

# Efficiency Improvement in Shell and Tube Heat Exchanger Using CFD Tool

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**ABSTRACT:** The shell and tube heat exchanger plays a vital role in the chemical industries. In this project work the shell and tube heat exchanger was modelled (catia), meshed (hyper mesh) and simulated with CFD (ansys 15.0). The agenda of the project is to improve the efficiency of the heat exchanger using ansys 15.0. The shell diameter of the heat exchanger is 90 mm and the length is 600 mm with 7 tubes. The helical baffle of a heat exchanger is maintained at an angle of 400. The comparison has been made between the two types of flow breakers. The wave type of flow breakers gives the better result than the step strip flow breaker.

**KEYWORDS:** Shell and tube heat exchanger, baffles, helix angle, flow breaker.

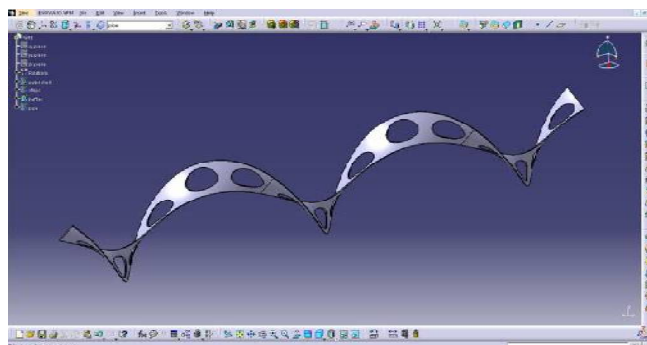
## I. INTRODUCTION

The device used to transfer the heat energy from one fluid to the other is the heat exchangers. The heat exchangers exist in the boilers, condensers and radiators. The classification of heat exchanger is based on the transfer of heat. Heat transfer coefficient, pressure drop, baffles and fouling are responsible for the efficiency of the heat exchanger. By increasing the flow resistance the heat transfer rate can be increased by creating the turbulence in the shell side of the heat exchanger.

The material which is depositing on the inner sides of the tube is responsible for the formation of fouling, the fouling rate can be reduced by pre- treatment of fluid (water). The proper cleaning of the heat exchanger can minimize the effect of fouling. Passing the higher temperature over the shell side will reduce the fouling rate

## II. BAFFLES

The baffles are used to increase the heat transfer coefficient by diverting the fluid. The perfect baffle spacing should be done for the better heat transfer rate. Increasing the surface area of the heat exchanger the heat transfer rate can be increased, the number of baffles used in the heat exchanger is 6, the baffle pitch is 223 mm. by increasing the baffle spacing the flow velocity can be increased due to this the heat transfer can be increased because of reduction in leakage baffle shell clearance [1]. The helical baffles at 400 inclination will gives the higher heat transfer rate [2, 3].



*Fig. 1. Baffle model at 400 inclinations*

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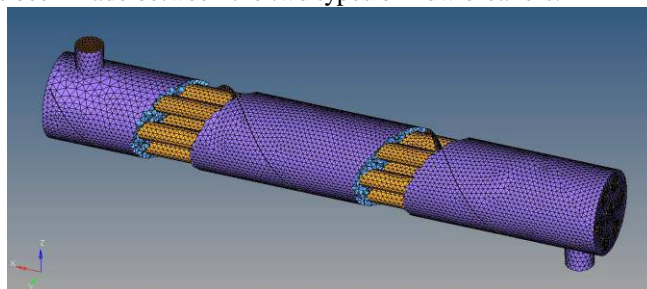
## II. MODELING AND MESHING

The shell and tube heat exchanger is modelled through catia version -5 (R-19).

*Table 1. Dimensions of heat exchanger*

Length, L	600 mm
Shell inner diameter, $D_i$	90 mm
Tube outer diameter, $d_o$	20 mm
Number of tubes, $N_t$	7
Number of baffles, $N_b$	6
Baffle pitch B	223 mm

The comparison has been made between the two types of flow breakers.



*Fig 2. Meshing of heat exchanger (outer fluid)*

### A. Dimensions of flow breaker (wave strip)

The wave strip type of flow breaker has been modelled and it is meshed with hyper mesh 13.0.

