Turbulent Tube Flocculator (SWaT II) ↑

Skills: AguaClara processes, fluids, Process Controller

Tasks and goals

- Read the notes on flocculation models and in particular slides 17-51. There is also good information on how to estimate clay surface coverage starting on slide 57.
- Design and build a frame http://courses.cit.cornell.edu/cee4540/Flocculationto support the tube settler at 60°
- Design and build an adjustable effluent elevation that can be easily adjusted to achieve the target flow rate given the water level in the raw water bucket. This flow control system should be easy to adjust, should have a clear location where the water switches from pipe flow to free fall, and should eliminate the problem of having the flexible tubing collapse. This system will likely be constructed out of rigid PVC pipe.
- The PID controller for turbidity requires additional tuning. The summer research team found that it oscillated significantly and that means that the P value was set too high. See manual tuning methods for PID and adjust the P and I values to get a steady control of the turbidity at the target value.
- Remove air from the effluent of the flocculator upstream from SWaT to prevent air from getting into SWaT. The air removal system can be identical to SWaT except have the tube be vertical and pump the air and water to waste. Consider using a 1 rpm peristaltic pump for this purpose. Use the largest tubing size (#18) to achieve a flow rate of 3.8 mL/min.
- Check the calculations for the capture velocity in the tube settler.
- Design for 12 hour tests without replacing the PACl stock. Use a target range of PACl dosages that match the range as determined by the the Laminar Tube Floc team.

Experiments!!!!

The goal is to test our hypotheses concerning flocculator performance as a function of turbidity, coagulant dose, residence time, and energy dissipation rate. The first experiments should test system performance, ensure that the system produces repeatable results, and ensure that we understand how long to operate the system to arrive at steady state operation. We expect steady state operation to occur sometime between one and two hydraulic residence times counting both the flocculator and the tube settler. Devise a time efficient method of cycling through different experimental conditions with the goal of obtaining reliable and repeatable settled water turbidities. There shouldn't be any need to flush the system between tests. Thus the time for one experiment will likely be approximately 2 times the hydraulic residence time of the flocculator and SWaT system. It is likely that the entire matrix of 25 tests can be conducted in one day.

Consult with the laminar tube floc team to obtain guidance on the best range of coagulant dose. The turbidity range is 5, 15, 50, 150, 500 NTU. It should be possible to run the flocculator continuously and increment the coagulant dosages. Process Controller can also be set to increment two parameters and thus it may be desirable to have Process Controller vary both coagulant dose and turbidity to collect the entire array of experimental data. The challenge will be getting the turbidity control to work well over the factor of 100 range from 5 to 500 NTU. That range will require adjusting the stock concentration because the pump can only vary from about 2 rpm to 100 rpm - a factor of 50.

The 3rd parameter to vary is the capture velocity of the tube settler. This can be varied by changing the flow rate of the peristaltic pump that pulls the water through the effluent turbidimeter and the tube settler. A reasonable range of capture velocities to test would be 0.06, 0.12, 0.25, 0.5, 1.0 mm/s.

The tentative model for turbulent flocculation that we have derived is shown below. W is the Lambert W function, t is residence time in the flocculator, the colloid size is approximately 2 µm, Γ is the coagulant coverage of the clay, and phi is the original volume occupied by the clay and coagulant precipitate. This model does not yet incorporate the 2 phases of flocculation and thus this model over predicts performance when the term in the parenthesis is less than about 1.