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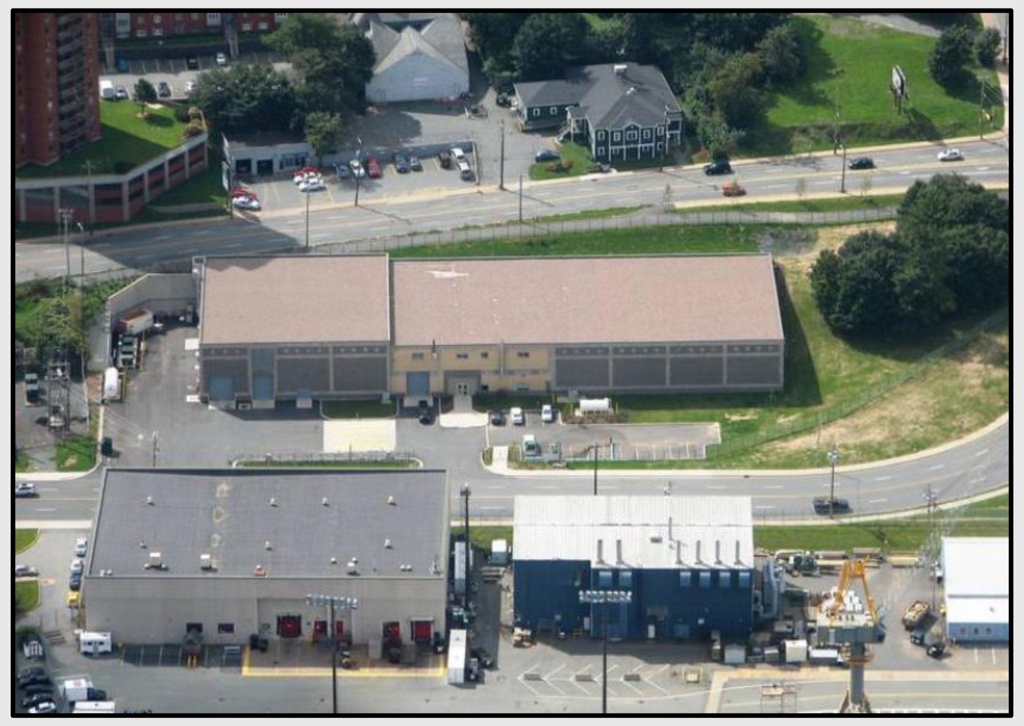
Halifax WWTF – Grit System Optimization

Introduction

- The main purpose of the Halifax Wastewater Treatment Facility (WWTF) is to process and filter the incoming wastewater into clean water before flowing into the Halifax Harbour.
- Recently, an imbalance between the inflow and outflow was identified in the grit removal tank.
- The objective of this project was to perform computational fluid dynamics (CFD) analysis on the grit tank to identify any occurring imbalances in the system and to propose a solution to the client.

