Modeling and Analysis of Flower Baffle Plate in Shell and Tube Heat Exchanger Using CFD

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Abstract: Especially in many industries like food industry, oil industry they used shell and tube heat exchangers in boiler. In heat exchangers baffle plates plays a major role to hold tubes in position preventing sagging, both in production and operation. That reduces the vibration in long tubes during transmission of fluids. Mostly shell and tube heat exchanger segmental baffle plates are used in industries. The main drawbacks of segmental baffle plate are high pressure drop during heat transfer. Material wastages are also high. Due to the high reverse flow so corrosion occur in existing baffle plate used in the shell and tube heat exchanger. To avoid these drawbacks we have modified the existing baffle plate design. Design and analysis of the flower baffle plate we have been done using softwares. For modeling the heat exchanger we have used solid works to create the 2D model, 3D model parts and assembly. And for the analysis Computational Fluid Dynamics is used to calculate the Temperature, Pressure drop and vorticity. Analysis is done for both the segmental baffle plate and flower baffle plate for the best comparison of results. Thus result indicated that the reduce pressure drop and increase in heat transfer co-efficient is quite successful and there is also reduction in material wastages and increases the life of heat exchanger.

Keywords: Boundary conditions, Computational fluid dynamics, Heat exchangers, Shell and tube.

I. Introduction

A baffle is designed to support tube to transfer the heat between two fluids and also improves the efficiency. Baffles are used to hold tubes in position preventing sagging, both in production and operation. That reduces the vibration in long tubes during transmission of fluids. Prevent the effects of vibration, which is increased with both fluid velocity and the length of the exchanger. Direct shell-side fluid flow along tube field. This increases fluid velocity and the effective heat transfer co-efficient of the exchanger. Computational Fluid Dynamics are used to calculate the efficiency of different baffles and compared with final results. Analyzing of critical flows and surface properties are quite easy with CFD. Heat exchangers are gadgets that encourage the trading of warmth between two liquids that are at various temperatures while shielding them from blending with each other. A shell and tube heat exchanger is a class of warmth exchanger plans. It is the most well-known sort of warmth exchanger in oil refineries and other substantial compound procedures, and is suited for higher-weight applications. As its name suggests, this kind of heat exchanger comprises of a shell an expansive weight vessel with a heap of tubes inside it. One liquid goes through the tubes, and another liquid streams over the tubes through the shell to exchange heat between the two liquids. Two liquids, of various beginning temperatures, move through the heat exchanger. One courses through the tubes the tube side and alternate streams outside the tubes however, inside the shell the shell side. Heat exchanged from one liquid to the next through the tube dividers, either from tube side to shell side or the other way around. The liquids can be either fluids or gasses on either the shell or the tube side. There can be numerous minor departures from the shell and tube outline. Regularly, the finishes of each tube are associated with plenums some of the time called water encloses through gaps tube sheets. The tubes might be straight or bowed in the state of a U, called U-tubes. The shell and tube heat exchanger that main purpose to the cool the water. Here the hot fluid that flow into the tubes and the cold fluids that flows into the shell. The heat transfer done by the tube to shell. This is the main principle of the heat exchanger. In this paper we are going to take some analysis. The analysis that is done by using fluid stimulation. The analysis that contains the factors of pressure drop, temperature profile and reverse flow. The main reason to corrode the baffle plates is that the reverse flow of the fluid. So we modified the main design of the baffle plates. We know that the baffle plates done the main role play tin shell and tube heat exchanger. The shell side outline of a shell-and-tube warm exchanger; specifically the perplex separating, bewilder cut and shell distance across conditions of the warmth exchange coefficient and the weight drop are researched by numerically displaying a little warmth exchanger. The Flow and temperature fields are determined by the analysis which is done by using CFD software. The analysis is done for better results and comparisons are taken with the existing model so results are taken by this comparison [1].

II. Heat Exchanger

Heat exchangers are devices that exchange the heat transfer between two states. Here the hot fluid that flows into the tube. Heat exchangers are normally utilized as a part of practice in an extensive variety of utilizations, from warming and aerating and cooling frameworks in a family, to concoction preparing and control plant.

