Performance Analysis of a Shell & Tube HEX for a Parallel & Counter Flow Arrangement using CFD

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Aim of the Project

The Aim of the project is to study the different types of flow patterns that are practiced in Shell and Tube Heat Exchangers through CFD analysis of a parallel and counter flow arrangement.

- Carry out and discuss a critical literature review on shell and tube heat exchangers and how CFD is used to improve the efficiency of them.
- Create a 3D model of a shell and tube heat exchanger using solid works.
- Run a CFD analysis on the created model using Solid Works flow simulation for both a parallel and counter flow arrangement.
- Compare the results obtained from the CFD analysis.

Background

The PA Hilton shell and tube heat exchanger is a miniature heat exchanger that is mounted to the front panel of the PA Hilton Heat exchanger test rig. The shell and tube HEX manufactured by PA Hilton is what was modelled using SolidWorks. The dimensions for the HEX were gained from the data sheet supplied by PA Hilton. Stainless steel was applied as the material for the tubes and the baffles with glass being applied to the outer shell.

Figure 1: PA Hilton Shell & Tube HEX

Parallel Flow

For the parallel flow simulation cold mains water at 15 degrees Celsius will flow through the outer shell and the heated water will pass through the seven stainless steel tubes at 50 degrees Celsius and will enter the HEX from the same side.

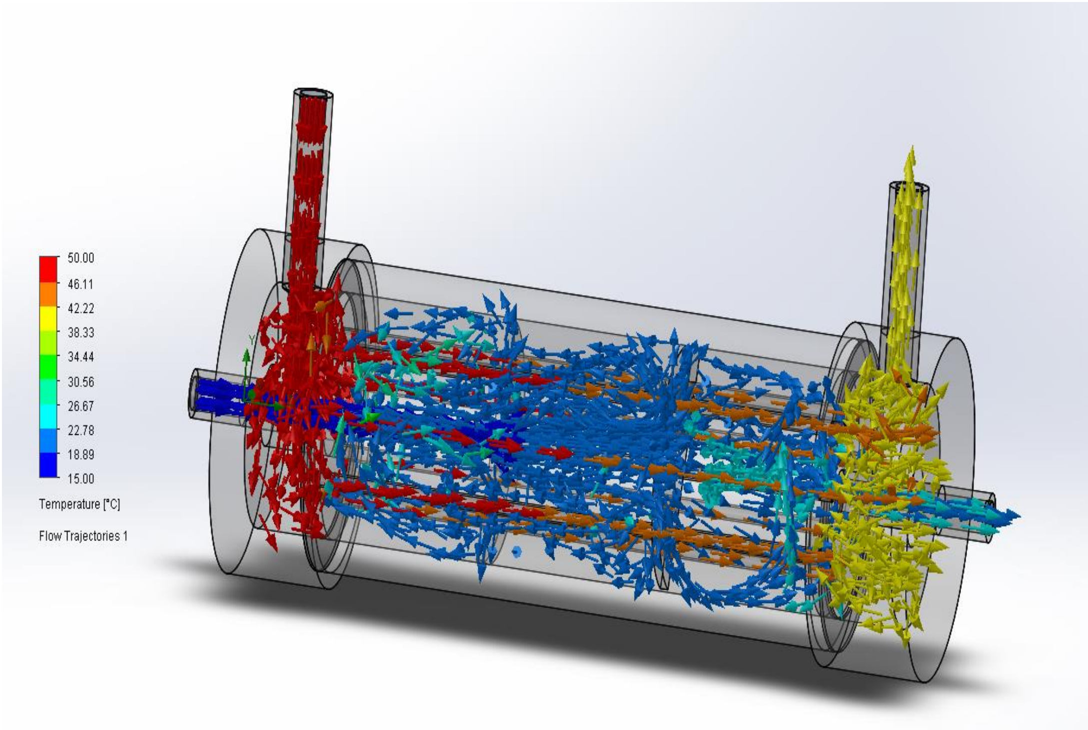
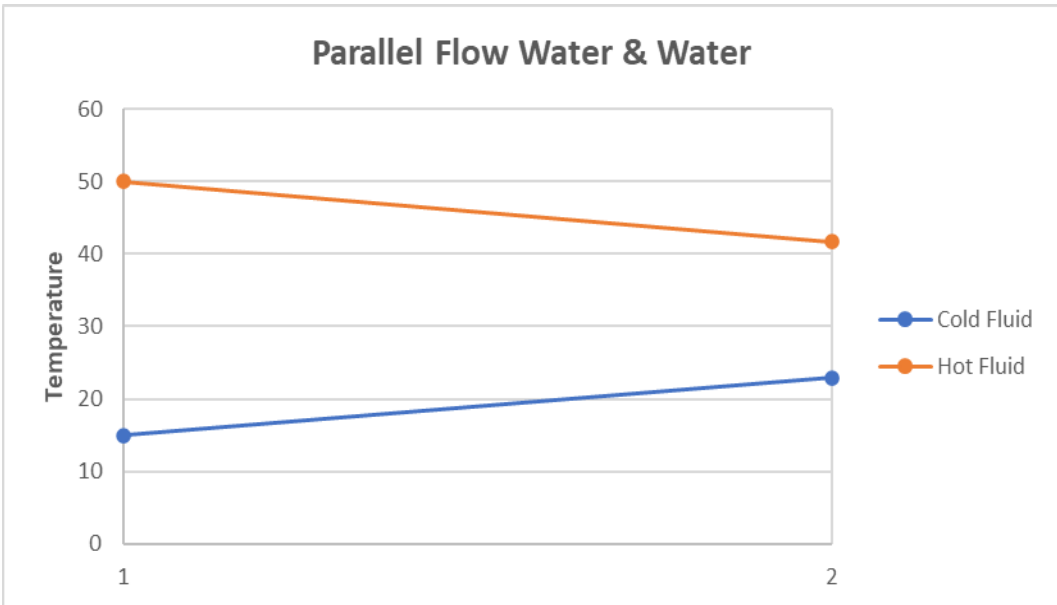


