Sedimentation Tank Economics

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Introduction

Currently, the design tool requires that the user inputs the number of sedimentation tanks and number of sedimentation bays desired. The goal of this semester is to write code which will choose the number of sedimentation tanks and bays that optimize cost as well as performance and ease of operation, taking that responsibility off of the user. First, cost will be taken into account. The code will calculate cost as a function of plant flow rate and number of sedimentation bays and tanks. The optimal number of sedimentation bays will be found by minimizing the cost of concrete, PVC, and building materials. A cost analysis algorithm will produce a certain number of sedimentation tanks and bays. This will then be implemented in the design tool so that when a design is requested for a certain flow rate Mathcad automatically assigns the optimized number of sedimentation tanks and bays for that flow rate. This should make the design tool more user friendly as well as assure that the sedimentation tanks are designed with minimal cost and maximum performance and ease of use.

Design Details

The sedimentation tank economics depend on the nominal diameter of the manifold pipe. A larger diameter manifold allows for more flow through a single sedimentation bay. Therefore for the same flow rate and a larger manifold diameter, fewer sedimentation bays are required to divide the flow. At the same time, with a higher flow rate through each sedimentation bay a longer tank is required to provide the same capture velocity. It should also be noted that if there are fewer sedimentation tanks, the inlet and outlet channels will be shorter. Therefore, the economic analysis will determine which is more cost effective: a larger-diameter manifold, fewer sedimentation bays, longer tanks, and shorter channels or a smaller-diameter manifold, more sedimentation bays, shorter tanks, and longer channels. This concept is illustrated in Figure 1.

The number of sedimentation bays will set the nominal diameter of the manifold. Therefore, to find the minimum cost, I will create a function that, given a range of number of sedimentation bays, will find the minimum cost and the number of sedimentation bays and nominal diameter associated with that cost.

It should be noted that though the cost is a function of the number of sedimentation tanks as well as bays, the number of sedimentation tanks will not be taken into account during analysis. Instead the number of sedimentation tanks will be set to one when finding the minimum cost. Once the optimal number of sedimentation bays are found the number of sedimentation tanks will be minimized, but operator access and maintenance must be taken into account. Therefore, there can be no more than two bays per tank because more would make it difficult for the operator to remove the plate settlers during cleaning. Another restraint is that there must be at least two sedimentation tanks so that if one is taken offline to be cleaned there is still one running.

Also the cost of having an odd number of sedimentation bays versus and even number of sedimentation bays must be analyzed. For instance, if the optimal number of sedimentation bays is five, would it be more cost effective to have five separate sedimentation tanks each with one bay or add on an extra bay and have three tanks each with two bays? The most cost-effective choice would be to have two sedimentation tanks each with two bays and one sedimentation tank with one bay, but is this practical for construction and maintenance? These questions must be analyzed and answered.

An algorithm will then be implemented into the design code that would produce the optimal number of sedimentation tanks and bays given a certain flow rate by minimizing the cost. This algorithm will make sure to take into account the fact that energy dissipation rate may change due to the Floc Sed Optimization team's research.

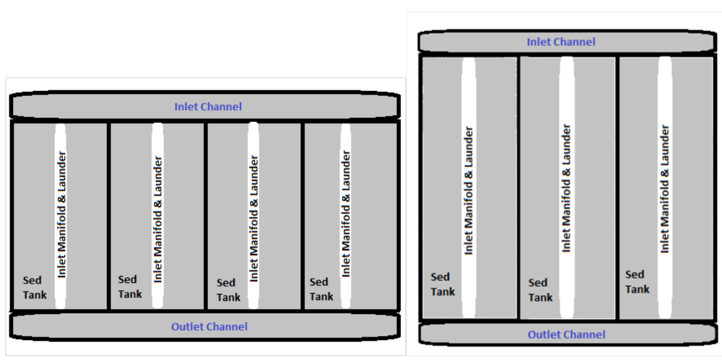

Figure 1: Example of sedimentation tanks with smaller-diameter manifolds (left) versus tanks with larger-diameter manifolds (right)

Documented Progress

When I first started to create the cost analysis code, I found that the way I was implementing it, making all the sedimentation tank calculations functions of plant flow rate, number of sedimentation tanks, and number of sedimentation bays, caused the final cost function to evaluate very slowly. I eliminated this problem by making only costs functions of plant flow rate, number of sedimentation tanks, and number of sedimentation bays. These costs are evaluated by calculating all the parameters needed in a program bar. The final cost is then returned. The total cost function now evaluates within seconds.

I then created an algorithm that finds the minimum cost and the number of sedimentation bays that is associated with that minimum cost. Using this number the algorithm finds the optimal number of tanks given the constraints (i.e. maximum of two bays per tank and at least two tanks). Also if the optimal number of sedimentation bays is odd and higher than four the algorithm evaluates the costs for subtracting versus adding an extra bay and chooses the lower cost of the two.

It was determined that a simpler, expert algorithm should be implemented in the design code. This algorithm should be as simplified as possible and only take into account flow rate and energy dissipation rate (in case this changes in the future). A draft of the simpler algorithm has been created. Monroe suggested that below 12 L/s only a 6 inch manifold should be and the number of tanks should increase accordingly. Even though this is not the optimal number of sedimentation tanks and bays cost wise, it will be easier for operators to maintain and operate the sedimentation tanks. The simpler algorithm takes this into account as well as that the number of sedimentation tanks should always be even above 12 L/s. Below is a graph (Figure 2) that shows how the simpler algorithm results compare to the original cost minimization algorithm.

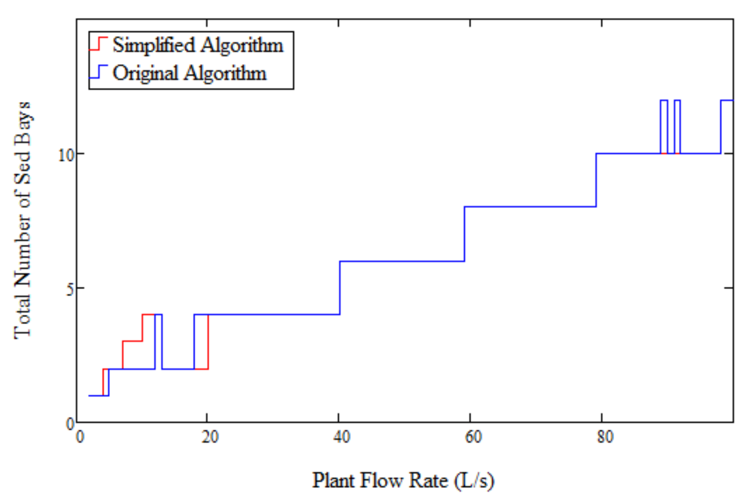

Figure 2: Graph showing the total number of sedimentation bays for both the simplified and original algorithm as a function of plant flow rate.

Future Work

Before the simpler algorithm is implemented, the results will need to be confirmed as practical and easy to construct. For instance, in some cases the cost analysis suggests a plant should have only 2 sedimentation tanks with 1 bay per tank even though it is possible to decrease the size of the manifold and therefore increase the number of tanks and bays. Having more than two tanks may be beneficial for cleaning and maintenance purposes. Once the opinions of the AguaClara field engineers have been taken into account and the necessary changes have been made the simpler algorithm will be implemented into the design code.