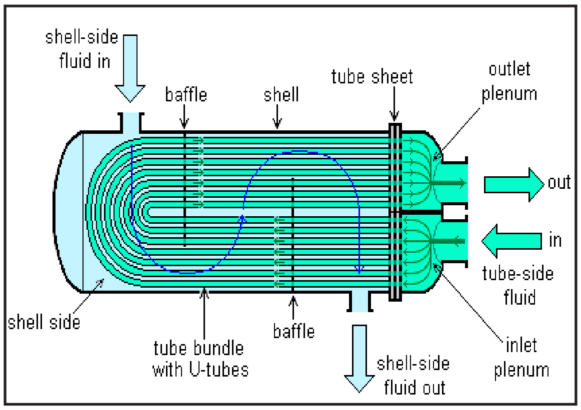

Fig. 1: Shell and Tube Heat Exchanger

III. Baffle Plates

Baffles are used to stable the flow of shell and tube heat exchanger. Then it improves the heat transfer of the shell and tube heat exchanger. There are many types of baffle plates are there in industries. Baffle plates hold the tubes in the heat exchanger.

A. Baffle Cut

Baffle cut is that permits the flow to across the baffle. Segmental baffle plates take more usage of material than our modified baffle plates. The important parameter to consider for baffle cut is the material percentage. We should consider the percentage of the shell inside diameter.

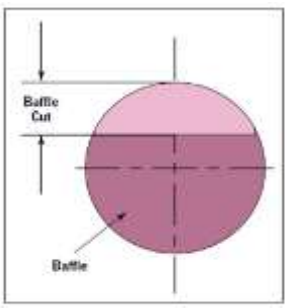

Fig. 2: Baffle Cut

B. Baffle Models

Baffles are used to guide the direction of the flow inside the shell and also it supports the tubes. Welding technique is used to fix the baffle models.

Following baffle models are,

i. *Single Segmental Model*: The overall diameter of the baffle is 400mm. The cut section where occurred at the length of 240mm.

Fig. 3: Segmental Baffle

ii. *Flower Baffle Model*: The overall diameter of the baffle is 400mm

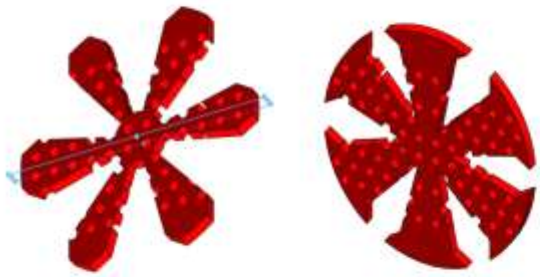

Fig. 4: Flower Baffles

iii. *Types of Baffles*: There are some kinds of baffles depending upon their design they classified to types of baffles. It should support more tubes.

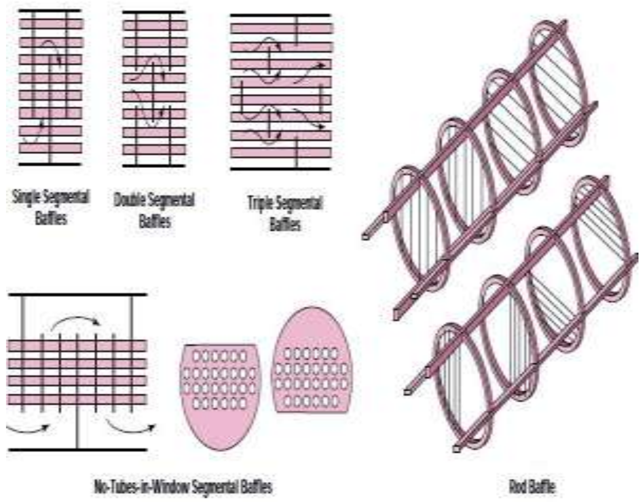

Fig. 5: Types of Baffles

iv. *Specification of Heat Exchanger*

- Length of shell and tube is 3000mm

- Inner diameter of the shell 400mm
- Outer diameter of the shell 415mm
- Thickness of plate 20mm
- Diameter of the tube 17mm
- There are 104 tubes are place inside the shell
- Length of the dish is 263.40mm
- Thickness of the dish separator 10mm