*Table 2. Dimensions of wave strip flow breaker*

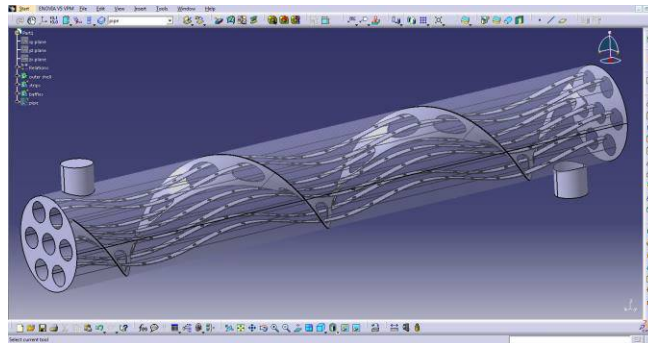
Length	600 mm
Width	8 mm
Hole diameter	0.5 mm
No of holes	22
Hole spacing	28 mm
Wave length	200

The flow should not distract the flow breaker so that the pressure drop will be formed hence the holes has been made to flow over the sides of the tube. By making the holes in the flow breaker, it reduces the friction loss over the sides of the tubes. Adding fillers at the sides of the tubes reduces the friction loss.

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**Fig 3. Heat exchanger with wave strip type flow breaker**

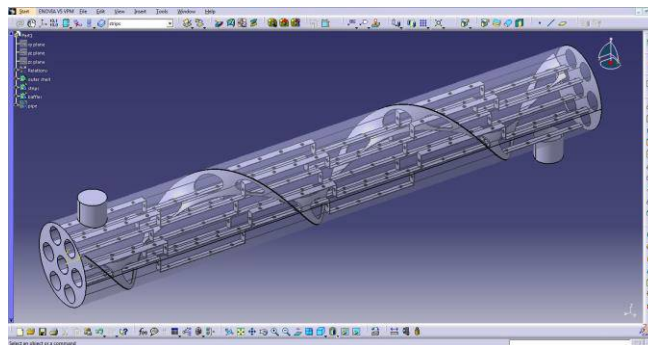
### B. Dimensions of flow breaker (step type)

Another type of flow breaker has been modeled and the dimension are kept as same for the wave strip.

**Table 3. Dimensions of step strip flow breaker.**

Length	600 mm
Width	8 mm
Hole diameter	0.5 mm
No of holes	24
Hole spacing	25 mm
Wave length	200

In step type flow breaker the holes numbers has been increased, because of the design aspect of the step type flow breaker.



**Fig 4. Heat exchanger with step type flow breaker**

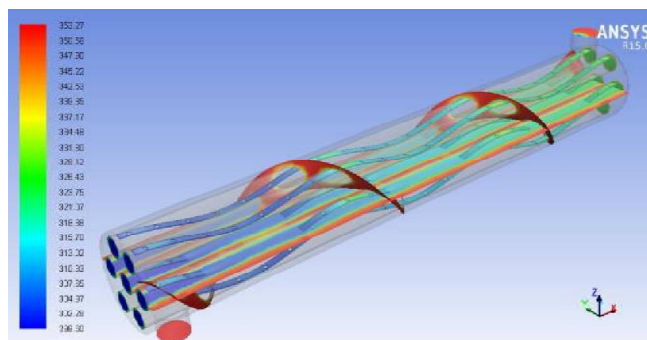
## IV. CFD ANALYSIS

Computational fluid dynamics is a tool to find out the numerical analysis of fluid flow. By discretizing the elements the various distributions can be found [4]. The accuracy level of the analysis can be increased by increasing the number of elements. The hot water flows over the shell side and the cold water is to be passed over the tube side of the heat exchanger.

**Table 4. Material selection and input parameters of heat exchanger**

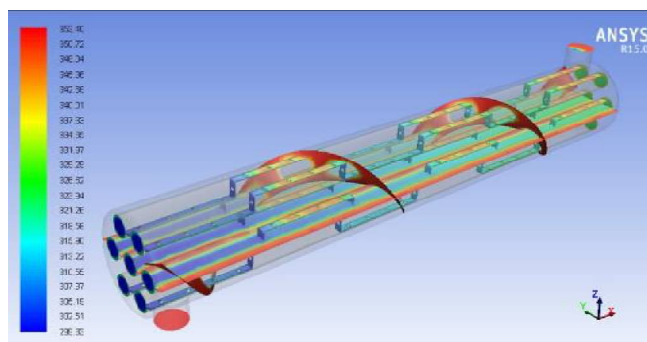
Type	Inlet Temperature (K)	Inlet mass flow rate (kg/s)	Fluid	Solid material
Shell	353	1	water	Aluminum
Tube	300	0.05	water	Copper

The pressure based solver type is used in the fluent analysis. The velocity formulation was maintained at absolute. Density is maintained at 998.2 (kg/m<sup>3</sup>), specific heat of 4182(j/kg-k), thermal conductivity of 0.6 (w/m-k) and viscosity of 0.09003 (kg/m-s).



**Fig 4. Analysis of wave strip flow breaker**

The step type flow breaker has been also analyzed to compare for the better result approach.



