Turbulent Flocculator

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Abstract

Our flocculation research has been conducted using a laminar flow tube flocculator. Our goal is to create a turbulent flow flocculator performance model and to do that we need to conduct performance studies using a turbulent flow flocculator.

- Skills: Fluids, Plumbing Design, Fabrication

1 Introduction

AguaClara plants use turbulent flow hydrualic flocculators.

$$S = \left(\frac{K_B}{H\varepsilon_{Max}}\right)^{\frac{1}{3}} \frac{Q}{W} \tag{1}$$

In the above equation S is the spacing between baffles, H is the distance the water travels between baffles (depth of water in a vertical flow flocculator), K_B is the head loss coefficient for flow around a baffle, W is the width of the flow, and Q is the flow rate.

$$\Pi_{HS} = \frac{H}{S} \tag{2}$$

If we assume the flow passage is square then

$$W = S \tag{3}$$

Substitituing and solving for the flow rate Q we obtain

$$Q = \left(\frac{S^7 \Pi_{HS}\varepsilon_{Max}}{K_B}\right)^{\frac{1}{3}} \tag{4}$$

Alternately, in terms of velocity we have

$$V = \left(\frac{S \Pi_{HS}\varepsilon_{Max}}{K_B}\right)^{\frac{1}{3}} \tag{5}$$

The Reynolds number constraint for turbulent flow will set the minimum value of velocity and flow dimension and that will set the minimum flow rate for a turbulent flow flocculator

$$Re = \frac{S}{\nu} V \tag{6}$$

Substituting 5 into 6

$$Re = \frac{S}{\nu} \left(\frac{S \Pi_{HS} \varepsilon_{Max}}{K_B} \right)^{\frac{1}{3}} \tag{7}$$

Solving for the minimum flow dimension, S

$$S = \left(\frac{(\nu Re)^3 K_B}{\Pi_{HS} \varepsilon_{Max}} \right)^{\frac{1}{4}} \tag{8}$$

The minimum flow dimension for a turbulent flow flocculator is approximately $3.7\,cm$. Substituting 8into 4

$$Q = \left(\frac{(\nu Re)^7 K_B}{\Pi_{HS} \varepsilon_{Max}} \right)^{\frac{1}{4}} \tag{9}$$

The minimum flow rate for a turbulent flow reactor is about $110\,\mathrm{mL/s}$.

2 Challenge

Design, fabricate, and instrument a new apparatus to test turbulent flow flocculation in the laboratory. The apparatus must have the capabilities of the laminar tube flocculator including raaw water turbidity control, flow rate control, and FReTA for measuring residual turbidity. It is likely that the laboratory water supply can not provide $110\,\mathrm{mL/s}$. If that is the case, then devise a method of recycling the water and adding enough base to counteract the addition of coagulant.

The fabrication of the turbulent flow flocculator will require special consideration. One option is to use a pipe of diameter larger than $3.7\,cm$ and create a string of balls with the balls designed to occupy 60% of the flow area of the pipe.

The turbulent flow flocculator apparatus could be set up near the sink in B60A.