Agua Clara Inlet Manifold Fabrication Team

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Abstract

This report will cover the research that is currently being done in Cornell's AguaClara lab to create a fabrication method for the diffuser tubes on the inlet manifold. This team needs to develop a method by which the diffusers can be easily manufactured in Honduras. Very little work had been done on this fabrication process as this is a new part of the AguaClara plant. This report will first discuss the need for the diffusers and how they help the plant be more efficient. The diffusers must be fabricated in fast and efficient way and each diffuser should be identical to one another. It was concluded that the best method for fabrication of diffuser tubes is to use boiling water to heat the pipe and then a metal mold to expand the bottom of the pipe into the correct rectangular dimensions.

Literature Review

The Inlet Manifold is a part of the sedimentation tank. The diffuser tubes which this team will be fabricating extend from this inlet manifold, see Figure_1. The tubes are necessary because they help to create a uniform flow between the manifold ports by eliminating any horizontal velocity components and they also create a line source which will divide the two sides of the sedimentation tank and suspend all flocs heading toward the center of the tank. The specifications for the design were determined in August 2011, and this is the design that will be fabricated for new plants beginning this fall. Suggestions for how the diffusers could be created include various ways of heating the PVC they will be made out of and then using a mold or a jack system to create the specified shape.

In August of 2011, a design to improve the ability of AguaClara plants to form floc blankets was discovered and this design will be built in Atima, Honduras. The conceptual design for the new system has been created. However, a new method is needed to fabricate the inlet manifold system.[1] The preliminary design for the Atima plant calls for a 15.24 cm diameter manifold, 4.4 cm diameter ports every 12.1 cm, diffusers that are 7.62 cm in diameter and approximately 60 cm long. The diffusers pipes will be heated, reshaped, and stretched by 20% into a rectangle that is 3.2 cm wide and 12.1 cm long, see the Diffuser tube in Figure_1-. The rectangular section should extend as long as possible so that there is a long distance for the fluid to approach uniform flow.[2]

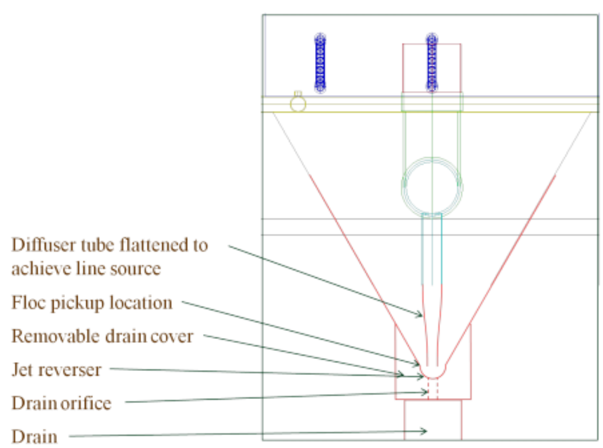

Figure 1: Sketch of the inlet manifold with diffuser tubes

Methods

An easy and cheap method is needed to fabricate the new inlet manifold. In order to do this, PVC pipe should be heated and then molded into a rectangle that is 3.2

cm wide and 12.1 cm long. After some research was done, it was determined that PVC pipe could be heated using boiling water, a heating blanket, or a heat gun.

Boiling Water Method

Boiling water is by far the cheapest method and easiest resource to come across. An initial test was done to see whether boiling water could heat the PVC pipe up to a high enough temperature that it could be molded.

1. Place water in a microwaveable container that the PVC pipe fits in
2. Put the container full of water into the microwave
3. Heat the water using the microwave until it starts to boil
4. Submerge the PVC pipe in the boiling water
5. While the PVC pipe is heating, repeat steps 1-4 with another container
6. Put the PVC pipe in the new boiling water container and reheat the old one
7. Keep switching containers with boiling water until the PVC pipe is very hot
8. Using protective gloves, stretch the PVC pipe over the mold

Revised Boiling Water Method

Due to the fact that the initial boiling water method worked, the idea was revisited. This time, an efficient hot plate was used to heat up the water to a high enough temperature so that the PVC could be molded once it was placed in the water.

1. Place water in a glass beaker large enough to fit the PVC pipe
2. Put the container full of water on the hot plate and turn the hot plate to its highest setting
3. When the water comes to a full boil, place the PVC pipe into the water for 3-5 minutes
4. While wearing protective gloves, take the hot PVC pipe out of the water and shove it onto the mold (the mold is discussed later)
5. Place the PVC pipe that is on the mold into cool water until it is room temperature
6. Use a hammer to remove the mold from the PVC pipe
7. Repeat steps 3 through 6 until the desired amount of PVC pipes are created

Design of the Mold

A plaster of paris mold has been created to press the hot PVC pipe onto so that it stretches to the dimensions at the end of the mold (See Figure 2). To make the mold the triangular sides of the mold were cut out from foam board (See Figure 4). They were then laid down side by side and taped together. The plaster of paris was then poured into the poster board form and left to dry. The final product can be seen in Figure 3. The mold is made of plaster of paris so that it can withstand the high temperatures and water that it will come into contact with when the PVC pipe is placed onto it. The plaster of paris mold has also been covered in a waterproof epoxy so that it will not be a problem for the mold to constantly coming into contact with water.

