International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 09 | Sep 2020 www.irjet.net p-ISSN: 2395-0072

DEVELOPMENT OF SHELL AND TUBE HEAT EXCHANGER USING HELICAL BAFFLE PLATES

ESHWAR BIRADAR

M-Tech Scholar, Department of Mechanical Engineering, P.D.A College of Engineering, Kalaburgi, Karnataka.

Abstract - *The development of Shell and Tube Heat Exchanger is the need of the new upcoming technology. The better performance of this would solve our problem of non-renewable sources of energy a lot. This paper shows all the results obtained in various numerical and CFD calculations. Further it shows the comparison between the segmental Shell and Tube Heat Exchanger with the Helical Shell and Tube Heat Exchanger Baffle plates.. This is done by two methods numerical method and CFD calculation. Baffle is a shell side component of Shell and Tube Heat Exchanger. The Helical Baffle improves the performance of the Heat Exchanger over the segmental it gives the better heat transfer rate reducing foulimng factor, etc. The desirable features of Heat Exchanger obtained a maximum heat transfer Coefficient and a lower pressure drop. From the Numerical Experimentation result the performance of Heat Exchanger is increased in Helical Baffle instead of Segmental Baffle.*

***Key Words*: Shell and Tube Heat Exchanger, CFD ANSYS Fluent, Helical Baffle plates.**

1. INTRODUCTION

A Heat Exchanger is equipment built for efficient heat transfer from one medium to another. The media can be any solid or liquid bur we need the efficient heat transfer rate. There are numerous applications and are widely used in space heating, refrigeration, air conditioning, power plants, chemical plants, petrochemical plants, petroleum refineries, natural gas processing, and sewage treatment. The performed work is done on two fluids that are flowing one from the tube side and the another from the 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 are considered over segmental Baffles for numerous advantages such as:-

- Reduced shell side fouling.
- Reduced bypass effects.
- Increased heat transfer rate/ pressure drop ratio
- Prevention of flow induced vibration.

The segmental Baffles make fluid perpendicularly impact the shell wall and the tubes, leading to an increased power load which is overcome by Helical Baffles.

The complexity with experiment will help in getting accurate results and the efficiency of the Heat Exchanger wiil be more increased more. Computational Fluid Dynamics is now an established industrial design tool, offering obvious advantages. In this study, a full 360° CFD model of Shell and Tube Heat Exchanger is considered. By modelling and geometry we get the design of Heat Exchanger that is highlyefficient.

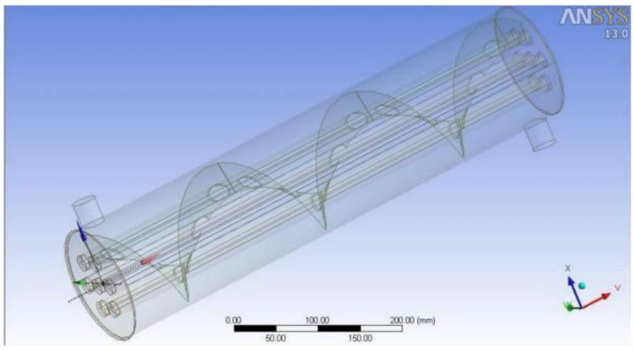
1.1Methodology

Purpose of Use of Helical Baffle:

A new type of Helical Baffle, called the Helical Baffle. This type of Baffle was first developed by Lutcha and Nemansky, 1990. The helix Baffle angle plates are investigated with different helix angles. These Baffle plates will reduce shell side pressure drop and to improve heat transfer performance.

Computational model for Heat Exchanger:

The computational model of Heat Exchanger is experimented on different angles and the shell side direction with total number of 7 tubes. The inlet and outlet of the Heat Exchanger are connected with tubes. For the simplification we have to assume some characteristics.



Isometric view

Method of Approach:

Structure of calculations for the design of Heat Exchanger

➢ Analysis of process specification, including temperatures, flow rates, and compositions and familiarization with operational limits, including permissible pressure drops, velocity ranges, mechanical ratios, and standard lengths.

➢ Determination of the heat duty across the unit using a flow rate with a 10% design factor of safety.

➢ Collection of stream properties, namely density, dynamic viscosity, heat capacities, and thermal conductivities at mean temperatures of both streams

. ➢ Estimation of the overall heat transfer coefficient for the Heat Exchanger.

➢ Calculation of the log mean temperature difference across the unit.

➢ Determination of the heat transfer area.

➢ Calculation of the tube-side heat transfer coefficient.