v. Modeling of Flower Baffle Plates

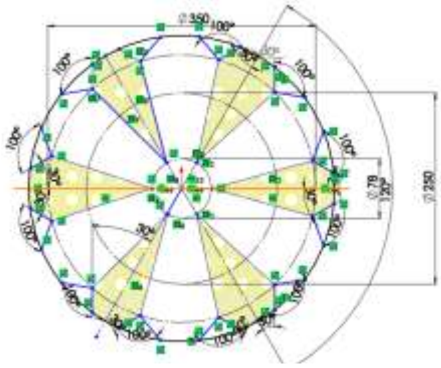

Fig. 6: 2D Diagram of Flower Baffle

IV. Analysis of Heat Exchanger

A. Boundary Conditions

Hot water input temperature (tube side) = 87^0C
Cold water input temperature (shell side) = 34^0C
Outlet volume flow (tube side) = $0.0055m^3/s$
Outlet volume flow (shell side) = $0.0376m^3/s$

Fig. 7: Assembly of Heat Exchanger with Flower Baffle Plates

B. Temperature Profile

The temperature profile is used to identify the temperature occurred inside the heat exchanger, this profile view dentally explain the temperature variations of exchanger through the colors. Right side of the plot result values are indicated based on the colors.

The input value of the hot fluid is 87^0C it travels through the 104 tubes, at the same side the cold water inlet at 34^0C in shell side heat exchanger. Shell side fluid is observed the heat of tube side fluid. The color variations say the heat transfer range step by step inside the heat exchanger.

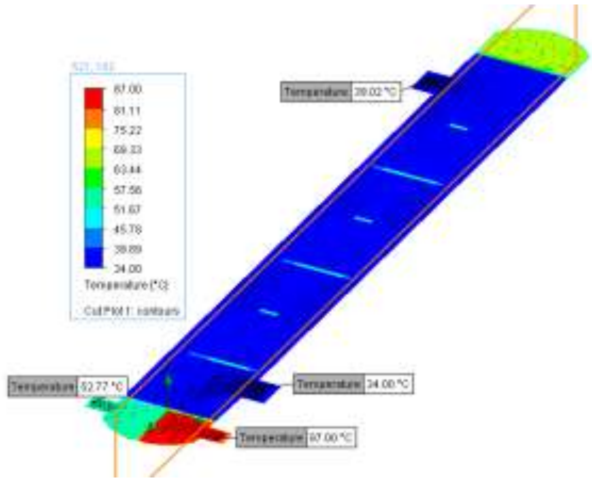

Fig. 8: Temperature Profile

C. Pressure Drop Profile

The pressure drop profile is used to identify the pressure drop occurred inside the heat exchanger, this profile view dentally explain the pressure variations of exchanger through the colors. Right side of the plot result values are indicated based on the colors.

The input value of the hot fluid is 244351.96 Pascal, it travels through the 104 tubes, at the same side the cold water inlet at 48689.40 Pascal in shell side heat exchanger. The color variations say the heat transfer range step by step inside the heat exchanger.

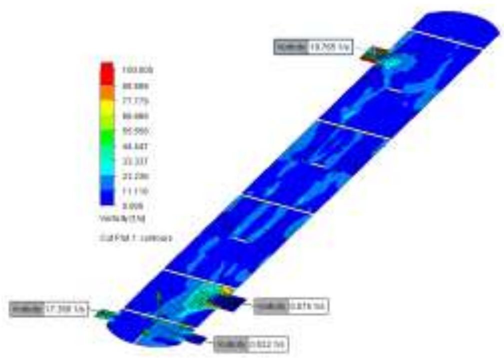

Fig. 9: Pressure Drop Profile

D. Vorticity Variation Plot

The vorticity profile is used to identify the reverse flow occurred inside the heat exchanger, this profile view dentally explain the reverse flow of exchanger through the colors. Right side of the plot result values are indicated based on the colors.

