Analysis of a Shell and Tube heat exchanger comparing length to effectiveness.

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Aim of the Project

The aim/purpose of this dissertation is to prove that the size of a heat exchanger, specifically a shell and tube design directly impacts the overall effectiveness of the actual heat exchanger.

Objectives

1. Create CAD models of STHE and then conduct a CFD analysis on the models
2. Using results from the CFD analysis determine the overall effectiveness of each of the STHE.
3. Compare each of the STHE effectiveness results to each other and determine if the length of the STHE affects the effectiveness.

Background

"Heat exchangers are devices used to transfer heat energy from one fluid to another"(Patel et al., 2015). STHE are essential industrial components as the allow the transfer of large amounts of heat either for cooling or heating. The only drawback is they are quite large components, this project was to see if the STHE could be made smaller and still be just as effective at transferring heat. To achieve this three STHE models were made identical except for the length of the internal tubes of the HE.

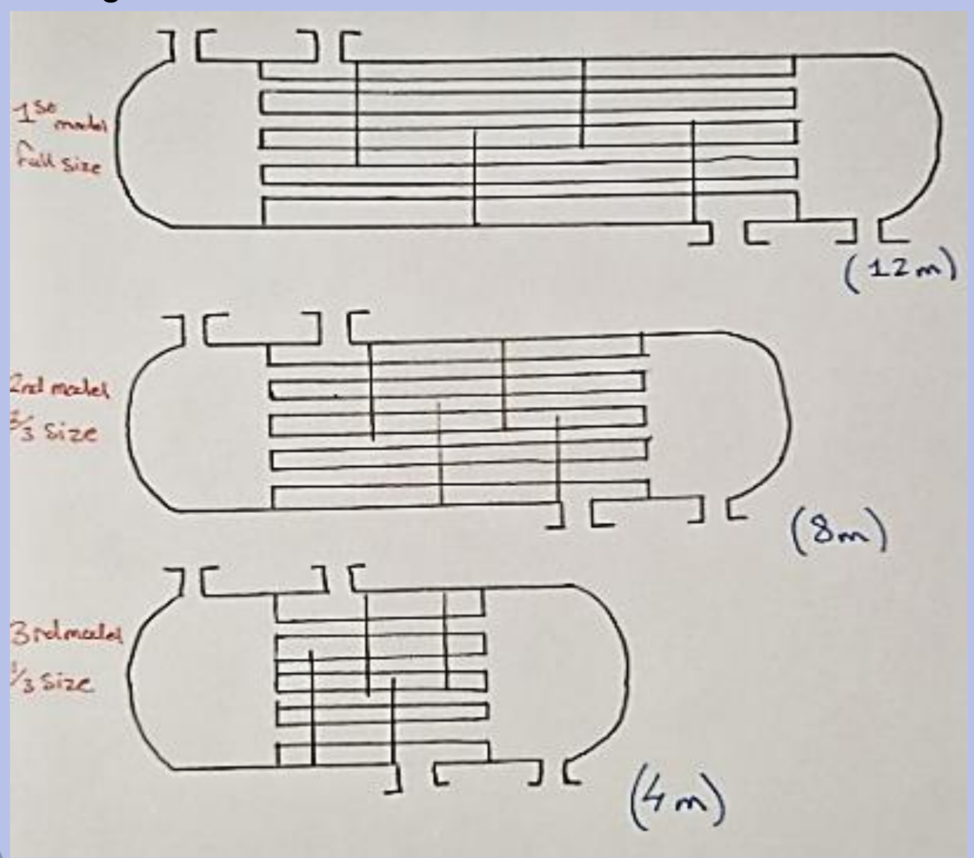

Figure 1: Three Different STHE sizes

CAD Models

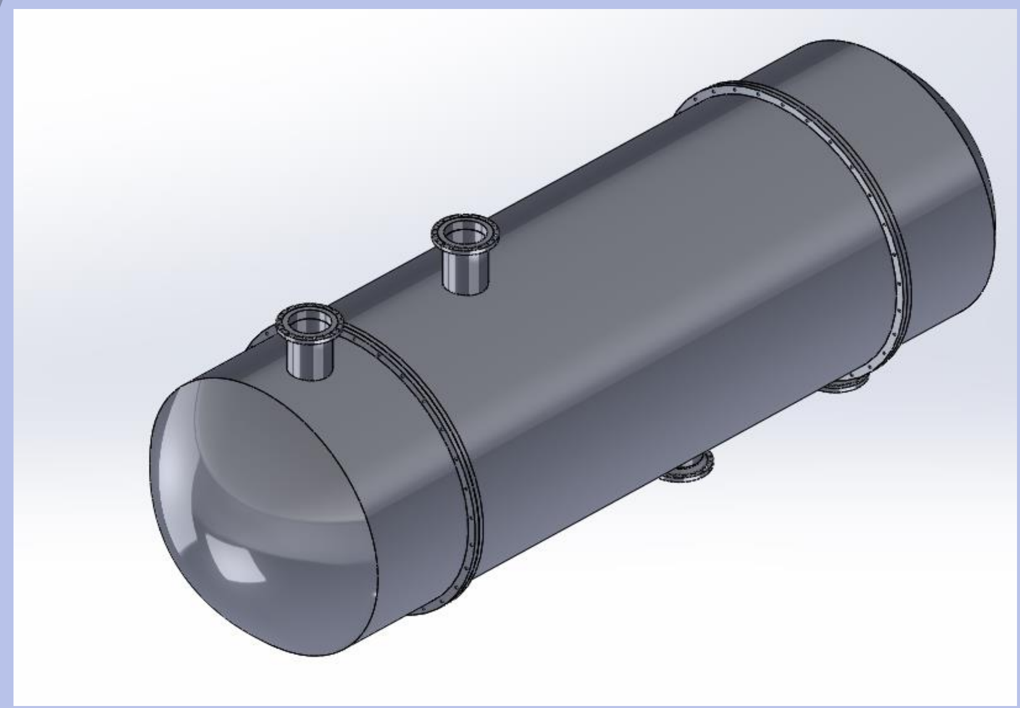

Figure 2: CAD model of One of the STHE models

The Three CAD models were created with the different lengths of internal tubes being the only difference between them. The design of the STHE has two inlet and two outlet pipes shown in *Figure 2:* on the top and the bottom of the CAD model for the inlet and outlet of the hot and cold fluid.

