

**MEMORANDUM**

**DATE: August 26, 2009**

**TO: Laboratory Group D**

**FROM: Tony Butterfield**

**Engineering Training Supervisor**

**SUBJECT: Clear Heated Microscope Stage**

Our lab is studying perfluoropentane microdroplets. These particles are to undergo a phase change from liquid to vapor in the body upon heating, to therapeutic ends. We want to visualize these droplets and their transition to bubbles with light microscopy.

We are therefore in need of a clear, temperature-controlled stage for our microscope. A cursory look at available commercial options revealed that a clear stage, one meeting merely our heating requirements, would be costly. However, we suspect we can create a better device with the parts we have on hand. I will provide you with these parts and a prototype of the clear stage. Your task is to assemble a system to meet our needs and conduct some preliminary characterization. I propose a fairly simple design, as shown in the figure at the end of this memo. Though only one thermocouple is shown, you will likely want to use the additional thermocouples in your experimentation (e.g. at the stage outlet and inlet).

While temperature control is our ultimate goal, please understand that the development of the control scheme will be left to another group.

In the proposed design, water from a heat or ice bath, kept at a constant temperature, is pumped between two clear plates, which make up the clear stage. On top of the stage will be a glass slide and the sample of interest. For this project, we will ignore the error found in coupling the thermocouple to the cover slip or slide. In the final design, the controller will adjust the flow rate of two pumps in order to compensate for the heat loss (or gain) that will occur in the stage and tubing exposed to room temperature, but we will only use one bath and one pump in this project.

Please run the system at the lowest and highest temperatures you can safely achieve, and at multiple points in-between. Describe the steady state conditions necessary to reach those temperatures. At a minimum, the stage should be able to reach 50 °C to be useful in our work, but we hope for a range between 5 and 80 °C.

Because this system involves complicated geometries and we are ultimately looking to control a measured variable, significant simplifying assumptions may be made. Assume this is a steady state one-dimensional heat transfer problem. Ignore thermal contact resistance, and take your measurement of the outlet temperature as the temperature of the fluid within the stage, *Ts∞*. It may be particularly difficult to decide on a convection coefficient within the circulating liquid. Use your data and model to estimate what this convection coefficient should be at each flow rate. Given the known flow rate and volume in the stage, does the estimated flow rate from the convection coefficient seem reasonable? If you find this model to be insufficient, please theorize as to why in your report. Which assumptions are the most suspect? Also, if you feel we could improve the prototype’s design, your recommendations would be appreciated.

Finally, record the transient behavior of the system when stepping from a flow rate of zero to the maximum allowable, and from the maximum back to zero. At a minimum, we wish to know, qualitatively, how this set up compares to our existing, opaque heated stage, but an above average effort would include modeling the transient behavior. It takes about 30 min to reach 45 °C from room temperature with the stage we are using now; we hope for a much quicker response to a set point change.

If you have any question regarding this project or what is expected of you, please feel free to contact me at any time. I look forward to our meeting on or before Wednesday, September 9th, 2009.