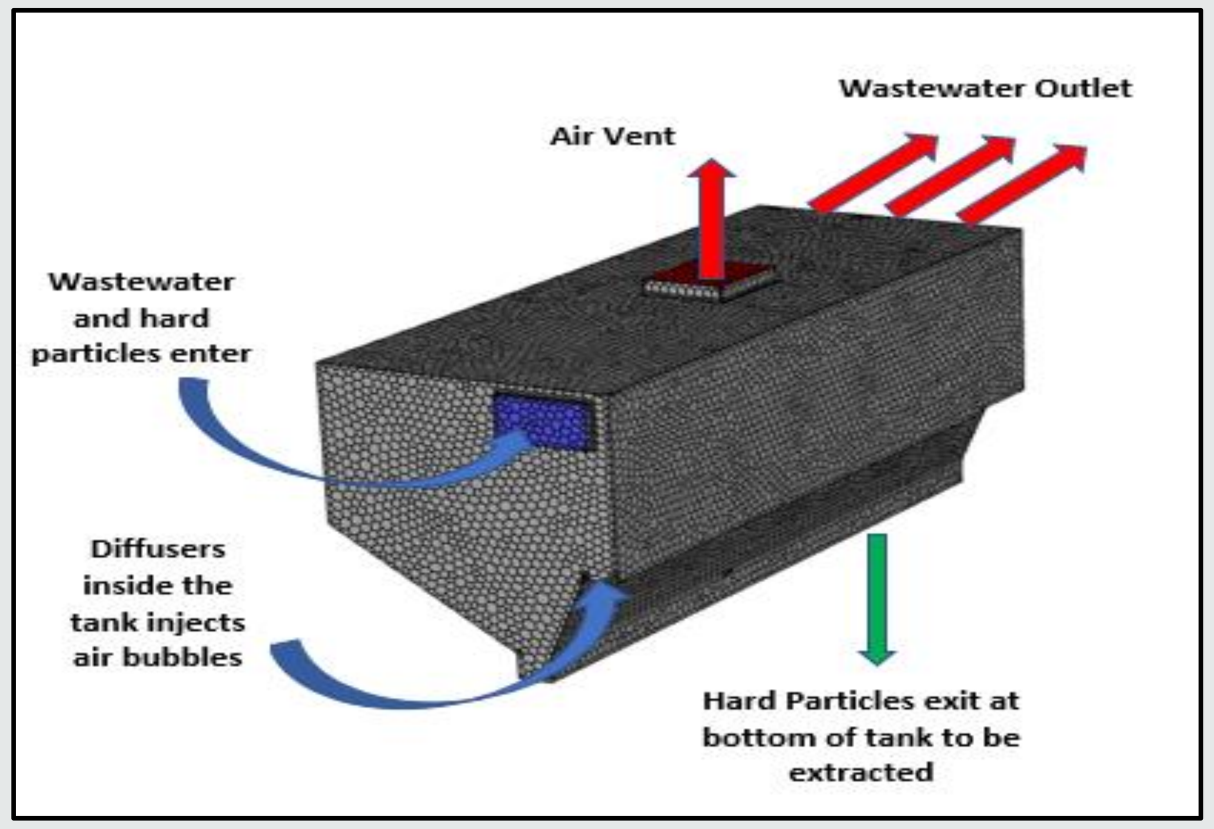


Design Process

- Understand the geometry of the tank and how multiple phases (water, air, and solids) interact inside the tank.
- Large portion of design process was learning how to use ANSYS Fluent. Multiple CFD experts were consulted for advice as well as YouTube videos to help design a method to solve this system.
- Create a basic model with a single phase (water).
- Add 2nd phase using a Discrete Particle Model (DPM), release from flat edge of single side of tank.
- Replicate 2nd phase as grit particles, now 3 phase model.
- Requirement to redesign tank with air outlet at the top. This additional Boundary Condition (BC) changes how the model functions.
- Adjusting the (BC) for this model proves to be complex.

Parameters	Air Particle	Grit Particle	Influent
Density (kg/m^3)	1.225	1600	721
Diameter (m)	1x10^{-6}	1x10^{-6}	N/A
Total Flow Rate (kg/s)	0.107	0.100	1.000

