Floc Hopper Probe, Fall 2015

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December 11, 2015

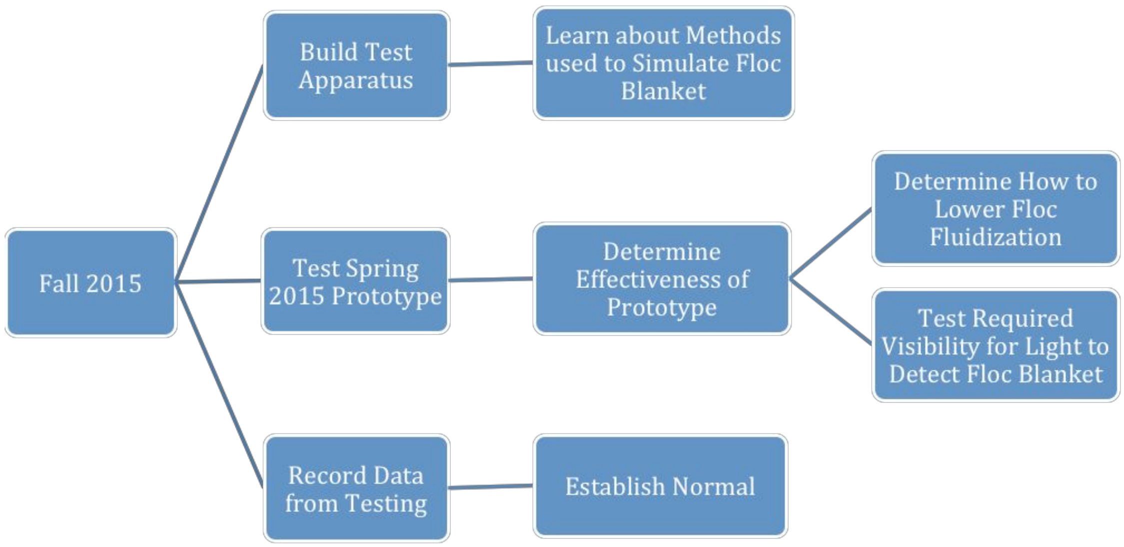
Abstract

The floc hopper probe team aims to create a fully functional floc hopper probe design for future visits to Honduras and elsewhere. Currently, very little information is know about the location or condition of the floc blanket in the floc hopper. This year's research should lead to a better understanding of the events preceding sedimentation as well as more details on the location of the floc blanket inside the hopper. An experimental setup was created to test different floc hopper probe designs and observe which one gave accurate readings. This year's team contributions include: a final design of the floc hopper probe and an assembling manual for the current probe design. The team has tackled the problem in the lab and now field testing is required for further improvement of design.

Table of Contents

Task List

Task Map



Task Details

1. Build Test Apparatus/September 18th - Miguel Castellanos. This task will require research and communication with other subteams in order to develop an accurate floc blanket suspender apparatus for testing purposes. Miguel, who has been assigned as the Materials Coordinator of the team, will be responsible for acquiring the necessary materials to bring forward this design so one may begin testing floc hopper probe prototypes.
    a. This will allow people to gain a deeper understanding of how the floc blanket behaves inside the floc hopper. The main focus of this will be to try and recreate, to the best of our abilities, the processes that are taking place inside a floc hopper.
2. Test Spring 2015 Prototype/September 18th-25th - John Lopez. The team will begin testing a prototype that was left by the last group. Of course, this is contingent on how fast the current team is able to create a floc blanket simulant.
    a. Appropriate adjustments will be made to any current design if something new is discovered about the properties of the floc blanket or any issues with the prototype.

b. Determining how to lower the floc fluidization will follow testing the current probe design. Again, this will require the team to construct a test apparatus first in order to observe if the current probe is displacing the floc in the system and giving an inaccurate reading.
c. This semester, the team would also like to look into the required visibility of light to detect floc blanket. This will be carried out and analyzed through a series of experiments using the floc blanket simulation, Casey Garland was kind enough to provide the team with a clay-flocculant mixture from her research.

