Vortex Separator: An Investigation of Flow

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1. Introduction

The aim of this presentation is to compare the velocity of flow in a vortex separator with the velocity of flow in a simulation of the vortex separator.

If these velocities are approximately equal and, hence, the simulation accurately models the flow in a vortex separator, then particles can be introduced into the vortex separator and the simulation's geometry can be modified to optimise its efficiency for solids removal, rather than using empirical methods to improve the performance of the vortex separator.

Sedimentation Tank | Lamella Plates | Vortex Separator

Figure 1 – Three methods for separating solids from wastewater

2. Background

Solids can be separated from wastewater in a number of ways (Figure 1):

- One of the most common is to let them settle out in a Sedimentation Tank. However, these tanks can be costly to build, take up a large amount of potentially valuable space and the process of sedimentation can be very slow.
- Another way is to use Lamella Plates. However, their performance can be significantly affected by shock loading and by FOG (Fats, Oil and Grease) build-up.
- An alternative way is to use a Vortex Separator. It is cheaper to build and uses less space than a sedimentation tank, because of its greater depth and higher loading rate, and it has a higher resistance to shock loading and FOG build-up than Lamella plates, because there are fewer small spaces for FOG to accumulate.

Vortex Separators have been installed in some wastewater treatment works but they are not as popular as Sedimentation Tanks or Lamella Plates. The aim of this project is to optimise their efficiency for solids removal and quantify their performance to allow better market positioning.

Figure 2 – Photographs depicting the experiment set-up

3. Method

A. The Experiment

A model of a vortex separator (approximately one-tenth scale) was set up in a laboratory and water was pumped through it at a loading rate, equivalent to that used in a full-size vortex separator. Figure 2 shows a series of photographs depicting the experiment set-up.

Note that, in practice, pumping is not necessary to operate the vortex separator; it was simply used in this experiment to recycle the water.

Velocity readings were taken at 120 locations inside the model, using a rotameter, connected to a control unit, which took an average reading every ten seconds. Five readings were taken at each location.

The precise location of the rotameter was achieved through using two 3D-printed jigs: one to hold the rotameter in place and the other to facilitate aligning the face of the rotameter to coincide with the radius of the vortex separator chamber.

The experiment was repeated for four different loading rates.

B. The Simulation

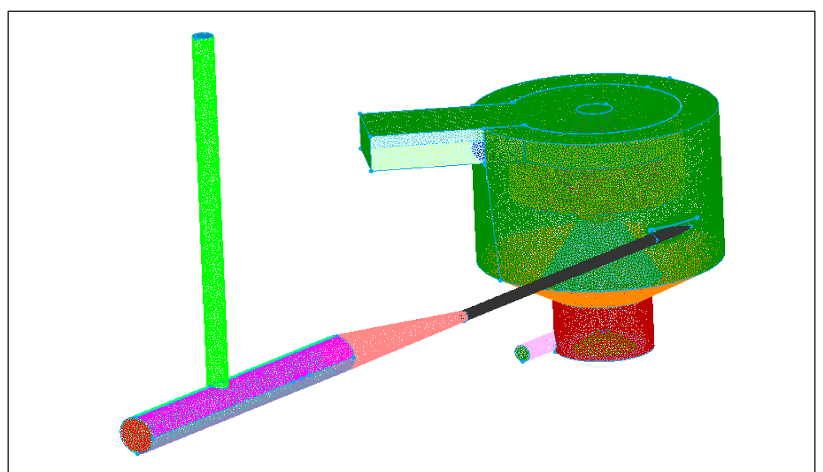

Figure 3 – The simulation mesh

The geometry was created and meshed in Pointwise®, forming approximately 1.5 million isotropic tetrahedral cells (Figure 3).

The simulation was carried out in OpenFOAM®, using the simpleFoam solver and the k-epsilon turbulence model. Where appropriate, second order schemes were used to achieve a more accurate solution.

4. Results

The average velocities of the simulation and experiment show similar profiles (Figure 4).

Statistical analysis of the simulation and experiment velocities reveals a linear relationship between them ($R^2 = 0.94$); however, the experiment velocities are significantly (on average 15%) smaller than the simulation velocities.

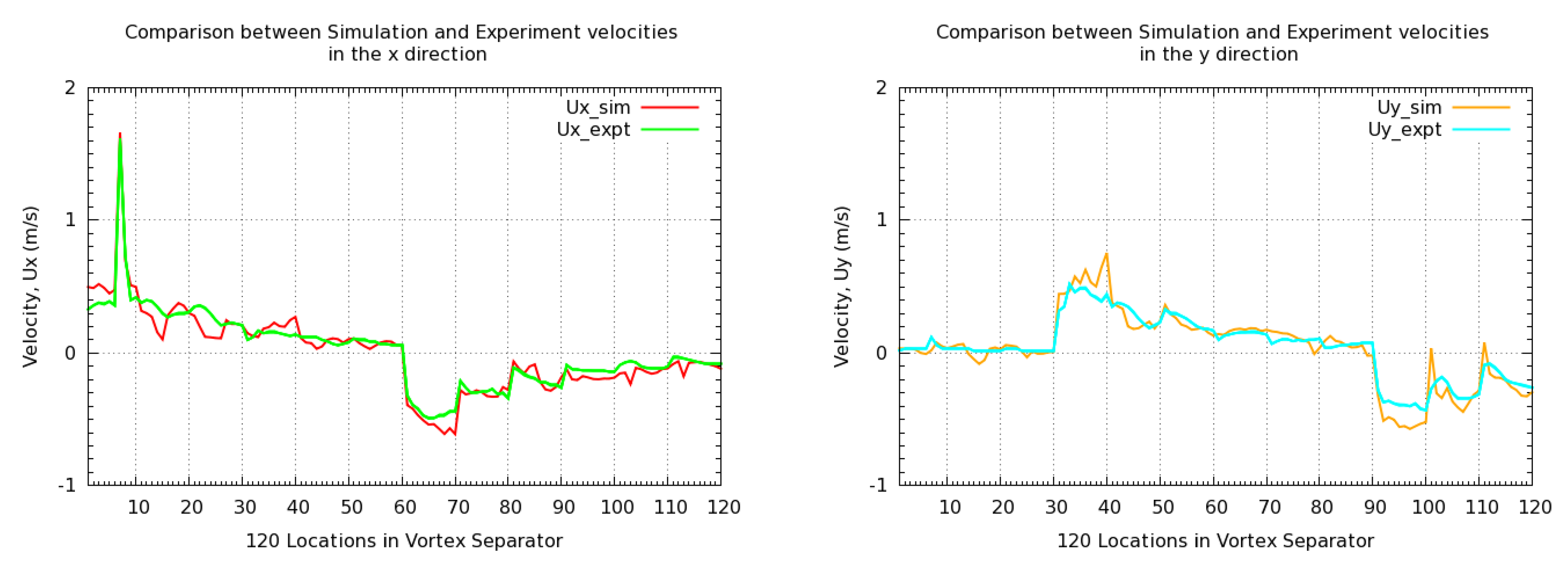

Figure 4 – Comparison between simulation and experiment velocities

5. Conclusions

The simulation accurately models the velocity profile inside the vortex separator. However, the experiment velocities are on average 15% smaller than the simulation velocities.

With this in mind, the next steps of the project are to:

1. Introduce particles to the experiment and simulation.
2. Modify the simulation's geometry, in order to optimise its efficiency for solids removal.

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