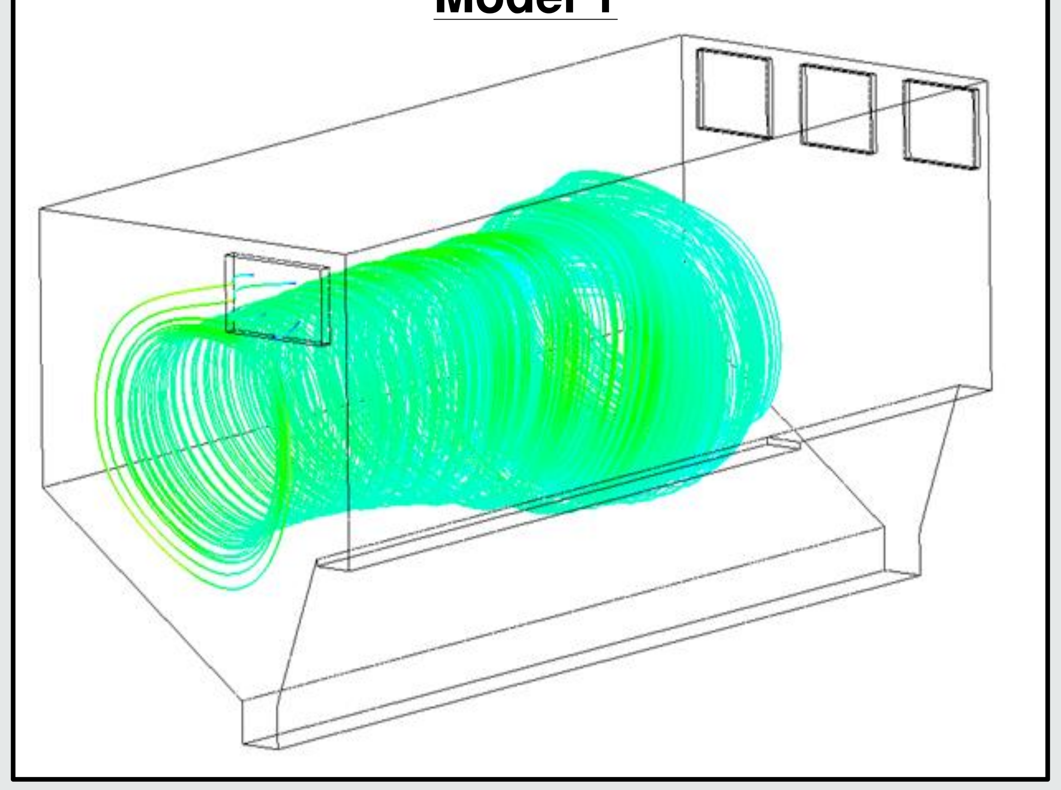
Details of Design



Inside the grit (hard particle) removal system is shown to the above left with air diffusers seen in two rows on right side. The injection of air reduces the density of the fluid inside the tank facilitating heavier particles to fall to the bottom. In order to determine efficiencies of particle removal, various flow rates and grit quantities would need to be tested. The right photo is a complete model with all inputs and outputs.

Computational Fluid Dynamics Modelling

Model 1

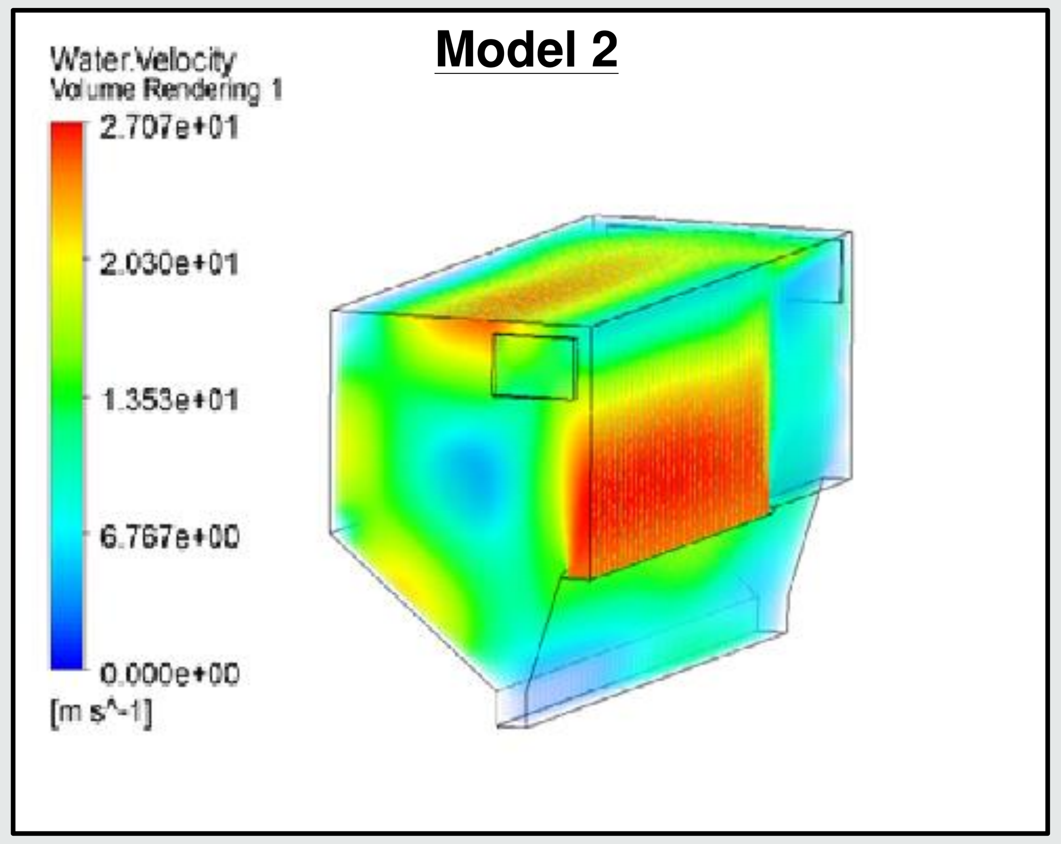


Model 1 : Verifies that the dynamic flow of the grit system can be simulated software where there is one output. The air vent added complication to modeling at this point in the design process. The resulting flow from wastewater and air cause rotation to occur which disperses the air particles in the fluid to reduce its overall density.

