1 LPS Plant Testing

Manual

Sung Min Kim, Sidney Lok, Erica Marroquin

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Introduction

The goal of the 1 Liter per Second (1 LPS) Plant Testing team this semester is to complete the fabrication of the current plant and to test the plants performance. The performance testing will be done using clay and coagulant to mimic real-world conditions. The plant will also be connected to the newly built Enclosed Stacked Rapid Sand (EStaRS) filter, in order to test the functionality of the 1 LPS plant as a full water treatment train including flocculation, sedimentation, and filtration.

At the time of the first report, the team set up and finalized the smaller parts of the plant. Parts of the chemical dose controller (CDC) needed to be adjusted; the lever arm in the entrance tank needed to be installed as well as the dosing tubes connecting the CDC to the plant influent.

Lever Arm Perforation

One of the first tasks the team had to complete was securing the lever arm onto the side of the entrance tank. At the beginning of the semester, the lever arm and entrance tank were still separate pieces as shown in Figures 1 and 2. At this point, the lever arm could slide into the hole in Figure 1 made on the attachment at the side of the entrance tank, but there was no way to ensure that the lever arm would not slide out of the hole.

Figure 1: There is a hole in the PVC bar attachment at the side of the entrance tank. This is where the lever arm slides in.

Figure 2: Pictured is the lever arm before modification. Note that there is no visible way of securing the lever arm in place after sliding the metal bar into the hole at the side of the entrance tank shown in Figure 1.

The team consulted AguaClara Engineer Juan Guzman and determined that a perforation should be made in the metal bar of the lever arm so that a pin could be placed inside of it and act as a stopper as illustrated in Figure 3.

Figure 3: A schematic of how the lever arm should fit onto the entrance tank. There should be a perforation in the metal bar of the lever arm in order for a

pin to fit inside and act as a stopper. After being slid into the hole shown in Figure 1, a pin should be inserted into the perforation to secure the lever arm onto the entrance tank.

The team first found a piece to act as a pin and determined the size of it. The lever arm was brought to Timothy Brock in the Hollister Hall Machine Shop and perforated according to the size of the pin using a mill as shown in Figure 4. The pin fit snugly into the perforation as shown in Figure 5.

Figure 4: Timothy Brock used a mill machine in the Machine Shop to perforate the metal bar. It was important that the piece was brought to Tim to perforate as a safety precaution as the team did not have experience working with drilling into metal.

Figure 5: Sung Min held up the finished perforation and pin design. The pin fit snugly into the perforation because the team had measured the pin beforehand and determined the size of it.

CDC Apparatus

During Spring 2017, AguaClara fabricated a new design of the chemical dose controller (CDC). The past research report can be found here. The CDC system was designed to maintain a constant chemical dose to the treatment process as the plant flow rate and influent turbidity change. The main difference from the old design and the new is that slimmer PVC pipes were used in the new design. The current CDC system is incomplete for chlorination but is complete for coagulation, which the team is testing this semester.

The CDC works in conjunction with the lever arm on the side of the entrance tank. The team has to ensure that the height of the lever arm when horizontal is the same height as the coagulant level of the CDC when the float values are submerged. Because running the 1 LPS plant first with water was the priority, the team has not properly made sure that the heights were equal on the pole. The team plans to match the heights as shown in Figure 6 after assembling all the materials needed for the coagulant run.

Figure 6: Pictured is the Chemical Dose Controller (CDC) in relation to the entrance tank and lever arm. The CDC will need to be shifted up in order to ensure that the height of the lever arm when horizontal is the same as the coagulant level of the CDC as described above.

Dosing Tube Calculations

In order to get the proper flow rate of chemicals into the plant, the team needed to calculate the correct length and sizes for the dosing tubes. The yellow arrows in Figure 7, below, are pointing to the dosing tubes on the CDC apparatus.

There are two types of dosing tubes that are two different diameters: the tube that connects the constant head tank (CHT) (which contains the chemical stock) to a tee fitting on the lever arm, and the tube that connects the tee fitting to the influent water coming into the plant. For information on how the CDC works, the most current research report can be found here.

Figure 7: A schematic of the CDC system, showing the entrance tank, lever arm, constant head tank, and the dosing tubes. The dosing tubes are highlighted by the yellow arrows.

The tube that connects the CHT to the tee fitting on the lever arm needs to be a very small diameter. This is so that major losses will dominate within the tube over the calculated length, leading to the proper flow rate out of the tube. The tube that connects the tee fitting to the influent water needs to be big enough that surface tension will not dominate within the tube, and water and air can flow freely through the tube.

