Floc Filtration

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Abstract

Filtration performance is strongly dependent on the size distribution of the particles entering the filter. Increasing the size of the influent particles dramatically improves removal efficiency. Filter performance is thus limited by the fraction of particles that have the smallest diameter. Overall plant performance is thus strongly influenced by the size distribution of the particles that arrive at the filter.

- Skills: Fluids, Process Controller

1 Introduction

The filter at Tamara, Honduras tends to perform much better than the laboratory filters at Cornell. One possible explanation is that the Tamara filter is receiving settled water that was well flocculated and thus the particles that make it to the filter are not primary particles, but are small flocs. This observation led to the hypothesis that better flocculation (and possibly floc blankets) could improve filter performance and that the energy dissipation rate between the sedimentation tank and the sand bed should be kept low enough to prevent floc break up. The goal of this research is to test the hypothesis that the energy dissipation rate in the filter influent line controls filter performance. These results will facilitate generation of a comprehensive performance model for a drinking water treatment plant.

During the Spring of 2012 a team of students conducted preliminary research on the effect of the energy dissipation rate on filter performance (see theirfinal report). Mickey Adelman conducted additional experiments during over the summer.

We need a good set of data that we can publish and that we can use as the basis for creating the comprehensive drinking water treatment plant model. We have preliminary evidence of a correlation between energy dissipation rate and filter performance. Now we need to conduct a carefully controlled and well designed set of experiments. The colloid concentration at the end of the flocculator can be predicted using our new flocculation model.

$$t = \frac{1}{G\Gamma} \frac{V_{Capture}}{\eta_{Coag}} \left(\frac{\rho_{Colloids}}{C_{Colloids}} \right)^{\frac{2}{3}} ln \left(\frac{C_{Colloids_0}}{C_{Colloids}} \right) \tag{1}$$

where $C_{Colloids}$ is the concentration of colloids that can not be captured in the sedimentation tank, G is the average velocity gradient, t is time in the flocculator, Γ is the fractional coverage of the colloids by coagulant,η_{Coag} is currently determined empirically for each coagulant, and $V_{Capture}$ is the capture velocity of the plate or tube settlers. Determine the conversion efficiency from colloids to flocs with the current tube flocculator and if the flocculation efficiency is comparable to the expected filtration efficiency, then either reduce the filtration efficiency (decrease the sand depth) or increase the flocculator efficiency by increasing the flocculator length so that the flocculator efficiency won't influence the filtration efficiency. The goal is to have the floc size set by the energy dissipation rate in the orifice upstream from the filter rather than by the flocculator. If too many colloids are present exiting the flocculator, then the filter performance will be poorer because the colloids are smaller than the broken up flocs.

Evaluate the possibility of using orifices to set the energy dissipation rate and hence the floc size entering the filter and compare with the current setup of a needle valve.

Vary the energy dissipation rate over a wide range and test the influence of energy dissipation rate on filter performance. An approximate relationship between floc size and the average energy dissipation rate in a laminar flow flocculator was obtained by (Tse, et al).

$$\varepsilon = \left(\frac{D_{Floc}}{75\mu\text{m}}\right)^3 \frac{W}{kg} \tag{2}$$

Also vary the coagulant coverage of the colloids, Γ, by adjusting the coagulant dose. This will influence the strength of the flocs and hence the size of the flocs after exposure to high energy dissipation rate and the attachment efficiency in the filter bed.

Create plots of filter performance as a function of energy dissipation rate and coagulant coverage of the colloids. Compare the measured values with predicted filter performance.