Stock Tank Mixing Reflection Report 1

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AguaClara Reflection Report

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Abstract

The Spring 2011 Stock Tank Mixing Team is tasked with improving the current stock tank mixing system in AguaClara plants. We are conducting experiments with aluminum sulfate (alum), polyaluminum chloride (PACl), and water. The team's objectives include determining the range of acceptable concentrations the stock solution can be, analyzing and improving the efficiency of the existing mixing system, and designing a new mixing system for use on future plants. Thus far, we have conducted experiments testing different ranges of concentrations with alum, designed several types of mixing systems, and begun small scale testing one of the mixing system designs.

Keywords: stock tank, mixing system, aluminum sulfate, polyaluminum chloride

Introduction

The Spring 2011 Stock Tank Mixing Team has approached the problem of efficient stock solution mixing from the standpoint of minimizing operator effort. Currently, the primary method of homogenizing alum or PACl with water is simply to pour the appropriate amount of either chemical into a 55 gallon drum of water. The operator then stirs the solution with a wooden paddle until visible grains of alum or PACl are no longer visible. This method requires a large amount of effort on the part of the operator. Perhaps more importantly, this method does not guarantee that that all of the coagulant will fully dissolve. It has been observed that the coagulant will tend to settle and fully saturate the layer of water at the bottom of the tank. Any coagulant that settles to the bottom will therefore require more effort to dissolve. Additionally, different layers of concentrations within the tank may exist: the bottom-most layer will be the most concentrated and the top-most layer will be the least. **We hypothesize that a mixing system that fully dissolves the coagulant with a volume of water at a point above the water level in the tank and allows that coagulant solution to pour into the tank will help alleviate the problem of partially-homogenized solutions and concentration gradients.**

Experimental Design

The primary design we are testing is the "double bucket" design. This involves filling a holding container with pores that line the bottom and sides with coagulant. The container is then placed inside another larger container. This system allows the system to be continuously submerged in water (Figure 1).

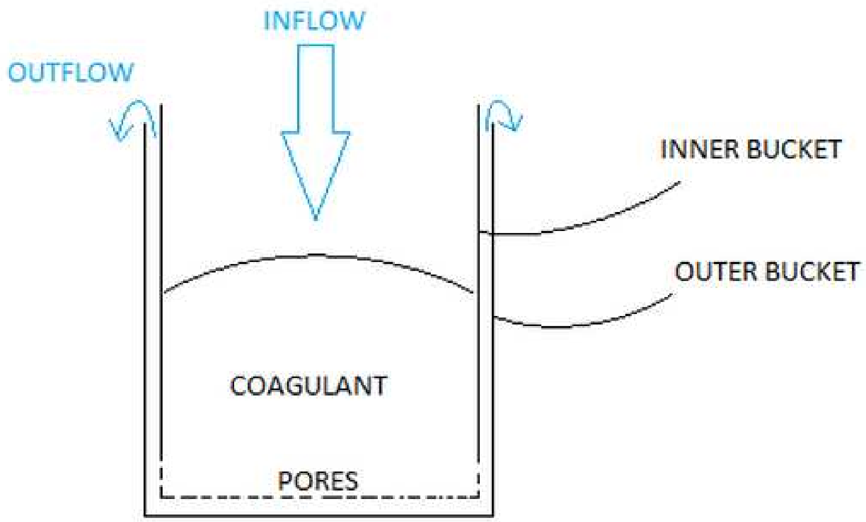

Figure 1: Double bucket design schematic.

As the primary purpose of the outer bucket is to maintain a constant water level in the device, we have so far focused most of our testing on the inner bucket. Variables that affect the efficiency of the mixing process in the device include the following:

- The thickness of the layer of coagulant
- Rate of Inflow and The diameter of the "bucket", which means the Velocity of Flow
- Type of coagulant (PACl vs Alum)

The Stock Tank Mixing team has begun analyzing the effects different pore sizes and different coagulant depths have on mixing. The ultimate goal is to discern the optimal values for all variables. This will allow for the most efficient mixing.

Our main method of testing thus far has been using PVC pipe with varying sizes of filter paper attached to the bottom. The alum is then placed inside the pipe. Then, keeping the flow roughly constant by keeping the water level in the bucket constant, we can measure what concentration has been achieved.

Different diameters of pipes have also used for testing different depths of the coagulant. A wider, shallower container corresponds to a smaller depth, while a narrower, deeper container means the depth of the coagulant will be greater.

Results and Discussion

The Stock Tank Mixing team has confirmed that alum that is saturated with water can become a taffy-like substance that is difficult dissolve. To prevent this from occurring, we have concluded that alum should always be submerged. Therefore, the bucket should be filled with water first and then put the alum granular in.

The experiment shows that the double bucket mixing system works with alum. With that experiment we got the outflow to be approximately 50 g/L average concentration. Further testing also showed that the dissolution rate decreased with the reduction of available alum, which means a reduction of the total granular surface area.

Our hypothesis for this occurrence is as follows: As the dissolving of the alum continues, the thickness of alum layer getting smaller. This decreases the amount of time spent by the water passing through the alum layer. This in turn means the water has less time in contact with alum.

We have first experimented with a 1.1 inch inner diameter pipe and 0.22 micrometer pore size filter paper. We started with 50 grams of alum and it took 1 liter of water to completely dissolve the alum. This is because with the 1.1 inch diameter, the 50 grams of alum could only form a shallow layer, thus resulting in not enough water contacting it.

For the experiment performed with 0.55 inch inner diameter pipe and 0.22 micrometer pore size filter paper, the outflow concentration was higher. We used 200 milliliters of water to dissolve about ⅔ of the solid. However, because the alum layer was much thicker in this experiment, the head loss through the pipe increased. As a result, the flow rate through the pipe was lower.

From the experiment results, we hypothesize that the two main factors that affect the efficiency of the double bucket system would be the thickness of the granular layer and the flow velocity through the granular. A thicker layer of granular and a higher flow velocity will lead to higher efficiency. However, the thicker the granular layer is, the higher the head loss will be. And a greater head loss will lower the flow velocity, given limited head available.

Future Work

The Stock Tank Mixing team will continue testing with the same diameter pipe but with varying thicknesses of the layer of alum (amounts of alum) to determine the correlation between the thickness of that layer with the outflow solution concentration. To do so, we will need to determine the optimal pore size to maximize the effluent concentration.

Meanwhile, we will continue to search for mixing guidelines and implementable theory for our experiments.

Team Reflections

Our team has made progress over the last several weeks. As stated above, preliminary experiments have been promising but there is still a lot of research that needs to be done. Most of the problems we have been encountering so far have been equipment and supply issues.