Shell and Tube Heat Exchangers are usually made from a bundle of tubes approaching to each other at rear and front end. The tube sheets present in these helps in preventing the mixing of the fluid. Fixed tube sheet are less costly especially when there is no joint on the rear side. We can do mechanical cleaning of the tube after the cover has been removed. The shell is not available for cleaning as it contains the heavy fluid and only the chemical cleaning is effective. Baffles are also included along the length of the tube bundle. They serve to produce the turbulent flow so as the heat transfer is increased.

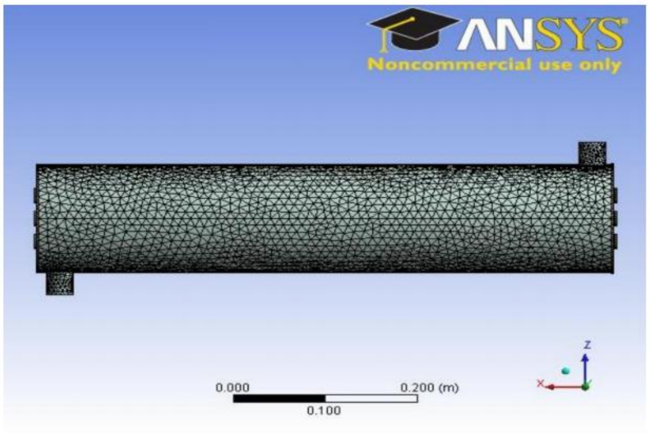
1.1 Modelling and Analysis

Boundary conditions:

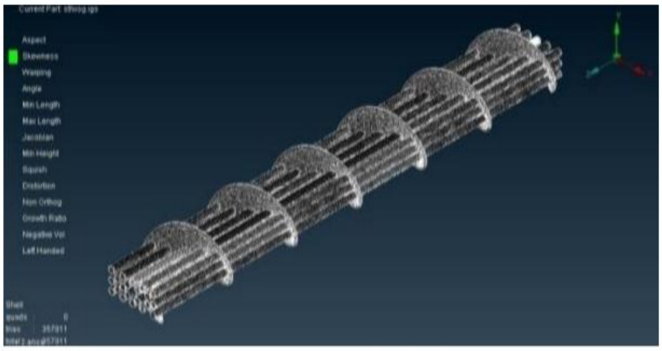
Different boundary conditions are applied for different zones. Since it is a shell-and-tube Heat Exchanger, there are two inlets and two outlets. The inlets are defined as velocity inlets and outlets were defined as pressure outlets. The inlet velocity of the cold fluid is kept constant, whereas velocity of hot fluid is kept constant. The outlet pressures is kept default i.e. atmospheric pressure. The hot fluid temperature at inlet is 340k and cold fluid inlet temperature was is 300k. The other wall conditions are defined accordingly. The surrounding air temperature is kept 300k.

Meshing:

Initially a coarse mesh is generated using 1.8 million cells. This mesh contains both tetrahedral and hexahedral cells having triangular and quadrilateral faces. We should use the structural method of ANSYS. Due to this we can reduce the numerical diffusion. For the fine mesh, the edges and regions of high temperature and pressure gradients are fully meshed.



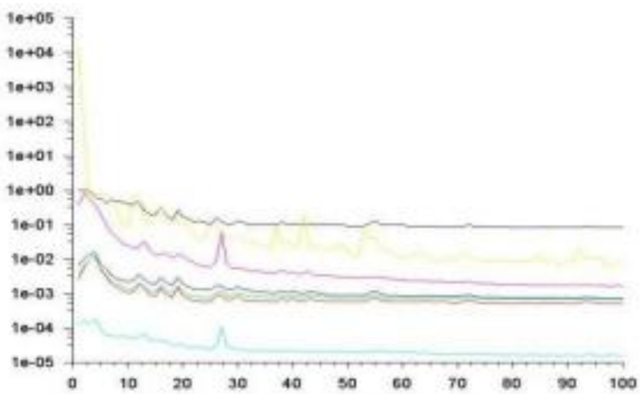
Meshing diagram



Surface mesh

Solution initialization:

Pressure Velocity coupling selected as simplec. Skewness correction is at 0. In Spatial Discretization zone gradient is set as “Least square cell based” .Pressure is “standard” .Momentum is “First order Upwind”. Turbulent Kinetic energy is set as “First order Upwind”. Energy is also set as “First order Upwind”. Solution initialization is “standard method” and solution is initialize from inlet with 300k temperature. Solution initialize condition simulation is set for 200 iteration.



