Stock Tank Mixing Spring 2011 Reflection Report 3

Authors: Chris Inferrera, Jae Lim, Boyang Mao

Primary Editor: Christopher Inferrera

Secondary Editors: Jae Lim, Boyang Mao

AguaClara Reflection Report

Cornell University

School of Civil & Environmental Engineering

Ithaca, NY 14853-3501

Date Submitted: 15/04/2011

Date Revised: 15/05/2011

Abstract

The Spring 2011 Stock Tank Mixing Team is responsible for researching and improving the current mixing system installed in AguaClara plants. Our team has currently been researching the properties of granular PACl to determine the necessity of a new PACl mixer for the 55 gallon tanks and Rotoplas tanks used at AguaClara plants. We are also developing a MathCAD file which will be able to calculate the minimum energy input required to fully homogenize a solution of PACl a stock tank. Another goal that our team has that is contingent on the completion of the previously mentioned goals is to develop operator guidelines on mixing PACl solution thoroughly. The team is also actively searching for potential granular PACl suppliers for the teams to use.

Keywords: polyaluminum chloride, stock tank mixing, energy difference, mixing guidelines, suppliers

Introduction

The Stock Tank Mixing Spring 2011 team has been working on improving the current mixing system in place at AguaClara plants in Honduras. Our team has been working primarily with PACl (and previously alum) with the goal of creating a mixer that would allow for efficient creation of coagulant solutions. Several things have changed, however, compared to when we started our research at the beginning of the semester.

After receiving information regarding the current mixing system used in Honduras from Mr. Antonio Elvir, an AguaClara technician, we had to significantly change our focus of attention. Antonio informed us that the mixing tool (a length of PVC pipe) for the 55 gallon drums was, in his opinion, adequate and there was no need to design a new mixing device. He has also informed us that the mixing device used for Rotoplas tanks was slightly more complex than that of the 55 gallon tank, since it has a blade mixer which allows for more efficient mixing. The purpose of these blades is to incorporate vertical mixing (forcing solution at the bottom of the tank to the top) and increase the amount of turbulence created when the mixing device is used as the Rotoplas tanks are larger than the 55 gallon drums. Antonio gave us his opinion in that the blades are a necessary feature of the Rotoplas mixing system. As such, one of our new team goals is to assess the efficiency of the Rotoplas mixing design and improve it or redesign it as necessary.

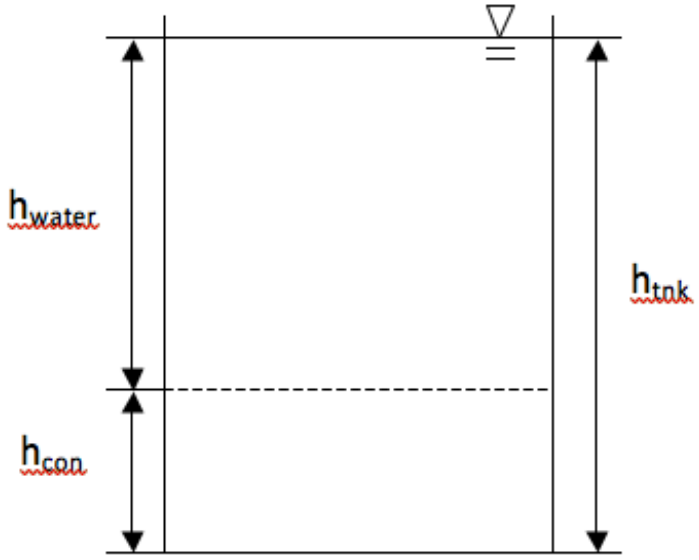
Antonio also mentioned that the PACl that they are using at AguaClara plants is not always the same brand. Depending on where the PACl was manufactured, there is the possibility of a variation in the size and shapeof the granules. In addition, although Antonio didn't explicitly state this, if there is variation in brand of PACl, there is the possibility that the percent PACl in the formula is not constant. This may be important if accurate dosing is to be achieved.

Another important piece of information given by Antonio was the detailing of what happens to 55 gallon drums after they have been emptied of solution. While we previously believed that the barrels were immediately refilled with solution, it turns out that they are actually completely emptied and cleaned before being reconnected to the system and used again. This is important as it may mean that there is unnecessary waste occurring during the cleaning process. It also means that if PACl is added before the water is, the turbulence created by dumping water into the barrel would aid in mixing.

This information from Antonio along with the facts that AguaClara is switching to PACl and PACl is quite easy to dissolve (these last two were discussed in detail in Reflection Report 2), means that our team has redefined its focus. Our team is attempting to obtain a 55 gallon drum to run full scale mixing experiments, get more information from Honduras on the Rotoplas mixing system, and formulate a set of mixing guidelines. In addition, we will continue contacting suppliers of PACl and learning more about this coagulant.

Experimental Design

The Stock Tank Mixing Team has created a MathCAD file for the calculation of the potential energy difference between a tank of fully homogenized PACl solution and a tank with a layer of un-dissolved PACl at the bottom and pure water at the top. This MathCAD file will help give us an approximation for the minimum amount of energy required to fully homogenize a solution of PACl. A critical piece of information that we have not yet obtained is the correlation between density and concentration of PACl.