Figure 2: Parallel Flow CFD

Table 1: Parallel Flow Results

Parallel Flow Water Sim 1	Inlet Parameters		Results Generated @ Outlet	
	Cold Fluid	Hot Fluid	Cold Fluid	Hot Fluid
Temperature (°C)	15	50	22.95	41.71
Velocity (m/s)	0.1	0.1	0.125	0.103
Pressure (Pa)	101361	101497	101325	101325

In Graph 1 the measured temperatures can be seen to show the standard parallel flow arrangement form points one to two.



Graph 1: Parallel Flow

Counter Flow

For the counter flow simulation cold mains water will flow through the outer shell at 15 degrees Celsius and the heated water will flow through the seven stainless steel tubes at 50 degrees Celsius with each fluid entering the HEX form the opposite side of each other.

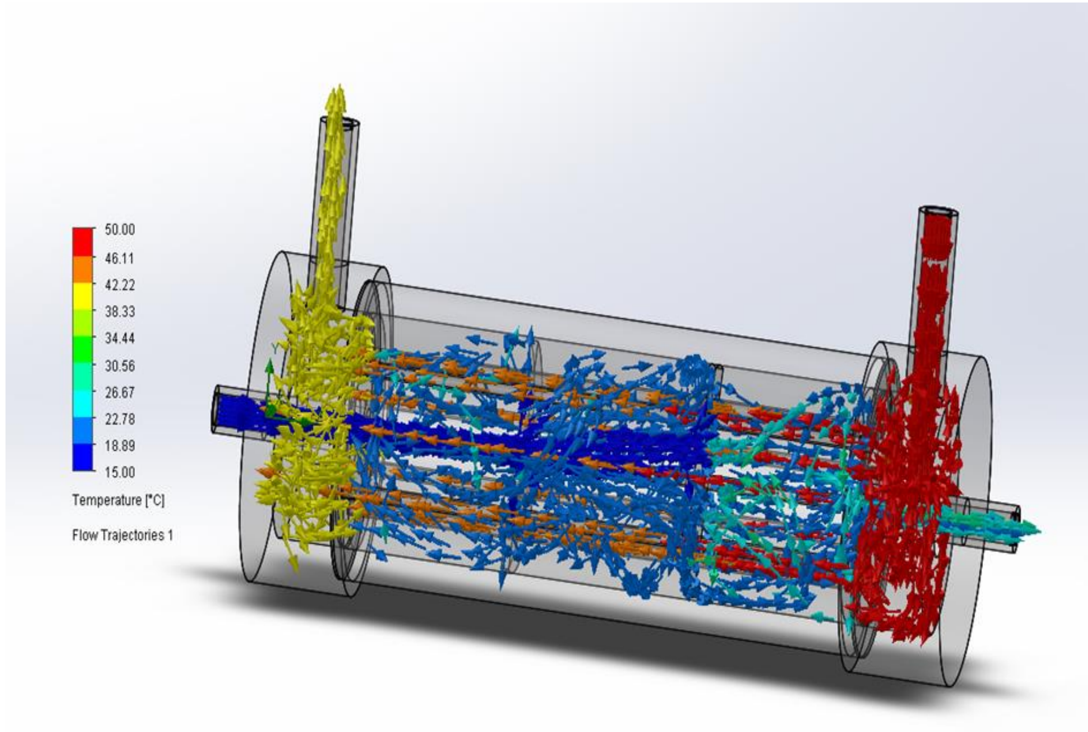
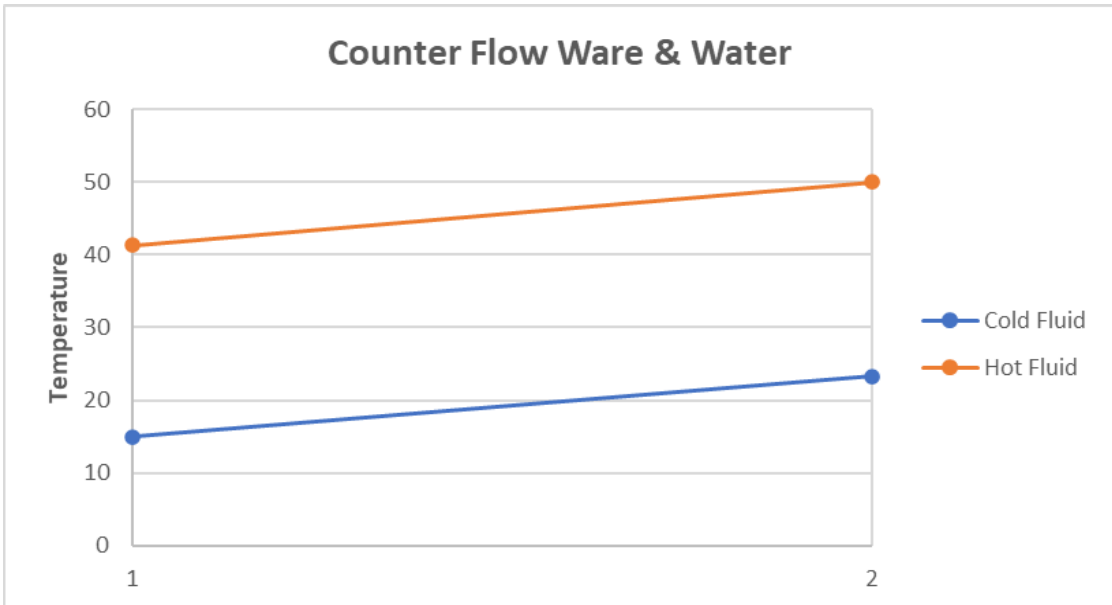