3. Record Data from Testing/September 25th- October 2nd - John Lopez. Our project will rely on constant testing and modifications to the probe design to ultimately present something that works at the treatment plants in Honduras and elsewhere. The purpose of conducting various test is to identify a normal for our device that will allow the user to precisely know the level of the floc blanket inside the floc hopper. Accuracy will be a large component to our project and our final design.
4. Rebuild/October 2nd - Miguel Castellanos. To design specifications and continue getting more videos to analyze for the purpose of assessing the new model.
5. Document/October 2nd to December 9th- John Lopez. Use videos to better understand the possible situations one might encounter in the floc hopper. Use this data to address any known problems. Innovations to the design will be made as needed once sufficient data has been gathered to establish a baseline for success. Also write down instructions to replicate our work.

Introduction

This project sees to build a tool that can be used to better understand the height of the floc blanket. Having a better sense of the floc blanket height will allow operators to observe if any relationships between floc blanket height and poor plant performance exist. Operators currently lack any information except that the blanket does exist. This simple tool will help operators working with AguaClara, and potentially outside, to find the height of the blanket. This will also alert the operators to any issues if the blanket is not forming properly.

Literature Review

The Spring 2015 team compiled information on sonars and other methods currently used at wastewater and water treatment facilities to measure the floc blanket. The floc blanket is a concentrated, stabilized, suspended bed of flocculated particles with a relatively clear effluent layer above. While in other areas, companies have been known to use sonar to getter a better picture of the blanket, utilizing a light source proves to be a far more feasible approach for the scale of the project. Although efforts have been made, it is clear that there is still a limited understanding of the floc blanket. Different factors limit the creation of flocs, such as high shear velocity on different sized particles as well as the main factor in floc creation, which is energy dissipation often caused by fluid expansions. (Weber-Shirk 2015)

Previous Work

The probe team from last fall spent a significant amount of time researching different ways to develop something to acquire information about the blanket. (Weber-Shirk Flocculation powerpoint) Their design did not work because it caused too much water to be displaced, and the previous idea seems to have rejected using sonar in order to keep costs low. This semester the team is changing the scope; working diligently to create a simple and affordable tool that can be used to collect a floc blanket height and return very basic data about its location.

Methods

The probe team used cameras and a simple understanding of fluids to try and create a working probe. One major change from last semester is that a plastic cut out, currently cylinder but in the first prototype a cone, from a water bottle is being utilized to prevent flocs from being pushed away from the light source at the end of the probe. This adjustment helped condense the flocs on top of the light source, giving a clear indication of the location of the floc blanket. The team made sure that there were holes above the cone so water can flow up through the cone shape and condense the flocs over the light source. The next step is to begin working on constructing for plant specifications including an approximate diameter of 5 cm (2 in) for the cone and pipe.

