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Performance of Shell and Tube Heat Exchanger with Various Helical Baffles

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ABSTRACT: The development and performance of shell and tube heat exchanger is an issue of great challenge and part of emerging nascent technology. The performance optimization would serve a great contribution to placate the inflated operating costs as well as energy crisis. This paper showcases all the empirical results obtained from the real time system analysis in various working conditions. Further it represents comparison for several shell-and-tube heat exchangers with baffle angle parametric variation. Like Various angles 15^0, 25^0,35^0’45^0. system identification has been carried out by two methods viz, CFD analysis and theoretical calculation. The combined results with respect to same shell-side flow rate show that, the heat transfer coefficient of the heat exchanger with helical baffles is higherthan that of the heat exchanger with segmental baffles while the shell-side pressure drop of the former is even much lower than that of the latter. Further enhancement techniques should be incorporated in order to enhance shell-side heat transfer based on the same flow rate. The comparativeanalysis of heat transfer coefficient per unit pressure drop shows that the Segmental Baffle Heat exchanger have significant performance advantage over Helical Baffle Heat exchanger for the same geometrical configurations. The performance enhancement of heat exchanger with helix baffle angle optimization could be considered as an innovation.

KEYWORDS- CFD analysis, helical baffles, shell- side flow rate, heat transfer coefficient, pressure drop.

I. INTRODUCTION

A heat exchanger is equipment built for efficient heat transfer from one medium to another. The media may be separated by a solid wall to prevent mixing or they may be in direct contact. They have numerous applications and are widely used in space heating, refrigeration, air conditioning, power plants, chemical plants, petrochemical plants, petroleum refineries, natural gas processing, and sewagetreatment.

The performed work is based on the analysis of Shell and tube heat exchanger, that contains two separated fluids at different temperatures flowing through the heat exchanger one through the tubes (tube side) and the other through the shell around the tubes (shell side). Several design parameters and operating conditions influence the optimal performance of a shell-and-tube heat exchanger.

The baffle configuration is selected on the basis of size, cost, and ability to lend support to the overhung tube bundles. In the presented work helical baffles with Various angles**.**

PURPOSE

1.Increased heat transfer rate/ pressure dropratio.
2.Reduced bypasseffects.
3. Reduced shell sidefouling. 4.Prevention of flowinducedvibration. 5.Reducedmaintenance

II. PROBLEM STATEMENT

Comparative Analysis of Shell and Tube Heat Exchangers with Helical Baffle Configurations in reference to Heat Transfer Co-efficient and Pressure Drop using Analytical and CFD analysis and identifying the most suitable Baffle angle Configuration for IndustrialApplication.

III. LITERATUREREVIEW

Literature review for the present study includes the guidelines which are as follows:-

1. Mustansir Hatim Panchaet al,"Comparative Thermal Performance Analysis of Segmental Baffle Heat Exchanger with ContinuousHelical
Baffle Heat Exchanger using segmental baffles, most of the overall pressure drop is wasted in changing the direction of flow, while helical baffle focus on better conversion of pressure drop into heat transfer that is, higher Heat transfer co-efficient to Pressure drop ratio. Also the undesirable effects such as dead spots/zones of recirculation causes fouling, high leakage flow and large cross flow, areavoided.

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2. **Qiuwang Wang et al**,‖Shell and tube heat exchanger with helical baffles‖ Power load present in segmental baffle can be reduced by helical baffles. The invention provides 2 methods of manufacturing of continuous helical baffles. The flow pattern in helical reduce fouling and increase the servicelife.

3. **B.Peng et al**, "An Experimental study of shell and tube heat exchanger using continuous helical baffles, Helical baffles prevent the flow induced vibration. The use of continuous helical baffles results in nearly 10% increase in heat transfer coefficient compared with those with the conventional segmental baffles for the same shell sidepressuredrop.