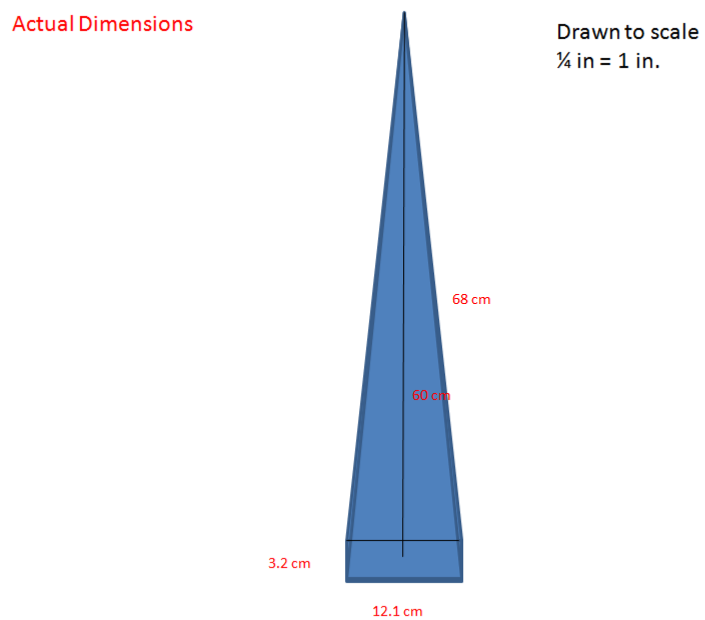

Figure 2: Mold design

Figure 3: Mold for 3" pipe made out of plaster of paris and coated with polyurethane

Figure 4: Cut outs of mold sides for plaster form

Design of Jack System

After the Mid-Semester Redesign (see below) the dimensions of the bottom of the diffuser pipe changed. Now that the pipe being used would be 2" pipe instead of 3" pipe, the rectangular bottom of the diffuser would be one centinmeter wide by eight centimeters long. To acheive this geometry it was suggested to us to try and use a jack system instead of a mold. The jack would consist of four steel bars connected with four moving joints. This apparatus was built in the CEE shop and can be seen being used below in figure 5. The jack system performed fairly well, but after using it once it was decided to also try using a new mold that would create the right size bottom geometry for the new size pipe. One problem that the jack system had was that since there was no support in between the two metal bars that created the main shape the pipe bowed in a bit in the middle. The deforming of the pipe could cause unwanted flow patterns in the water exiting the diffusers.

Figure 5: Use of Jack System

Design of Revised Mold (Metal)

After the testing of the metal jack was completed a stainless steel mold was built to create the same dimensions the jack created. The mold was built in the CEE shop out of a solid piece of 1cm thick stainless steel. The mold itself can be seen in figure 6below. The mold also has an additional piece of steel attatched at the top which can be used to help press and/or hammer the mold down into the pipe. After the mold was used we discovered that it worked significantly better that the jack system. Figure 7shows a section of pipe on which we used the the jack system to form one side and the mold to form the other side. The mold did not create the same bowing-in effect that the jack did, and the rectangle created with the mold was more defined than the rectangle created with the jack. More analysis of the differences between the two devices can be found in the anaylsis section of this report.

Figure 6: Stainless Steel Mold

Figure 7: Comparison of the perfomance of the jack system versus the metal mold

Mid-Semester Redesign

After meeting with the Design and Sedimentation Tank teams at the beginning of October we learned that a few changes to the diffuser tubes need to be made. The largest change is that, 2 inch pipe will now be used instead of 3 inch pipe. The sedimentation tank bottom geometry will also change (similar to 1). Instead of the rounded tip extending into the two angled sides there will now be a omega shaped bottom of the tank extending again into the two sides, now specifically angled at 50 degrees. The new bottom design will also include a piece of stainless steel extending from the tip in the middle of the omega shape up into a slit in the diffuser tube. This piece of metal has been added to help to keep the diffuser tube centered over the bottom of the sedimentation tank. See Figure 8 for a preliminary design of the new bottom geometry.

After more redesigns made by the Sedimentation and Design teams, it has been decided that the final design for the bottom geometry of the sedimentation tank will be a simple half circle. However, this should not affect the fabricfication of the diffuser tubes too much. This new design does create the need for a new way to keep all the diffuser tubes in line. Ideas for how to accomplish this alignment problem are discussed in the future research section below.