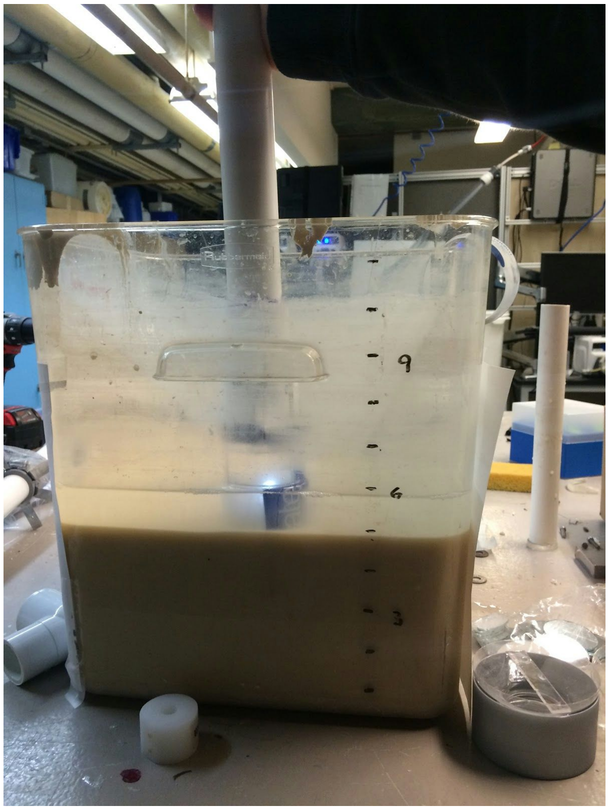


Figure 1:Floc Hopper Probe Testing Apparatus

The second prototype has already established success with a 13 cm (5 in) diameter cylinder and the change in diameter was later proven to not affect the success of the apparatus. The change to a cylinder occurred to make better use of the diameter that the device is constrained by. It was found that this change had no noticeable effect on the accuracy of the device. The parameters that need to be met for a floc blanket to form include continuous upflow velocity to suspend particles, which is the main factor that is addressed through geometry and design. In design, the model will need to be around 203 cm (80 in) or so in order to extend far enough into the floc hopper. The probe should be extendable so that small adjustments can be made if needed. For the sake of testing, the model we are using is 101.5 cm (40 in). The current model, which utilizes a cylinder shape rather than a cone with specific hole cut in the plastic above the light, is as seen below:

Figure 2: Floc Hopper Probe (Final Design)

Figure 3: Probe with PVC Cover, Light Source and Plastic Cylinder Removed (Exposing Lense)

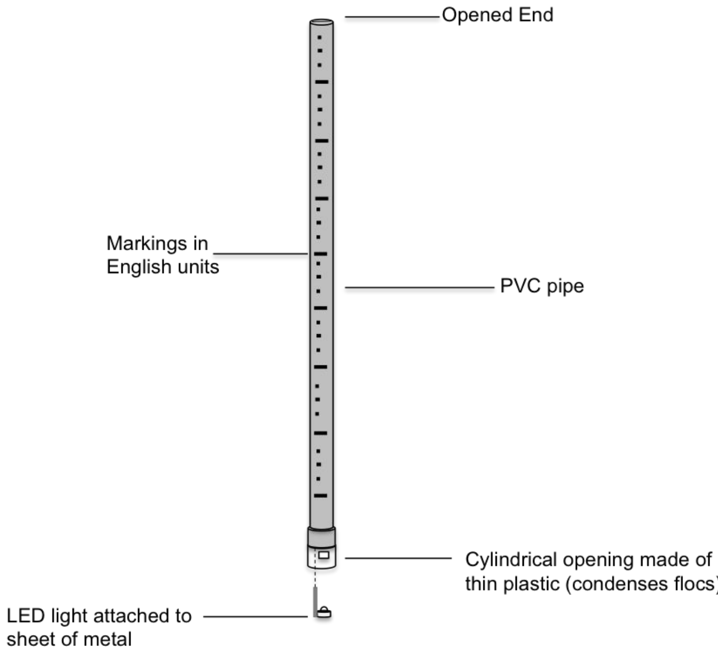


Figure 4: Floc Hopper Probe Schematic

For this design, being able to detect the top of a floc blanket in the probe would give the operator information about the height level and be able to adjust the valve that removes sludge to drain at a constant rate similar to the rate of deposition. Tests are being done by submerging the apparatus in water with a settling floc suspension to observe the light until it is covered. When a measuring scale is added to the side, the operator will know how deep the blanket is. Performance is measured with video feed that shows when the light disappears from view and how long it takes the operator to notice the difference.

Figure 5: Initial Floc Hopper Probe Design in Comparison with Current Design

Transcription of instructions has begun and work has been done to create a measurement system built into the side of the probe. Fine tuning these two things and possible testing in a plant at Cornell are being done in preparation of a prototype being used in Honduras as early as January 2016. A complete product will be developed and manual will be transcribed. Further precaution will be taken as one of the members of the team will be going to Honduras, and being fluent in Spanish, will be able to help those on site troubleshoot and design problems.