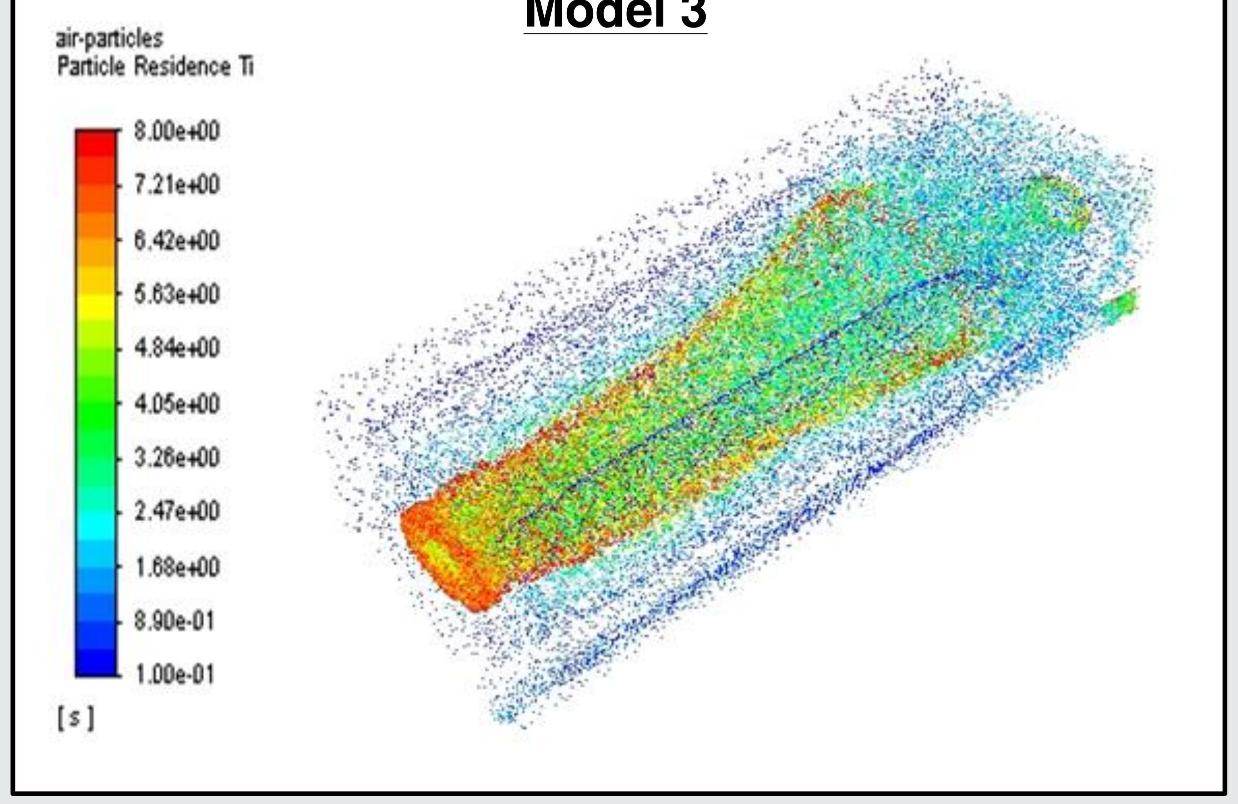
Model 2: Shows the velocity within the tank which can be seen to have the highest where the air diffusers are located. This can determine if there are dead zones within tank therefore causing collection of grit in unwanted areas.

Model 3: The detent time of grit particles within the system shows that with the tight screw like rotation, particle residence time increases. The more time each particle has within the tank, the higher chance it can be removed from the system.

Model 2



Model 3



Conclusion and Recommendations

- A three-phase model containing liquid, water, and gas operating in a closed system was achieved showing behavior of grit (solid) and air (gas) particles in transient (non-steady) time steps.
- Streamlines of fluid flow confirms theory of operation of a standard grit removal tank.
- Steady state flow was not achieved with maximum simulation length at 10 hours. Possible explanation may be due to concentrated zones located in the tank with air particles trapped.
- Grit Characterization, a process to further study the wastewater coming in, would be recommended to eliminate assumptions and build a more complete fluid model.
- Mesh optimization, refer to Model 3, would be recommended for better particle tracking to generate a more complete gradient within the tank.
- Progressing the close state model to an open system model with an addition of a vent would be recommended for more realistic simulation equalized atmospheric pressure.
- Progressing transient (non-steady) model to steady-state model would be recommended as real time plant is theoretically running at steady-state to study particles impeding flow causing imbalance in flow rates.

References

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