4. **M.Thirumarimurugan, T.Kannadasan and E.Ramasamy** have investigated heat transfer study on a solvent and solution by using Shell and Tube Heat Exchanger. In which Steam is taken as the hot fluid and Water and acetic acid-Water miscible solution taken as cold fluid. A series of runs were made between steam and water, steam and Acetic acid solution .The flow rate of the cold fluid is maintained from 120 to 720 lph and the volume fraction of Acetic acid is varied from 10-50%. Experimental results such as exchanger effectiveness, overall heat transfer coefficients were calculated. . MATLAB program was used to simulate a mathematical model for the outlet temperatures of both the Shell and Tube side fluids. The effect of different cold side flow ratesand different compositions of cold fluid on the shell outlet temperature, tube outlet temperature and overall heat transfer coefficients were studied.

4. **Usman Ur Rahman** had investigated an un- baffled shell-and-tube heat exchanger design with respect to heat transfer coefficient and pressure drop by numerically modelling. The heat exchanger contained 19 tubes inside a 5.85m long and 108mm diameter shell. For this reason, Realizable k – ε model is used with standard and then Non-equilibrium wall functions.Thus in order to avoid this and to include the lowReynolds

5. **Jian-Fei Zhang, Ya-Ling He, Wen-Quan Tao** developed a method for design and rating of shell-and- tube heat exchanger with helical baffles based on the public literatures and the widely used Bell–Delaware performed for a single shell and single tube pass heat exchanger with a variable number of baffles and turbulent flow. It is observed that the CFD simulation results are very good with the Bell-Delaware methods and the differences between Bell- Delaware method and CFD simulations results of total heat transfer rate are below 2% for most of thecases.

Geometricalparameter Shell
Shell diameter =100mm mm Thickness=2 mm
Tube
Outer Diameter=10 mm Length=245mm
Thickness=20mm
Helical baffle angles-15^0, 25^0, 35^0·45^0.

Boundary conditions
Ambient air temperature (inlet temp)=25^0C Water inlet temp=55^0C
Inlet mass flow rateof air = 0.1025kg/sec Inlet mass flow rate of water=0.052kg/sec

IV. HEAT EXCHANGER AND BAFFLECONFIGURATION

Helical Baffle Heat Exchanger is a type of shell and tube heat exchanger which has a Helical shaped baffle segment which are arranged at Helix angle (15^0,25^0,35^0&45^0) to the tube axis in a sequential pattern that guide the shell side flow over the tube bundle. The visual representation of the Helical Baffle over the tubes is similar to a spring wound around therod/tube.

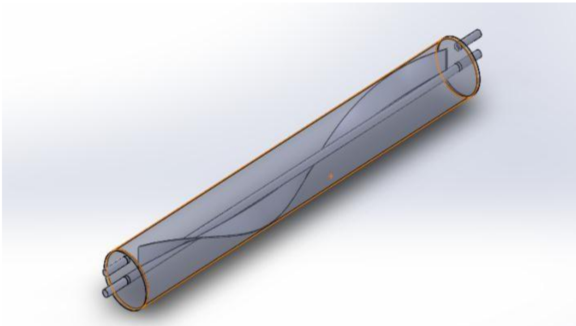

Fig.1. 15^0helical baffle configuration

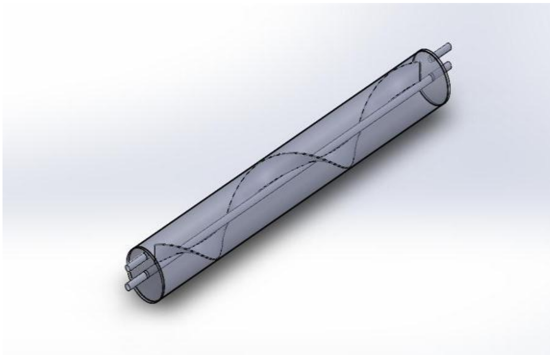

Fig 2. 25^0helical baffle configuration

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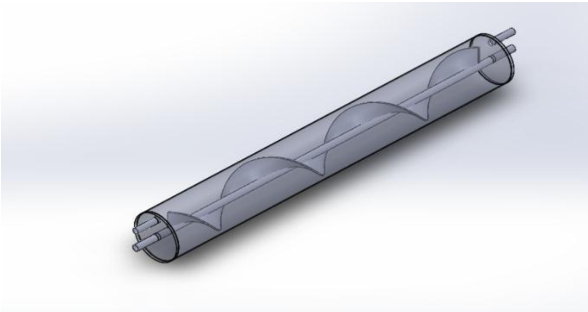

