID closed loop control on LabVIEW

This sub-system can then be duplicated for fluid switching and mixing when required.



Results





With the above system, the following fluid control was achieved:

- Flow rate range of 0.3 µL/s — 1.5 µL/s
- Flow regulation within ±1.7 nL/s (standard deviation) at 0.5 µL/s.
- Lowest flow noise power between 0 Hz — 10 Hz out of all available options including gravity drip.

Summary

The implemented sub-system enables users of the micro-calorimeter to easily alter fluid flow rates while being confident of the limited flow noise entering the chamber.

Future Work

- Further investigate the use of multi-input controllers for the piezoelectric pumps.
- Investigate possibility of oxygen leakage to ensure fluids remain oxygenated when entering the micro-calorimeter.
- Quantify and minimise fluid path and dead volume, as a result, decreases lag time between fluid reaching the micro-calorimeter.