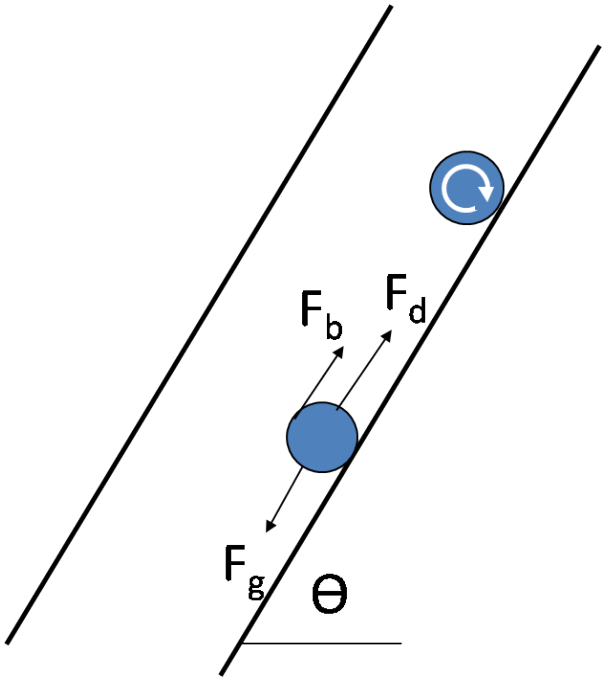
PSS Experiments with the Velocity Gradient

Abstract

The Plate Settler Spacing team is currently investigating the Floc Roll-Up Phenomenon in the tube settler. By developing a velocity gradient model, we hope to both analytically and experimentally determine the critical velocity floc particles experience when they begin to roll up the settler tube and into the effluent rather than settling back down the tube and into the floc blanket. The critical velocity is determined using a force balance for a floc particle. In addition to determining this critical velocity, we hope to understand how properties of the flocs themselves affect floc roll-up.

Overview of Methods



When fluid flows through a cylindrical tube its velocity relative to the walls changes as a function of the tube radius. In general, this velocity distribution is parabolic: the greatest velocities are achieved at the center of the tube (where R=0) eventually tapering off to 0 at the walls. The parabolic nature of the distribution arises from cylindrical symmetry and that the fluid does not move at the walls (the "no-slip" condition).

This gradient in the velocity profile contributes to the force that a floc rolling up the edge experiences, it creates a drag force acting on the edge of the particle closest to the center of the tube, which is one of three forces included in the force balance on the particle. In smaller diameter tubes, the velocity gradient will have a greater slope increasing the local velocity a particle of the same size will experience on the side closest to the center of the tube. This discrepency between the no slip condition at the wall and the velocity experienced on the side closest to the center of the tube in some cases may be great enough to cause floc roll-up.

Flocs actually begin to roll up when the forces that would cause a floc particle to move up into the effluent exceed the gravity force that sends the floc particle back to the floc blanket. The velocity experienced by the floc particles at the point at which they begin to roll up the tube rather than settle out is called the critical velocity. The settling velocity of a floc particle is dependent on floc diameter and floc density. Conversely, the critical velocity a floc experiences is dependent on floc diameter and the inner tube diameter.

Theoretical Analysis of the Velocity Gradient

Ramp State Experiment