Fig 3. 35^{0}helical baffleconfiguration

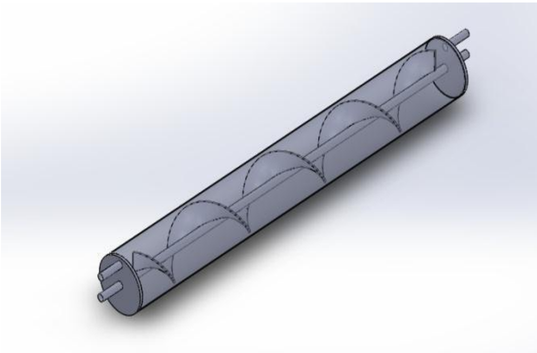

Fig 4. 45^{0}helical baffleconfiguration

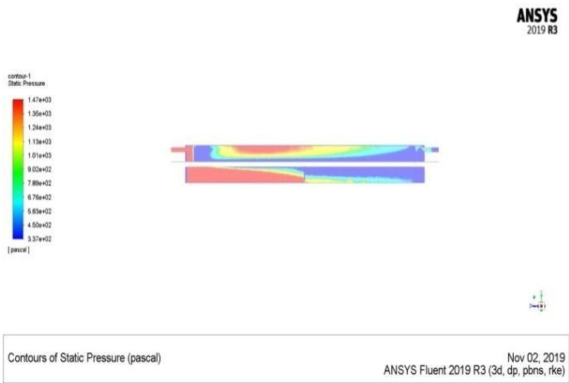

Fig 5.15^{0}Pressure Trajectory

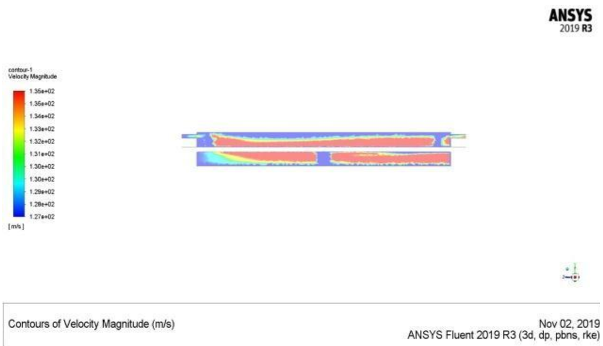

Fig 6.15^{0}VeloctyTrajectory

Fig 7. 15^{0}Temperature Trajectory

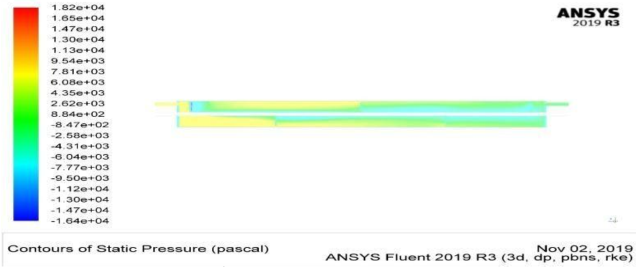

Fig 8.25^{0}PressureTrajectory

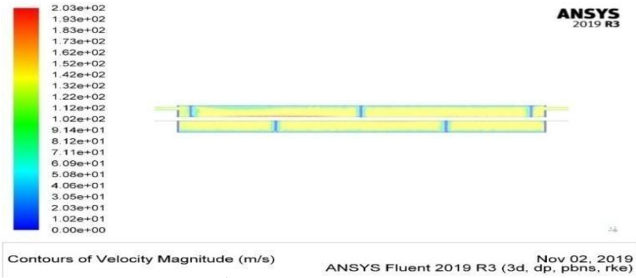

Fig 9.25^{0}VeloctyTrajectory

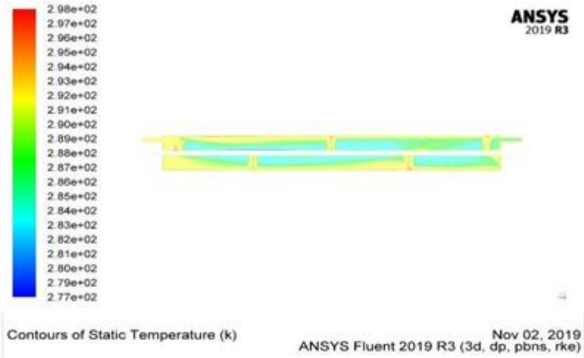

Fig 10.25^{0}TemperatureTrajectory

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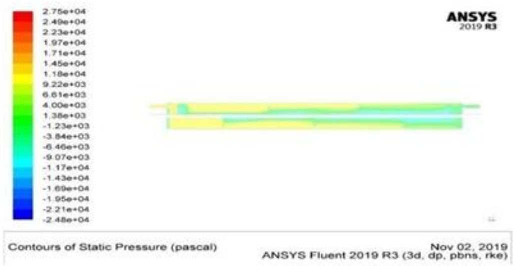