**Fig 5. Analysis of step type flow breaker**

**V. RESULTS AND DISCUSSION**

The efficiency of the heat exchanger can be altered by change in surface area, temperature and heat transfer rate. Also the pressure drop inside the tubes plays a vital role in the efficiency improvement in the heat exchanger.

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## A. Overall temperature

Table 5. Overall temperature of the both flow breaker

Heat exchanger	Inlet Temperature (K)	Outlet temperature (K)	
		wave strips	step strips
Shell	353	345.445	346.126
Tube	300	324.867	324.4377

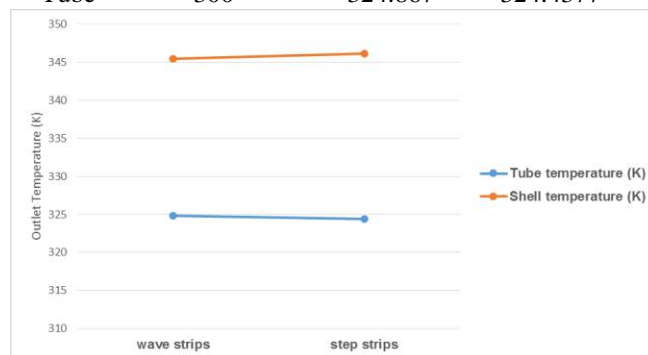


Fig 6. Comparison of overall temperature of flow breaker

## B. Pressure drop inside the tube

Type of strip	Pressure drop inside tube (Pa)
wave strips	3.71
step strips	6.42

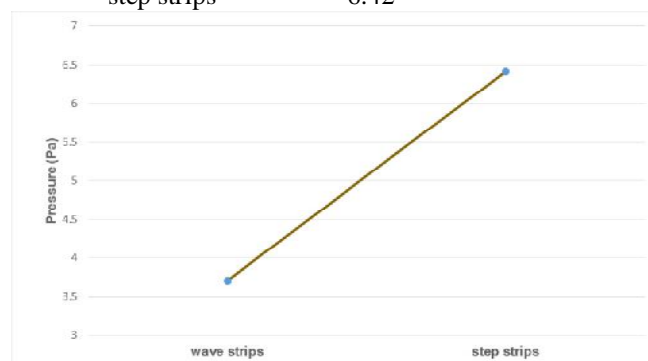


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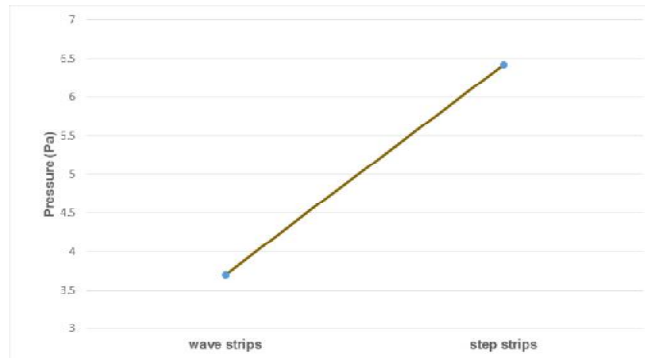
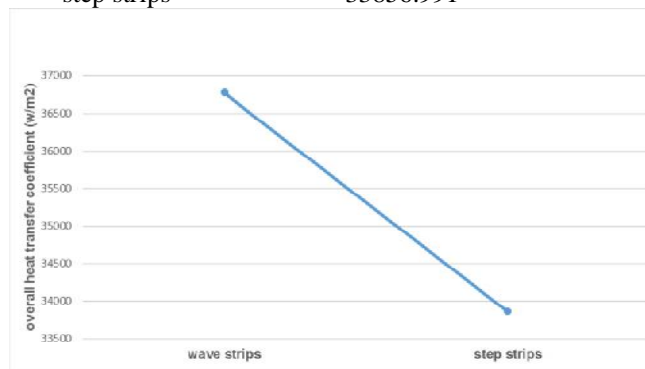


Fig 7. Comparison of pressure drop inside the tube

## B. Overall heat transfer rate

Overall heat transfer coefficient of flow breakers	Overall rate of heat transfer	Type of strip
	36773.787	wave strips
	33856.991	step strips



## VI. CONCLUSION

The factors affecting the efficiency of the heat exchanger is the temperature, heat transfer coefficient and surface area.

$$Q=HA\Delta T$$

Where,

H= heat transfer coefficient

A= surface area

$\Delta T$ = change in temperature

The baffles and the flow breakers will increases the surface area, the wave strip type flow breaker has a less pressure drop, with increased temperature range and hence the efficiency of the heat transfer (Q) is improved.

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