The calculations for the length and diameter of these tubes were done using code written by the AguaClara Infrastructure Design Engine (AIDE) team. The code can be found below in the section "Dosing Tube Calculations" under "Python Code."

The length of the CDC tube connecting the CHT to the tee fitting will be 0.4811 meters long and $\frac{1}{16}$ inches in diameter. The diameter of the tube connecting the tee fitting to the influent water will be $\frac{1}{4}$ inches.

1 LPS Plant Water Run

The teams main focus was to run water completely through the 1 LPS plant. Ideally the team would run the plant with the EStaRS filter but because it had not been tested, the team is separately troubleshooting and water testing the EStaRS.

The plant has been fully connected from the water source to the drain as shown in Figure 8. The testing has been postponed due to the problems in the DeFrees Lab's drain. The two drain pumps are broken and caused an influx of water to build up in the 16 ft deep drainage pit. The majority of the water has been drained but there is sludge at the bottom that requires hazardous chemical testing. The testing and replacing of the pumps will take roughly two to three weeks.

Figure 8: Pictured is the tube connection between the top of the sedimentation tank to the drain. It is connected by a combination of pipes and elbows, reinforced tubing from the DeFrees laboratory, and two male couplings.

EStaRS Testing

The EStaRS filter was built in Spring 2017 with the purpose of accompanying the 1 LPS plant. The information used by the 1 LPS team to assemble the filter was found in the EStaRS Spring 2017 research report, found here.

The EStaRS filter had been previously tested for water-tightness, however, when the 1 LPS team tested it, there were leaks in the welds under the exit tank. The team took apart the piping to check the inside welds.

In future weeks, the team plans to weld the leaks and run water through the filter. The team will then conduct an analysis on the filter inlet and outlet manifolds to see if they can withstand the force of backwash. If the filter passes this analysis, the team will add sand to the filter and begin testing with clay and coagulant.

Python Code

Variables

g: gravity

h_L: head loss

D: diameter of pipe

ν: kinematic viscosity of a fluid

Q: flow rate

K_e: minor loss coefficient

Equations

The equation for the length of a dosing tube is:

$$L = \left(\frac{g h_{L,Max} \pi D^4}{128 \nu Q_{Max}} - \frac{Q_{Max}}{16 \pi \nu} \sum K_e\right)$$

where $h_{L,Max}$ is the maximum head loss and Q_{Max} is the maximum flow rate in the tube.

Dosing Tube Calculations

```
#dosing tube calculations
from aide_design.play import*
```

```
import aide_design.cdc_functions as cdc

help(cdc.len_cdc_tube)

FlowPlant = 1*(u.L/u.s)
  #assuming the plant flows at maximum flow rate
DiamTubeAvail = np.array(np.arange(1/16,6/16,1/16))*u.inch
  #diameter of tubing available in lab
  #this indicates an array of tube sizings between 1/16" and 6/16"
  #with a 1/16" interval.
HeadlossCDC = 10*u.cm
  #set by the maximum height of water in the entrance tank
temp = 20*u.degC
  #room temperature
en_chem = 1
  #in cdc_functions, en_chem = 1 designates using PaCl
KMinor = 4
  #comes from Monroe; from two barbed fittings at the beginning
  #and end of the dosing tube. minor losses from CDC apparatus are
  #negligible because they are very small compared to the
  #losses from the CDC tubing.
ConcDoseMax = 20*(u.mg/u.L)
  #set by the maximum dose possible by the lever arm
ConcStock = 70.9*(u.gram/u.L)
  #concentration of stock in the lab
LenCDCTubeMax = 6*u.m
  #any longer than this would be ridiculous

DosingTubeLength = cdc.len_cdc_tube(FlowPlant, ConcDoseMax, ConcStock,
  DiamTubeAvail, HeadlossCDC, LenCDCTubeMax, temp, en_chem, KMinor)
print('The length of the CDC tube is ',DosingTubeLength,'.')

DTube = cdc.diam_cdc_tube(FlowPlant, ConcDoseMax, ConcStock, DiamTubeAvail,
  HeadlossCDC, LenCDCTubeMax, temp, en_chem, KMinor)
print('The diameter of the CDC tube is ',DTube.to(u.inch),'.')

NTube = cdc.n_cdc_tube(FlowPlant, ConcDoseMax, ConcStock,
  DiamTubeAvail, HeadlossCDC, LenCDCTubeMax, temp, en_chem, KMinor)
print('The number of CDC tubes is ',NTube,'.')
```

Contact Information

The contact information for the Spring 2018 1 LPS Plant Testing Team is as follows: - Sung Min Kim, EnvE '19 - Sub-team Lead - sk2795 - Sidney Lok, EnvE '19 - sgl38 - Erica Marroquin, EnvE '18 - em629