Construction Instructions

Below are construction instructions for the floc hopper probe:

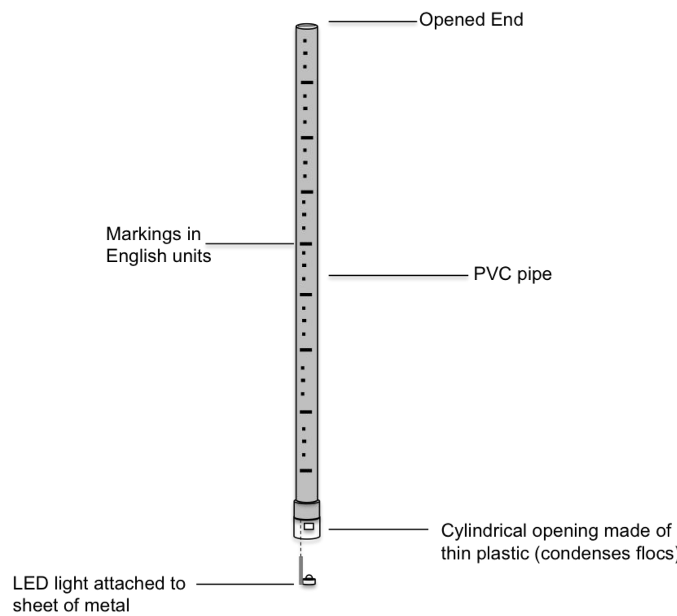
Floc Hopper Probe

Materials:

- 2 pieces of 1” diameter PVC pipe 40”
- 1 1.75” of 1.5” diameter PVC pipe
- 1 plastic bottle, preferred straight sides, or perfect cylinder
- 1 lens in a threaded pipe (see prototype)
- 1 12”x.5”x.028” steel metal bar
- 1 LED in waterproof casing
- 3 10/32 stainless steel screws 1/4th of an inch
- 1 stainless steel wire clamp (2” diameter)
- 1 female to socket weld adapter
- 1 Compression PVC coupling
- Epoxy

Tools:

- PVC primer and cement
- 10/32 tap
- Drill bit for the tap
- Drill bit for flushing
- Drill
- Saw for cutting PVC
- Teflon tape
- Masking tape



1. Make a cut in the 1.5” pipe parallel to the pipe itself. Cut only one side, this is done to expand the diameter.

2. Take a female to socket weld adapter and tape 2-3 layers of masking tape around the threaded end on the outside to increase the outer diameter. Then expand the cut piece of PVC over the top of the outside of the female threaded pipe and tap 3 holes for the screws.

3. After making sure that the screws fit, take the pipe off the adapter and take the lens and wrap Teflon tape around the threads and secure it within the threaded female side of the adapter. Then secure the 1.5” pipe over the top and screw it in place.

4. Then take one of the 1” pipes and cement the adapter on and a male adapter to one end.

5. Take the bottle and cut out the cylindrical part of the bottle. Then cut this straight down the side similar to the pipe. (This must be able to wrap completely around the lens end of the pipe.

6. Cut 2 rectangles in the plastic near the top with about 1/3” away from the top. Each rectangle must be approximately 14/16 of an inch height and 1 and 3/8 inch width. This must be the open area when the plastic wraps around the lens end of the pipe.

7. Then fold 1” of the metal bar at a 90 degree angle to the rest of the bar. Then secure the light on the 1” space of the bar with epoxy.

8. Wrap the plastic around the lens end of the pipe and mark it, remove the plastic bottle, and place epoxy on the overlapping sides to secure it in place, to ensure the diameter doesn’t change while drying use the hose clamp to hold it in place.

9. After it dries secure the long end of the metal piece with the light angled up towards the lens (as shown in the diagram) and place the plastic shield over the top with the holes that were cut positioned so that the light bulb is lower than the bottom of the openings, and secure both over the expanded pipe with a wire clamp.

10. Then set a mark indicating where the light fixture (the metal bar) needs to be with respect to the pvc pipe.

11. After this measure from the top of the light and mark every 10 centimeters until one meter. Make marking on the extension pipe.

12. Then to take measurement of the floc level in the hopper insert the pipe into the opening created over the floc hopper, with the light on, and lower the pipe slowly into the water. After it is in the water, lower until you reach an abrupt change in luminosity. At this point look at the marking on the sides of the pipe that indicate the height from the light. This indicates the height of the interface between flocs and water.