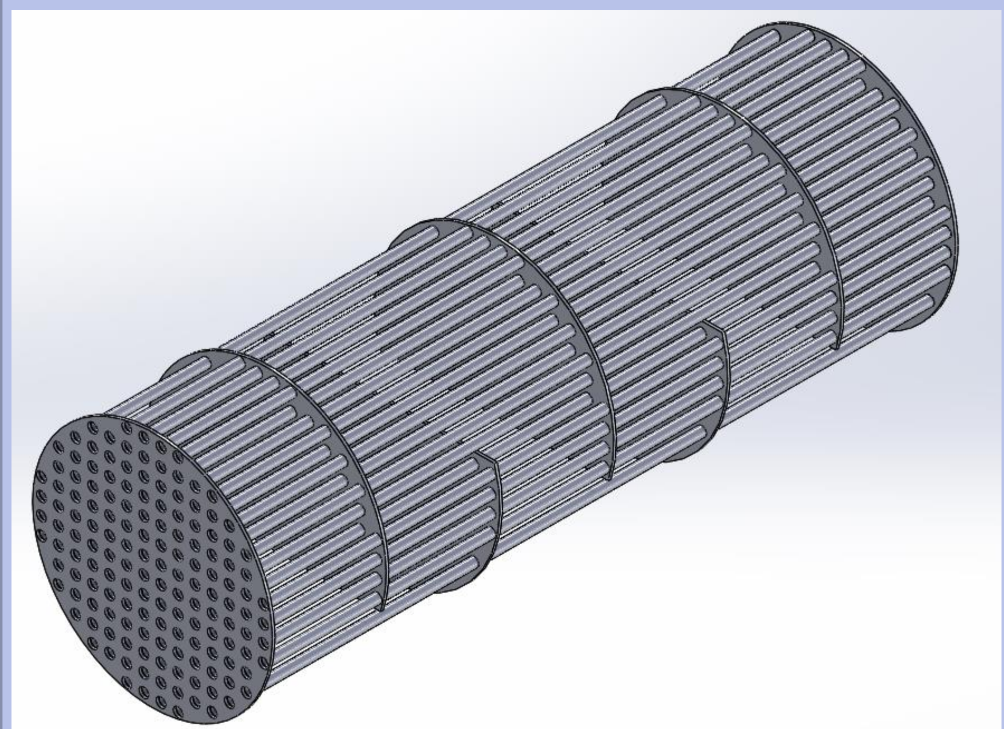

Figure 3: Internal Tubes and Baffles of STHE

In all of the models there are exactly 5 baffle plates for each STHE. To achieve the different lengths the baffle plates were spaced out by 2m for the 12m model, 1.3m for the 8m model and finally 0.6m for the third and final model with an overall length of 4m. Aside from changing the lengths of the internal tubes and the distances of the baffle plates no other variable in the models were changed, this was done to keep the analysis as fair as possible and if anything else was changed then it would not be a comparison between the length of the STHE and its effectiveness.

CFD Simulations

SolidWorks Flow Simulation was used to simulate the flow of a fluid through the STHE. For this project, the fluid used was water with the hot water