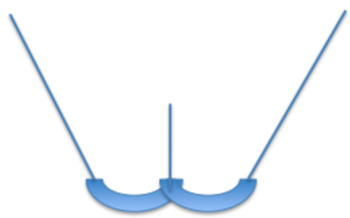

Figure 8: New design for bottom of sedimentation tank

Analysis

The method of using boiling water proved to be very successful in heating the PVC pipe up to an appropriate temperature. There was a bit of a problem in keeping the water hot because of the limited size of the microwave. It seemed that a hot plate would be a lot more efficient because it would keep the water at a constant boiling temperature so the PVC pipe can be heated a lot quicker and kept at the hotter temperature.

After testing with a hot plate we found that there were a lot of issuses we ran into. First, it is hard to find a suitable container large enough to hold the amount of water in which we needed to immerse the PVC. After deciding to use a large plastic container, we ran into problems when trying to heat up the water quickly as the plastic on the bottom on the container began to melt before the water was able to come to temperature.

The team first obtained a large metal cooking pot in order to boil water. It was found that the hot plate didn't get hot enough to be able to boil such a large quanitity of water. The team was then able to obtain a large glass beaker. Using the hot plate, the water in the glass beaker came to a boil. It was found that submerging the PVC pipe in the boiling water for about five minutes was enough to get the PVC malleable enough to be molded easily.

The team found that the jack system was hard to open to its full width due to the way that the joints were designed and that it puckered the PVC at the rectangular opening. The team ultimately ended up using the jack system as a sort of mold (opening it to its full width and shoving it into the pipe). Therefore it was concluded that a solid metal mold would be the best way to manipulate the PVC. A comparison of the performance of the jack and metal mold can be seen in Figure 7. The metal mold produced a rectangular end that was more crisp than what the jack produced. Also the mold produced a wider rectangular end and a more gradual transition from circular to rectangular, which will help to create a line source of water at the bottom of the sedimentation tank.

Accuracy of Mold Method

One of the goals of fabrication was to come up with a method that creates diffuser pipes that are identical to one another. Therefore, the team wanted to test the accuracy of the metal mold method by measuring the inner length and width of six different pipes (seen in Figure 9). This data can be seen in Table 1. The average width was found to be 1.01 cm $\pm$.015 cm. This is close to the 1 cm width that was requested by the design team. The average length was found to be 8.62 cm $\pm$.05 cm. From this data, we can conclude that the mold method is accurate and creates diffuser pipes that are more or less identical.

Figure 9: Pipes molded using the metal mold

Pipe #	Width (cm)	Length (cm)
1	0.99	8.64
2	1.02	8.64
3	1.02	8.66
4	1.02	8.51
5	1.02	8.62
6	0.99	8.64
Mean	1.01	8.62
Standard Deviation	0.015	0.05

Table 1: Inner widths and lengths of the molded pipes

Conclusion

It has been determined that using boiling water to heat up the PVC pipe and the metal mold to mold the pipe is the best method for fabricating the diffuser pipes. The exact methods used in the lab will probably not be used in Honduras though similar methods can be used to achieve the same result. For instance, instead of using a hot plate, an open fire or a stove might be used. An open fire and a stove will produce more heat than a hot plate; therefore, a metal pot instead of a glass beaker could be used to boil water in.

The team has decided that, at this time, no further research needs to be done on this topic. The problem of how to align the diffusers is discussed in the future research section. The team believes that the solution to this problem can be determined more easily in the field.

Future Research

A successful method has been tested using the boiling water method along with the mold made out of iron. Now, there are two more problems that need to be considered. The current mold stretches the pipe so that its outer diameter is about 9 cm. The goal is to make a new mold to stretch the actual PVC pipe that is used in Honduras so that its outer diameter is 10 cm. Research needs to be done on the PVC pipe they use, its dimensions, and how much of a stretch the PVC pipe needs to endure in order to get to a length of 10 cm with a width of 1 cm. Once this is determined, a mold can be created similar to the one previously tested.

Another problem that needs to be investigated is how to line up all of the diffuser pipes once they are installed. Ideally, they will all be uniform and 10 cm long. This means that they can be placed next to each other so that they are all touching. However, there is still room for one or more of the diffuser pipes to shift sideways so that it falls off the line. A method needs to be created to line up all the pipes so that they are rigid and touching. One idea is to glue some material on both sides of the tubes making sure that they are all aligned. Making this material straight along the tubes could prove to be a problem, but this is the first idea that will be tested.

Based on recent suggestions from engineers in Honduras, using some type of glue or PVC cement is not the best solution for aligning the diffusers. They have suggested to instead perhaps to either tie the pipes to a rod or melting the pipe together.

References

1. Floc Blanket Research
2. Inlet Manifold Fabrication