Hopefully this design will allow operators to turn on the light through the holes at the top of the plastic and also be easy to measure the top of the flocs in the floc hopper probe. Spanish translation coming soon.

A periscope was made to increase the ease of use for the operator, using a 90 degree PVC joint, tape, and a mirror. Tape was used initially so that this can be used in Honduras and the risk of gluing the mirror in at the wrong angle would mean there was a loss of supplies that the team did not want to risk.

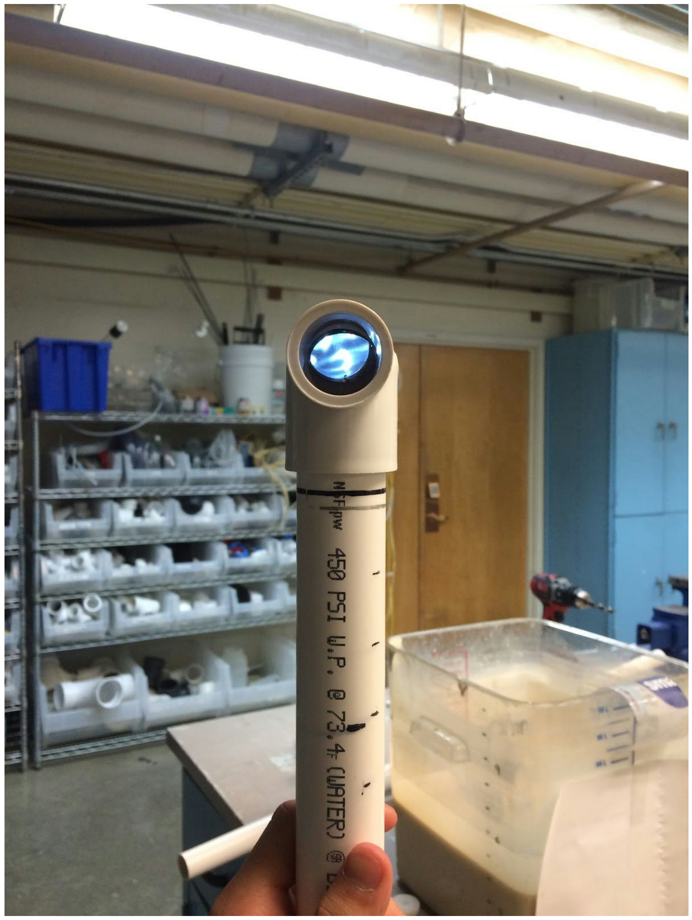


Figure 6: Fall 2015 Periscope Design

Another piece still in development is a device that prevents the probe from falling in the hole and allowing retrieval by expanding the diameter. To to this metal bars were cut and folded so they would fit within a rubber compression coupling held in place by a hose clamp. The sharp edges were filed down and tape was put over it to decrease the danger to the operator. The team members have decided this project would be easier to tackle next semester.

Analysis

Various tests were conducted on the three different designs that were manufactured this fall. The first design, which was left behind from the 2014 team, was not very effective. The lack of instructions for this design also made it very difficult to understand exactly what their specific design was meant to accomplish. The apparatus was tested on the sludge but ultimately failed to provide the users with any details on the location of the floc blanket.

Figure 7: Initial Floc Hopper Probe Design

As water is displaced due to an object entering water, the water being acted upon by a force gains some velocity radially outward. The greater the amount of water displaced, the more force that is pushing on the water to move out of that space, therefore the resulting velocity was disturbing the settled flocs and making the first prototype ineffective. To negate the effects of this a cylinder, in the current design previously a cone, with thin walls is used to displace such a smaller amount of water so that it does not create a large velocity change. The effect of minimal velocity change and the physical barrier prevents the flocs from being displaced and instead forces them into the path of the lamp.   This is made possible water flowing through the cone, or in our current design cylinder and out of the holes placed beneath the lens. To prevent the flocs from being substantially disturbed, a probe with a conical tip was implemented. The idea behind this was that the cone shape would force the flocs to condense and flow up over the light. In creating a smaller diameter cone, less water would be flowing up through the holes and reduce the velocity of the parcels of water.