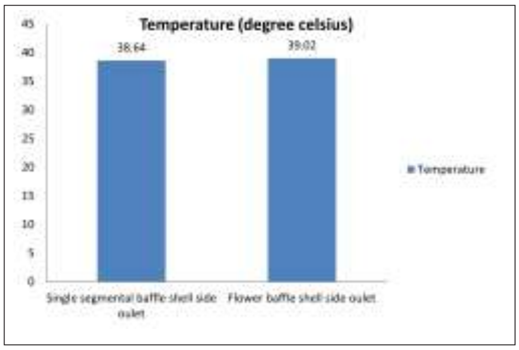

Fig. 10: Vorticity Profile

E. Temperature Comparison

In temperature comparison the outlet value of both segmental and flower baffles plates are calculated. By using these data the graph has been plotted.

Table I: Temperature Comparison

Design of Baffles	Segmental Baffles		Flower Baffles	
Outlet Value	Hot Fluid	Cold Fluid	Hot Fluid	Cold Fluid
Temperature (°C)	53.42	38.68	52.77	39.02

F. Pressure Drop Comparison

In pressure drop comparison the outlet value of both segmental and flower baffles plates are calculated. By using these data the graph has been plotted.

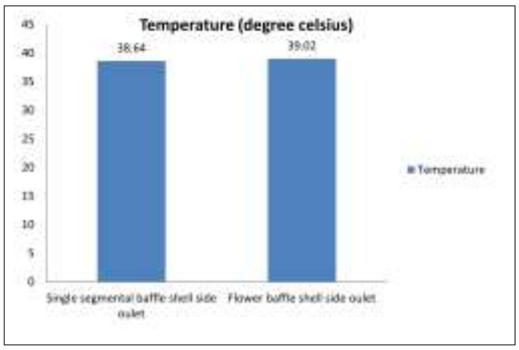

Fig. 11: Temperature Comparison Graph (Shell)

Table II: Pressure Drop Comparison

Design of Baffles	Segmental Baffles		Flower Baffles	
Outlet Value	Hot Fluid	Cold Fluid	Hot Fluid	Cold Fluid
Pressure (Pascal)	6046.05	13626.2	5953.2	8454.31

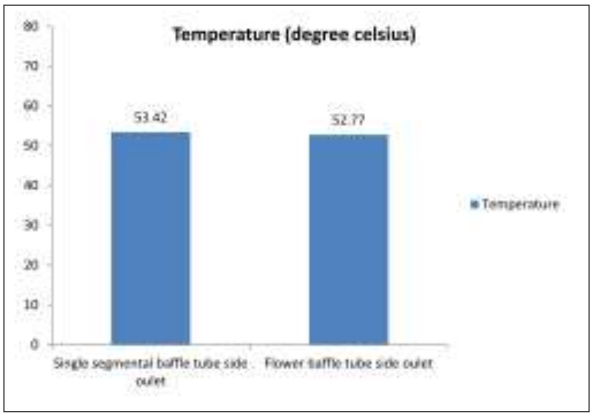

Fig. 12: Temperature Comparison Graph (Tube)

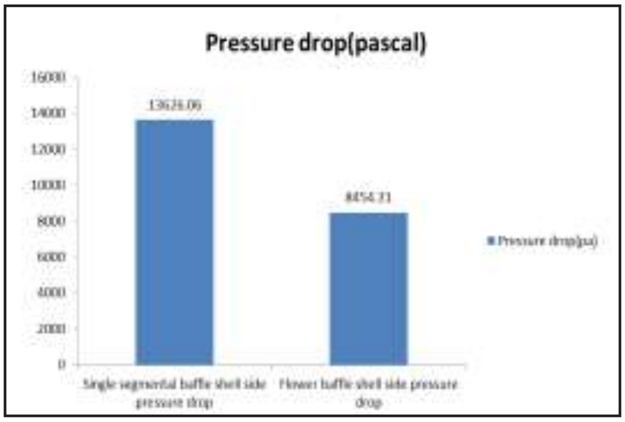

Fig. 13: Pressure Comparison Graph

V. Conclusion

Thus we conclude that our design of baffle plate reduces the pressure drop of about 5171.89 Pascal and also increases the heat transfer co-efficient. Overall usage of material is done in our baffle so there is no wastages occur. Maintenance of baffle and shell life time also increased. The main reason to corrode the shell and baffle is reverse flow that is occur on the single segmental baffle plate using heat exchanger so that it can be decreased by using this flower baffle plate using heat exchanger.

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