The potential energy of the concentrated salt layer ($E_{SaltSoln}$) is a function of the salt density ($\rho_{ConcSoln}$), area of the tank (A_{Tank}), the ratio of the concentrated solution volume and the total volume (r_{Soln}), the height of the tank (H_{Tank}), and gravity (g) (Equation 1).

$$E_{SaltSoln} = \rho_{ConcSoln} * A_{Tank} * r_{Soln} * H_{Tank} * g * \frac{r_{Soln} * H_{Tank}}{2} \quad (1)$$

The potential energy of pure water layer (E_{Water}) is a function of the density of water (ρ_{Water}), area of the tank (A_{Tank}), the ratio of the concentrated solution volume and the total volume (r_{Soln}), the height of the tank (H_{Tank}), and gravity (g) (Equation 2).

$$E_{Water} = \rho_{Water} * A_{Tank} * (1 - r_{Soln}) * H_{Tank} * g * (r_{Soln} * H_{Tank} \frac{(1-r_{Soln})*H_{Tank}}{2}) \quad (2)$$

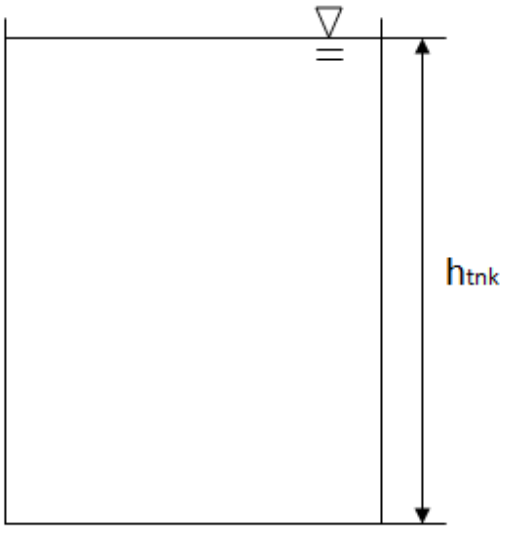
The total potential energy (E_{Total}) is a function of the potential energy of the concentrated salt layer ($E_{SaltSoln}$) and the potential energy of the pure water layer (E_{Water}) (Equation 3).

$$E_{Total} = E_{SaltSoln} + E_{Water} \quad (3)$$

After mixing the two layers, the potential energy of the homogenized mixture (E_{mix}) is a function of the final mixed density (ρ_{final}), area of the tank (A_{Tank}), height of the tank (H_{Tank}), and gravity (g) (Equation 4).

$$E_{mix} = \rho_{final} * A_{Tank} * H_{Tank} * g * \frac{H_{Tank}}{2} \quad (4)$$

Sketch of the homogenized solution system:



By giving a specific tank volume, tank height, desired final concentration and the assumed ratio between the height of the concentrated solution layer and the height of the tank, the file can calculate the potential energy difference between the two states.

We have designed a small scale test for the tube mixing system. We will have specified an amount of concentrated salt solution and adjust the density of the solution to be the same as the PACl solution we have in the “worst case scenario”. The concentrated salt solution will be set at the bottom of a small bucket with specified amount of clear water at the top.

As the concentration and the volume of the concentrated salt solution and clear water are known, we can calculate the final concentration of the homogenized solution. At the end of the mixing, we can take the top layer of the solution and measure its density; if the density agrees with the density of a homogenized solution, then the solution is fully homogenized. We can also dissolve small amounts of red dye in the high concentrated solution, in order to visually keep track of the mixing process and judge the degree of homogenization of the solution.

Results and Discussion

We have not yet obtained results from the potential energy difference MathCAD file. This is because the PACl information we have received from liquid PACl suppliers only includes the density but not the concentration of their product. Therefore, we do not have a function to turn the concentration to the corresponding density.

Experimentation with a small bucket could provide information on how the 55 gallon drum system works and would cost less in terms of salt, red dye, and time. With the information we get from the bucket experiment, we can go on with the full scale experimenting with the 55 gallon drum.

Regarding any experimentation done since the last Reflection Report, there is not much to comment on since the amount of experimentation has been very small. Instead, our team has focused much more heavily on literature review, discussion of options, and information gathering. Although it may seem regretful that more experimentation has not been done, the team has been very busy figuring out exactly what should focused on for the rest of the semester, and how to approach these goals.

Future Work

The goals for our team have not changed drastically, but our approaches to completing those goals have. The main objectives for the Stock Tank Mixing Team now is to provide mixing guidelines for PACl solution and examine the Rotoplas mixing system with the intent of improving it if possible. An impeller type mixing device may or may not be used. In the following weeks, we will test the PVC pipe mixing system currently in use in Honduras on a small scale using a bucket and a concentrated salt solution and red dye. This will simply be a precursor to full scale testing with the 55 gallon drum. After a 55 gallon drum is secured for testing, we will be able to figure out the efficiency of the PVC pipe mixing system, and using this information, together with the potential energy difference calculation result, we will be able to provide a set of mixing guidelines.

At the same time, the Stock Tank Mixing Team will continue to investigate the physical properties of PACl solutions in order to get more accurate calculation results and to determine a feasible concentration range of coagulant solutions for AguaClara plants to use. We will also continue to contact granular PACl suppliers to find the most economical way for AguaClara to get a PACl sample for experimental usage.

Team Reflections

The team has been making progress in researching PACl and its usage in Honduras. Mr. Antonio Elvir, an AguaClara technician in Honduras, has given us invaluable information for the past few weeks. He informed us how PACl is currently mixed in the 55 gallon tanks and the Rotoplas tanks and what his thoughts are on how the mixing system could be improved. He and Sarah Long, an AguaClara engineer in Honduras, will send us a video in the coming weeks of how PACl is mixed in the 55 gallon barrel which will give us an idea of the efficiency of their current mixing processes.

Our team leadership dynamic has changed over the last couple weeks. Chris Inferrera is now in charge of submitting, editing, managing all reflection reports and the final draft. Boyang Mao is in charge of designing and managing the final presentation.