High rate sedimentation

Skills: fabrication, process controller, experimental design

Big questions to answer

- Can the upflow velocity in the AguaClara sedimentation tank be significantly (factor of 2 to 10) increased without degrading performance?
- Can flocs be transported to a floc hopper when there are high upflow velocities in the sedimentation tank?
- What geometry is required for the floc blanket section of a high rate sedimentation tank?
    - Is it important that the floc blanket section of the reactor (including any internal components designed to increase floc blanket concentration) have an axis of symmetry that is vertical to eliminate excessive transport of flocs by gravity in a horizontal direction? If the floc blanket section should be vertical, then the reactor should include a vertical pipe section followed by a sloped section for the tube or plate settlers. This question is critical for the Prefab 1 L/s plant fab team because it will determine if they can use a single sloped pipe for a sedimentation tank or if they need to use a vertical section joined to a sloped section.
    - Can plates (zig zag, porous, sloped or horizontal, or other geometries) increase the concentration of a floc blanket at high upflow velocities?
    - Should the plate settlers be submerged (perhaps 2.5 cm) in the floc blanket? This might improve flow distribution through the plate settlers and might increase floc blanket concentration.
- What sets the minimum residence time of the 0.12 mm/s plate settlers?

Introduction

Sedimentation is the slowest process in the flocculation, sedimentation, filtration treatment train. The residence time of the current model of the AguaClara flocculator is about 8 minutes. The StaRS Filter residence time is about 1 minutes. The residence time for the sedimentation tank is about 24 minutes (based on version 7127 design for a 20 L/s plant). This is more than 8 times faster than the traditional 4 hour residence time horizontal flow sedimentation tank. Part of the low residence time for AguaClara sedimentation tanks is that our tanks are less than half the depth of traditional sedimentation tanks. Although this reduces the cost of construction somewhat, it is even more helpful to reduce the plan view area of the sedimentation tanks. Thus an increase in the upflow velocity through the sedimentation tanks would result in a direct decrease in plant construction costs.

Any significant further reduction in size of AguaClara facilities will likely be in the sedimentation tank. The current design sedimentation tank upflow velocity of 1 mm/s was set prior to 2010 in an effort to produce efficient sedimentation before AguaClara had invented the StaRS filter. Later that upflow velocity was determined to be in an efficient range for floc blankets. The challenge now is to invent an ultra-high rate sedimentation tank with upflow velocities between 2 and 10 mm/s. The plate settler capture velocity of 0.12 mm/s could be increased somewhat, but with a much higher upflow velocity the spacing of the plate settlers may need to be decreased and/or the length of the plates increased.

The constraint of approximately 1 mm/s on upflow velocity for the floc blanket has evolved because higher upflow velocities will produce very dilute floc blankets or no floc blanket because there

are few flocs that settle much faster than 1 mm/s. However, it may be possible to invent a whole new approach to floc blankets that will facilitate higher upflow velocities.

Plate settlers can easily have a capture velocity that is 1/10th the upflow velocity. Thus it might be possible to design plate settlers for an upflow velocity of 2 to 10 mm/s and a capture velocity of 1 mm/s. The 1 mm/s capture velocity would capture the same flocs that are normally captured by an AguaClara floc blanket.

Design objectives for the AguaClara sedimentation tank

- Low effluent turbidity (less than 1 NTU under most conditions)
- Can be taken offline for any maintenance by a single operator
- Hydraulic solids removal with zero sludge accumulation
- Floc blanket to improve turbidity removal and to improve flow distribution through the plate settlers
- High concentration of solids in the sludge to reduce the amount of water that is wasted
- The solid components of floc blanket concentrators must not occupy much volume because any volume occupied reduces the residence time in the floc blanket.

Floc blanket concentrators and sludge discharge

Maintaining a floc blanket with a higher upflow velocity will need an innovation. The preliminary results from Fall 2015 suggest that plate settlers angled at 60 degrees (not 45 degrees) could provide a mechanisms to maintain a higher concentration of flocs. However, the goal is to provide interaction between the flowing water and the flocs to generate shear and additional flocculation of colloids. The mere presence of flocs sliding down the plate settler doesn't achieve flocculation of colloids.

Thus the goal of these teams is to test potential geometries that result in colloid/floc interactions for the floc blanket section of a high rate sedimentation tank. Given that a vertical axis or plane of symmetry will likely be the best design it would be logical to test floc blanket concentrators in a vertical pipe section or in a square tank.

We have two possible methods to increase the floc blanket concentration. The first is to add some variant of plate settlers to the floc blanket zone to effectively decrease the capture velocity in the floc blanket zone.

The floc blanket concentrators should cause flocs to slide horizontally distances that are small compared with the vertical distance between floc concentrators. This will enable the falling plume of flocs to mix with the upward flowing fluid. To avoid having a net flow of flocs in a horizontal direction the floc concentrators must alternate directions.

- Design a simple geometry and experiment to test the hypothesis that sloped surfaced in a floc blanket can be used to increase the floc blanket concentration.
- perhaps divide into round or rectangular geometries or divide into porous or continuous plates
- porous plates for floc blanket thickeners that have sufficient solid area to create a capture velocity of 1 mm/s. They should also have an L/S ratio of at least 20. Porosity could be 0.5 with initial hole size set to be 1/10th of S
- Use continuous plates for floc blanket concentrators and plate setters. The floc blanket concentrator section will be shorter and the plates will be porous.

The second method to increase the floc blanket concentration is to recycle flocs from the top of the floc blanket through a floc hopper and then down a vertical tube to be resuspended at the jet reverser. This

method will require an efficient collection and concentration system for the flocs at the top of the floc blanket. The increased density of the sludge in the floc hopper should make it possible to transfer the sludge to the jet reverser with a simple tube (no pumping needed).