at 100°C in the internal tubes and the cold water at 20°C in the shell flowing over the tubes. After the temperatures had been inputted the mass flow rates of the water for both hot and cold fluids which were 0.0317Kg/s for the hot and for the cold was 0.0193Kg/s, these were selected for the inlet side which was the top of the heat exchanger.

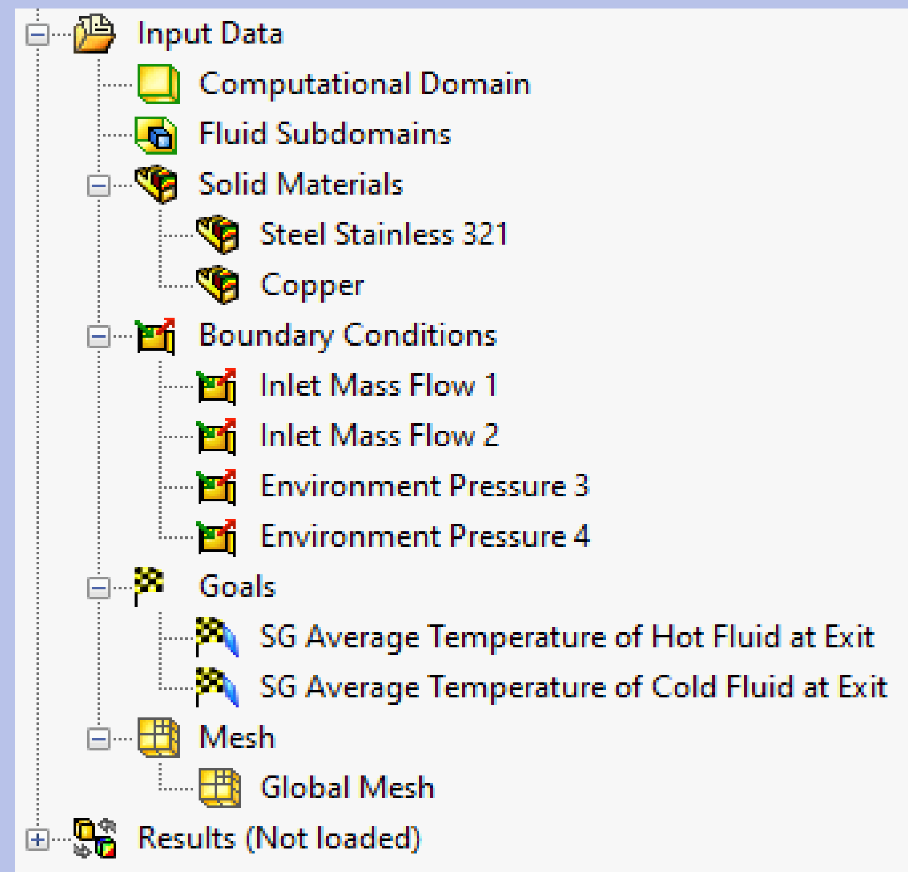

Figure 4: CFD Setup for the Simulations

There are only two materials chosen in the simulations for the STHE, copper was chosen as the material for the internal tubes and also the baffle plates. For the rest of the components in the STHE an alloy of stainless steel was chosen. Each of the three simulations were setup using the exact same values & materials. The Simulation was to determine the temperatures at the exit of the outlets.