Fig 11.35^0Pressure , Trajectory

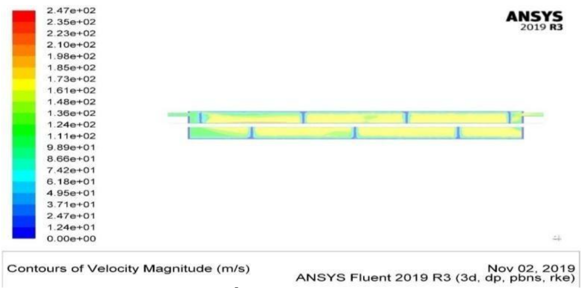

Fig 12. 35^0VeloctyTrajectory

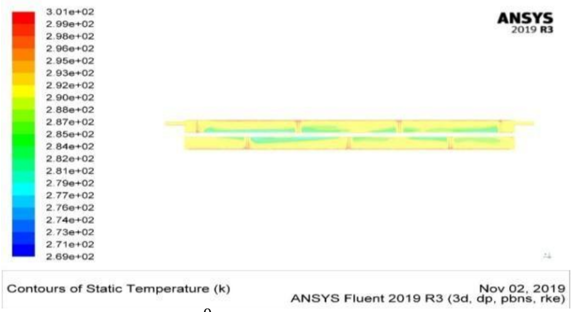

Fig 13. 35^0Temperature Trajectory

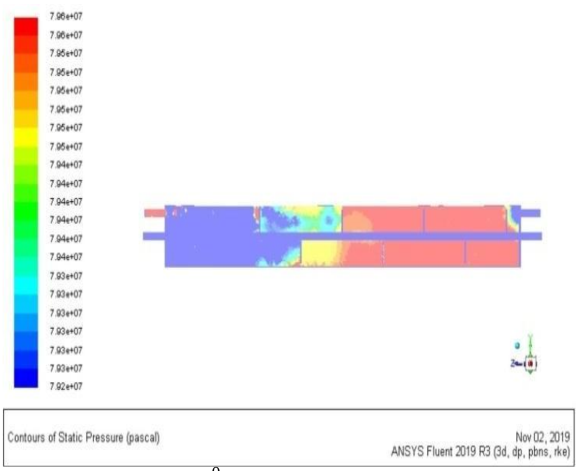

Fig 14 ^{0}pressure Trajectory

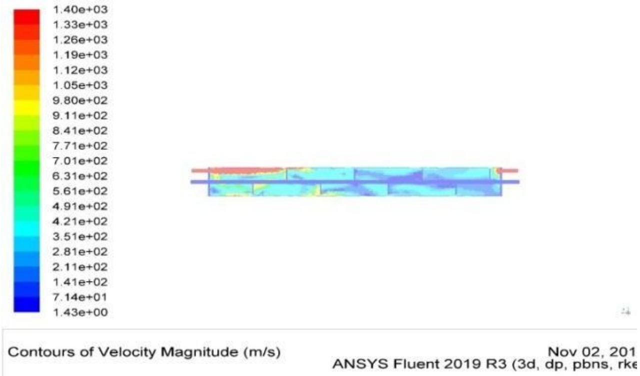

Fig 15.45^0VeloctyTrajectory

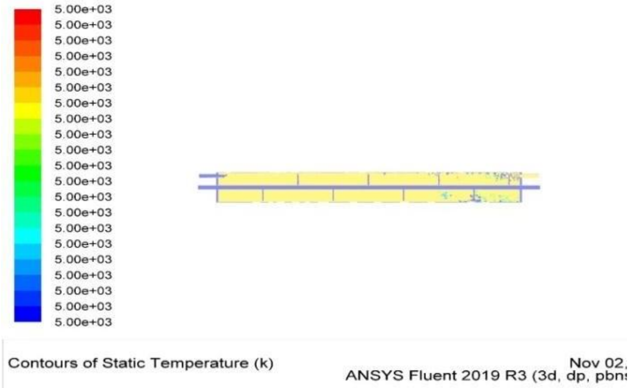

Fig.16.45^0Temperature Trajectory

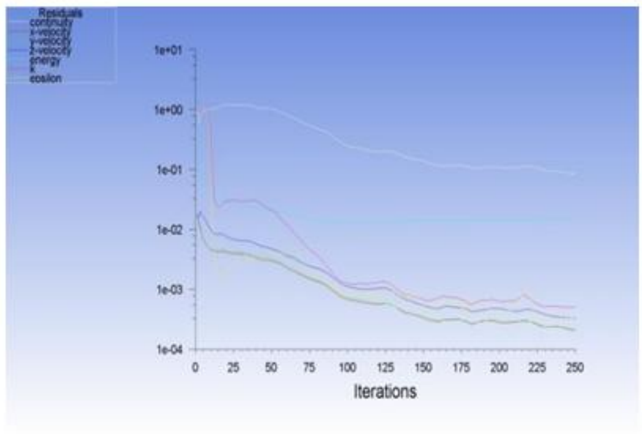

Fig.17. Flow Iteration

V. RESULTS

S.NO	Helix Angle o(deg)	Pressure Drop(Pa)
1	15	2.1319
2	25	0.2690
3	35	0.4130
4	45	0.0814

Table.1. Comparison of various Angle in PRESSUREDROP

S.NO	Helix Angle in o(deg)	Velocity Magnitude(M/ Sec)
1	15	0.098
2	25	2.479
3	35	3.016
4	45	0.030

Table 2. Comparison of various Angle in VelocityMagnitude

VI. CONCLUSION

The Shell Side Pressure Drop is discussed in detail and proposed model is compared with different helical baffle angles. The CFD results when compared with the results from different studies were well with in the error limits. The assumption worked well in this geometry and meshing expects the outlet and inlet region where rapid mixing and change inflow Direction takes place. Thus improvement is expected if the helical baffle used in the model should have complete contact with the surface of the shell, it will help in more turbulence across shell side and the pressure drop will increase Moreover the model has provided the reliable results by considering the standard k-epsilon model. Furthermorethe enhance wall function are not use in this project,buttheycanbe very useful

The pressure drop is poor because most of will be proper contact with the shell .In this project we are calculate the shell side pressure drop of Shell and Tube Heat Exchanger by varying different types of angles baffles. Among those, 45 deg helical baffle gives effective pressure drop. The flow pattern in the shell side of the heat exchanger with continuous helical baffles was forced to be rotational and helical due to the geometry of the continuous helical baffles, which results in an effective pressure drop in the heat exchanger. So helical baffle is preferred in pressure drop conditions. So helical baffles are preferred for effective pressure drop that is[450] 0.08142 Pascal's in shell side of Shell and Tube HeatExchanger.

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