Turbulent Tube Flocculator

Location: Project Lab left end of bench in B60

Major findings in summer 2013

- very good design for the flocculator
- flow rate of 100 mL/s required for turbulent flow flocculation
- Coiled tube can fit in B60 (perhaps on the floor with a reshuffle of the wire rack at the end of the room)

Goal

We need to do research with a turbulent flow hydraulic flocculator. We need to test our new limited growth flocculation hypothesis under turbulent conditions to see if the model is correct and to be able to revise the model as necessary. We need to learn how much collision potential is really needed in a turbulent flow reactor. We need to learn what the best energy dissipation rate is for a flocculator. Our current design standard of 10 mW/kg is based on "a reasonable number based on conventional designs". We aren't conventional and there is absolutely no expectation that 10 mW/kg is the right number! A higher energy dissipation rate could be useful to reduce the amount of flocs that settle to the bottom of the flocculators. As the energy dissipation rate increases it should be possible to reduce the residence time of the flocculator, but the head loss will increase and that will require the entrance tank to have a higher level.

The turbulent flow hydraulic flocculator will provide us help us understand the performance tradeoffs and hopefully to develop design modifications that substantially improve flocculator performance.

The turbulent tube flocculator must be designed to easily adjust the energy dissipation rate (perhaps by varying the flow rate) and to adjust the residence time by adding or removing flocculator sections. In the turbulent flow flocculator you will be able to vary energy dissipation rates by either varying Q (in which case energy dissipation rate increases with the cube of the velocity) or by changing the dimensions of the constrictions. If you vary Q, then you are holding the collision potential constant (because energy dissipation rate increases with the cube of velocity and the collision potential is proportional to the cube root of energy dissipation rate) and as you increase Q you are decrease the residence time (and collision potential is proportional to the residence time). If you vary the constrictions the energy dissipation rate will vary and the residence time will be almost unchanged.

Next steps

The flocculator design is well underway from summer of 2013 and some components have already been purchased. The next steps are to

- finalize design for fabrication of flocculator including compression tubes, support of the tube
- **Determine if our standard solenoid valves are able to deliver 100 mL/s as they are connected to the Hollister plumbing in HLS B**

- Design and build the once through constant head, temperature-controlled water supply system. This will require a hydraulic design to make sure that you are using the right size of tubing to deliver the required flow rate.
  - This system includes manual and solenoid valves that connect to the hot and cold water supplies,
  - a method to power the solenoid valves using the control box we use with Process Controller,
  - a constant head tank where the hot and cold water will be blended and the temperature will be measured
  - A system to control the flow through the flocculator. Likely based on a constant head tank and an adjustable effluent discharge level
  - A system to measure the flow through the flocculator. Likely based on an automated "bucket and stopwatch" - tank that fills and empties based on a pressure sensor that measures water depth and a solenoid valve that drains the tank

There are two options for measuring residual turbidity. For continuous measurements a tube settler could be added and the effluent of the tube settler would be measured by a turbidimeter. This would provide information on effluent quality at a single capture velocity. The flow rate of the peristaltic pump that pulls water through the tube settler could be varied to measure the residual turbidity at different capture velocities.
The other option would be to use FReTA. Given that FReTA is a batch system that requires cycling the flocculator off and on it seems that FReTA is not the best option.