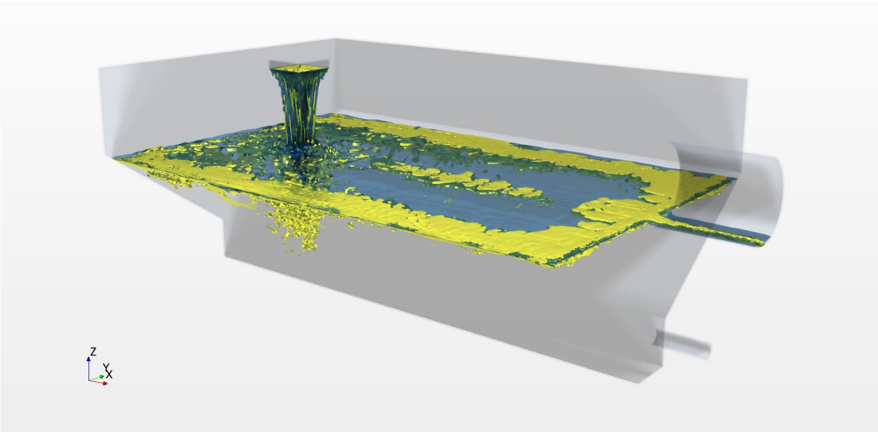
sabe FLUID DYNAMICS

Case Study

Sewage Treatment

Implementation of a flow diverter near the flow entry point which significantly improved flow velocity uniformity inside the tank



Video 1: Baseline tank with baseline volumetric flow rate

The client designs and manufacture liquid separators to be used in a preliminary stage of sewage treatment, with the aim of removing most of the lower density oils and fat from the mixture. This client had a well-established design with units being successfully used in many different locations.

An engineering challenge emerged when the operating condition in one of the plants became subject to a much larger input mixture flow rate compared to the operating rate in most of the plants, which in turn completely overwhelmed the system's ability to separate the phases.

Various approaches were considered for addressing this challenge. The possibilities ranged from higher level decisions such as installing additional units to process the higher flow rate, the design and manufacture of a larger scale version of the unit, to the more design specific options in the attempt to mitigate the issue.

The client ultimately felt that the most cost effective approach would be to put resources into exploring the possibility of tweaking the existent design, preferably with add-on parts, as this would return the cheapest/quickest implementation while keeping the unit design broadly the same. Sabe Fluid Dynamics was tasked the mission of recreating the baseline and higher volumetric flow rate scenarios in CFD for the evaluation of possible design tweaks.

The simulation of the baseline tank with the baseline volumetric flow rate (VIDEO 1) highlights a high level of mixing near and around the flow entry point, with a relatively smooth process of separation of the phases, the lower density phase moving upward and stabilizing above the water free surface far from the upper exit point, with zero oil/fat measured content exiting through the lower point.

Summary

Background Application:
Preliminary separation of the phases of a liquid mixture as part of sewage treatment.

Engineering Challenge:
Certain operating conditions with higher input flow volumetric rate were resulting in poor separation performance.

Engineering Constraints:
Modifications to be implemented as small design tweaks or, preferably, add-on devices to the existent design.

Technology/Methodology Employed:
Unsteady CFD RANS simulations with VOF (volume of fluid).

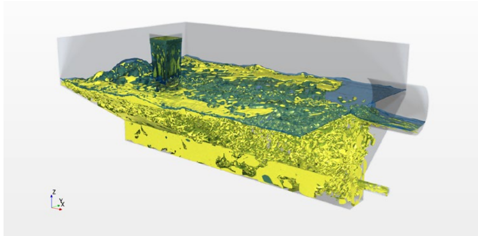
Outcome:
Implementation of a flow diverter near the flow entry point which significantly improved flow velocity uniformity inside the tank.