Figure 8: Progression of probe tips to condense flocs (from left to right)

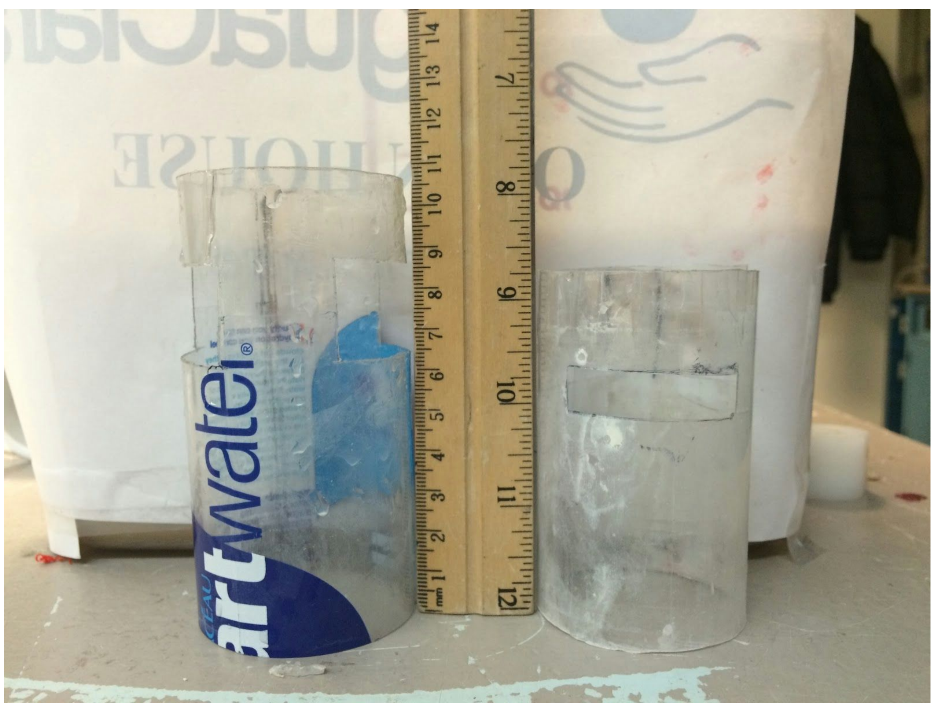


Figure 9: Cylindrical Condensers, Current Design (left) and Previous (right)

The cone designed proved to be rather difficult to manufactured and quite inconvenient, therefore the team moved forward with a cylindrical shape instead. The purpose of the cylindrical shape was to reduce the diameter of the shield. This cylinder was tested and once it proved to be effective, this was the preferred model. In order for this design to work properly, the blanket in the floc hopper needs to be at least 4 centimeters tall due to the height of the plastic which adds distance from the base of the probe to the light source. Although it has been observed that people with large fingers may struggle turning the light on without taking the shield off due to the distance between the plastic and the light.

Conclusions

The second prototype design worked very well because it was able to signal the operator within a millimeter or two of the top of the floc blanket height. From here, more tests will be conducted using a cylindrical shape to observe any differences. Although the flocs are still being disturbed, in no way does it impede the results of seeing the floc blanket heights. It is concluded that the next step is to keep innovating the design by studying the flow of water around the device in order to make this tool into something operators can use with consistent effects. Fine tuning and developing a way to measure the height of the floc blanket is all that is required now.

Future Work

The plan of action is to develop the plant-specific probe and work on getting data from video and testing. An attempt to develop a system of measuring the height in a sedimentation tank is the next objective in order to have a prototype ready to go to Honduras this spring. For future semesters, the issue of using cylindrical bottles will need to be compared to any shape bottles and see if expansion or contractions affect the success significantly. Some other things to look at are making the device more user friendly as the mechanism to turn on the light is somewhat difficult for people with larger fingers due to the small space between the light and the plastic. Other possible tests could include ways to gather more information about the floc blanket because currently little is known on the functionality of this system.

References

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