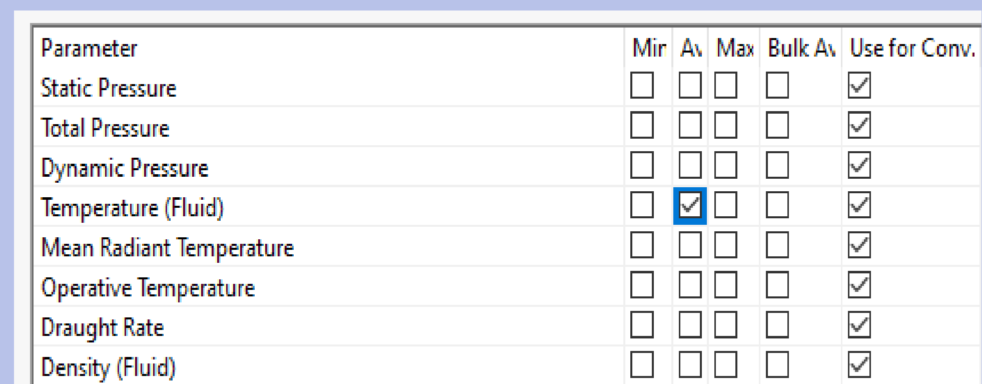

Figure 5: Parameter of STHE simulation result

Results

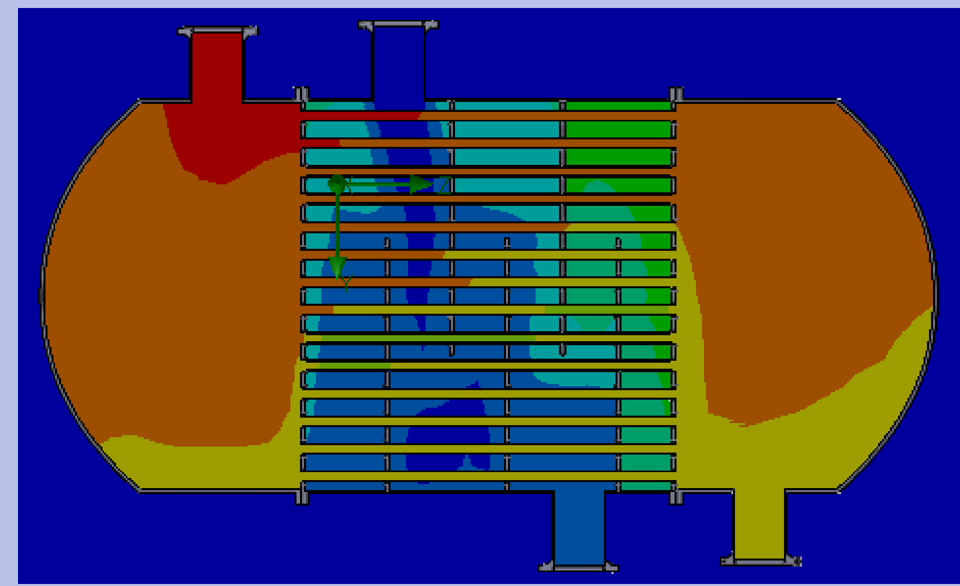

Figure 6: Simulation results for STHE model 3

Shown in *Figure 5:* is the Simulation result from the third model of length 4m. As can be seen the hot fluid goes from the inlet through the tubes and to the outlet and decreases in temperature whereas the cold fluid does the opposite.

Goal Name	Unit	Value
Temperature of cold at exit	[°C]	34.78
Temperature of hot at exit	[°C]	81.57

Table 1: Temperature results for STHE model 3

So the Cold water for the shell increase from 20°C to 34.78°C and the Hot Water decreased from 100°C to 81.57°C. Using these temperature values then the effectiveness can be found through calculations mass flow rates, specific heat capacities and actual and max heat transfer.

$$\varepsilon = \frac{Q}{Q_{MAX}}$$

Final Results of STHE Simulation	Q_{max} (J)	Q (J)	Effectiveness Results
1st Model 12 meters	1242.9	890.64	71.60%
2nd Model 8 meters	1897.49	1156.86	60.90%
3rd Model 6 meters	2442.08	1192.36	48.80%

Table 2: Effectiveness Values for all STHE