Figure 3: Counter Flow CFD

Table 2: Counter Flow Results

Counter Flow Water Sim 1	Inlet Parameters		Results Generated @ Outlet	
	Cold Fluid	Hot Fluid	Cold Fluid	Hot Fluid
Temperature (°C)	15	50	23.33	41.32
Velocity (m/s)	0.1	0.1	0.125	0.106
Pressure	101361	101498	101325	101325

In Graph 2 the measured temperatures can be seen to show the standard counter flow arrangement form points one to two.



Graph 2: Counter Flow

Conclusion

From carrying out the CFD study on the shell and tube HEX, the heat transfer rate for each simulation carried out was able to be calculated. For each of the simulations carried out the expected outcome would be that counter flow arrangements would show a greater heat transfer rate compared to the parallel flow arrangements. This can be seen for each of the simulations carried out with a water and water setup with the counter flow arrangements showing a greater heat transfer rate compared to that of the parallel flow arrangements with the same parameters.
But this is not the case for the water and oil setup with the parallel flow arrangement showing to have a slightly better heat transfer rate.
The parallel flow arrangement for the water and water setup was calculated to have a heat transfer rate of 259.2 Watts whereas the counter flow arrangement was calculated to have a heat transfer rate of 271.59 Watts.

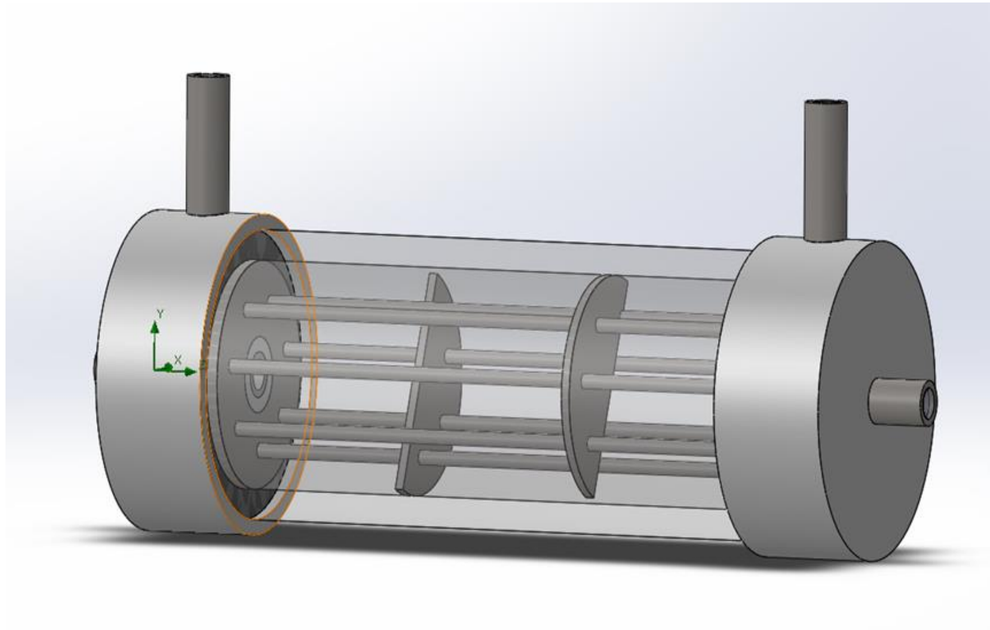


Figure 4: Modelled HEX