Animation links:
Video 1 – Baseline Operating Condition
Video 2 – 10x Flow Rate
Video 3 – 10x Flow Rate + Diverter

sabe TECHNOLOGY

Sewage Pre-Treatment

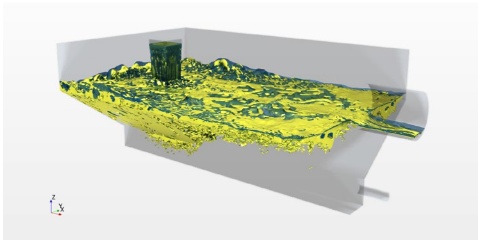
In contrast, the simulation of the higher volumetric flow rate (VIDEO 2) shows the development of a strong longitudinal flow component in the lower part of the tank, which in turn drives a high level of fat content toward the lower exit.



Video 2: Baseline tank with 10x volumetric flow rate

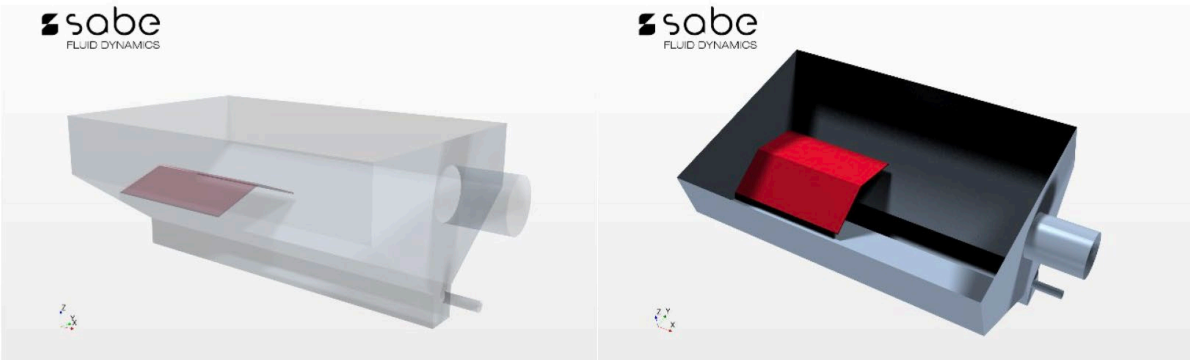
The performance of liquid mixture phase separators is strongly dependent on the residence time of the mixture inside the tank or vessel. A higher input volumetric flow rate into a given tank will return a lower average residence time, if the average residence time is too small then measures such as decreasing the input flow rate or lengthening the tank are likely to be required.

In many cases, however, the effective residence time in certain areas of the domain can be smaller than the average residence time. In other words, non-uniformities in the flow velocity field within the tank could result in large amounts of the mixture reaching the exit point very quickly. In these scenarios, design modifications are often able generate performance gains by improving the flow uniformity.



Video 3: Tank with Diverter and 10x Volumetric Flow Rate

Within this challenge, it was clear that the dominant longitudinal flow was responsible for a lot of mixing and a very small residence time for a significant fraction of the mixture. A few design modification options were considered for the attempt to suppress this strong longitudinal component and the implementation of a flow diverter under the flow entry point was chosen by the client.



The objective of the diverter was to redirect the inlet vertical flow momentum towards the side walls near the entry point. The simulation of the updated configuration (VIDEO 3) shows a large increase in the flow momentum dissipation around the flow entry point with a significant increase in the overall mixing as a consequence, however the previously dominant longitudinal flow component was successfully suppressed.

As a result, a much-improved level of flow velocity uniformity was measured downstream the diverter which in turn returned a reduced deviation of the flow residence time relative to the average. The design change successfully directed all the measured lower density phase towards the upper exit. Furthermore, the add-on diverter was relatively cheap and quick to be installed with little effect on the background operation activities such as cleaning and maintenance.

Sabe Fluid Dynamics is able to support our clients with multiphase flow simulations, contact us to discuss your challenge!

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