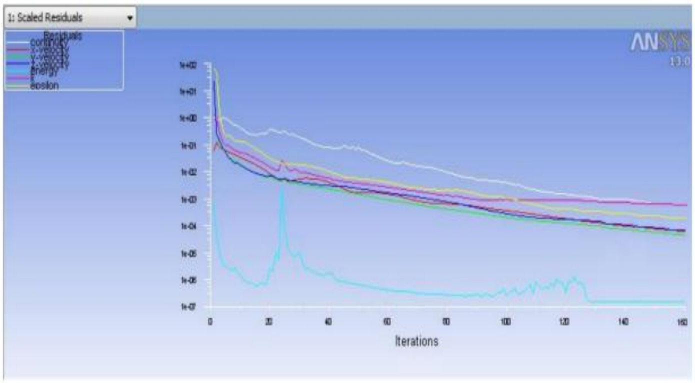
2. Results and Discussin

Convergence of Simulation:

The convergence of Heat Exchanger is required to get the parameters of the outlet. It also gives the values of the Heat Exchanger rate and the continuity x-velocity, y-velocity, z-velocity is a part of schedule residual which have to converge.

0^0 Baffle inclination:

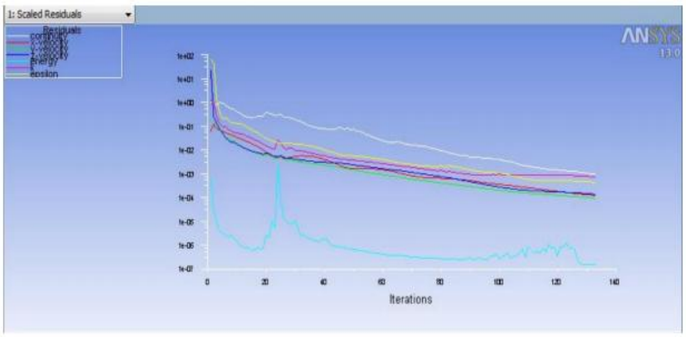
For Zero degree Baffle inclination solution is converged at 160 th iteration. The following figure shows the residual plot for the above iterations:



Convergence Simulation

10^0 Baffle inclination:

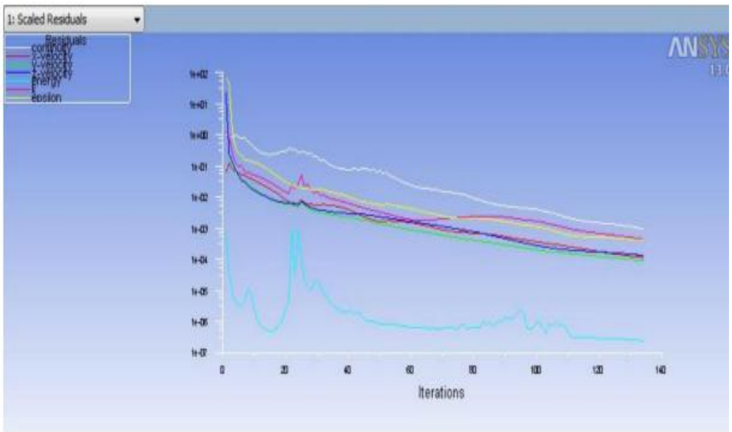
Simulation of 10^0 Baffle inclination is converged at 133th iteration. The following figure shows the residual plot:



Convergence Simulation

20^0 Baffle inclination:

Simulation of 20^0 Baffle inclination is converged at 138th iteration. The following figure shows the residual plot:



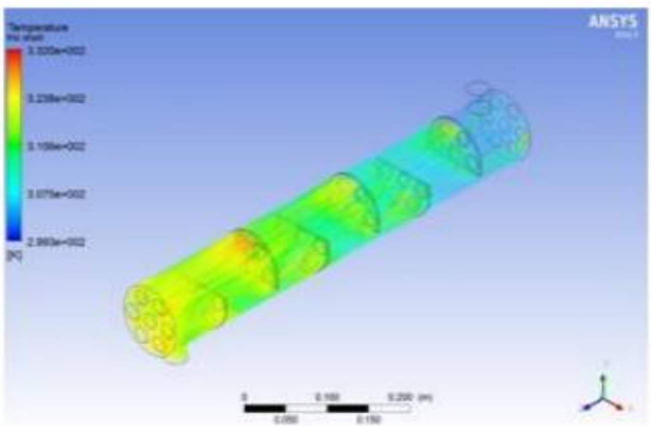
Convergence Simulation

Temperature Variation:

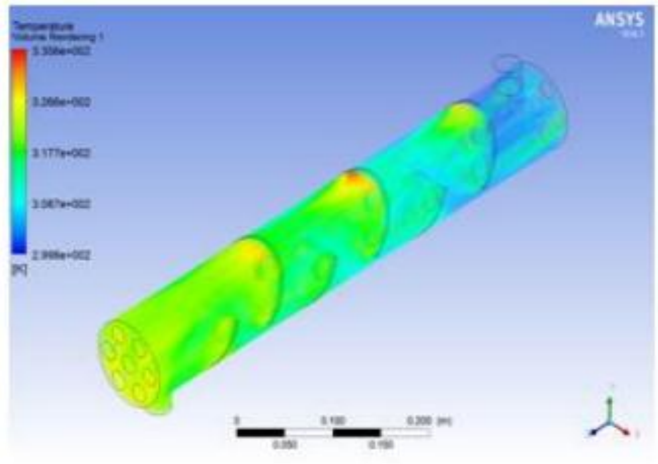
Simulation results are obtained for 0.5 kg/s fluid flow rate for the model with 0^0Baffle inclination angle is validated with the data available in. The exit temperature at the shell outlet and the deviation between the two is 0.04% to 1%. The simulation results for 0.5 kg/s mass flow rate for models with 0^0 and 10^0Baffle inclination are obtained. It is seen that the temperature gradually increases from 300 k at the inlet to 340K at the outlet of the shell side. The average temperature at the outlet surface is nearly 330K. There is no much variation of temperature for all three cases considered. The maximum pressure for model is 22.69 Pa, respectively. The maximum velocity is nearly equal to 0.11 m/s at the inlet and exit surface and the velocity magnitude reduces to zero at the Baffles surface.

The cooling side and the hot side both are considered to be specified at 1 atm pressure. From the Heat Exchanger specifications we have to decide which type of sheet we have to use for the tubes.

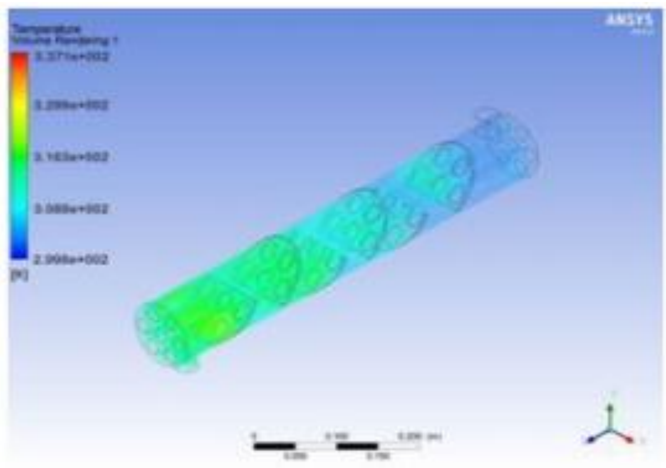
0^0 Baffle inclination:



10^0 Baffle inclination:



20^0 Baffle inclination:



Overall heat transfer co-efficient:

$Q = U*A*(\Delta T)m$

U – Overall heat transfer co-efficient W/m^2 k, A – cross-sectional area m^2, $(\Delta T)m$– logarithmic mean temperature difference.

Baffle inclination angle	**Overall Heat Transfer Coefficient W/m^2K**
0^0	2498
10^0	3300
20^0	3497

Heat transfer rate:

$Q = mh*Cph* \Delta Th = mc *Cpc*\Delta Tc$

m = mass flow rate, Cph,c= specific heat of fluids, ΔTh,c = Temperature difference between Shell and Tube sides

Baffle inclination angle	**Total Heat Transfer Q(W)**
0^0	66,848
10^0	64,148
20^0	70,349

Discussion:

The cooling shell-side fluid was assumed to be available at a pressure of 1 atm from its reservoir, and the hot tube-side fluid from the column is specified to be at 1 atm. From these pressure specifications, the Heat Exchanger TEMA designation is selected to be AEL. The front cover which is a channel with a removable cover is suitable for use in low-pressure tube side fluids in Heat Exchangers. Since the pressure of the tube side fluid is relatively low, the front cover is therefore suitable for use in this design. Moreover, because the front cover can be easily detached from the unit, access to the tubes for mechanical cleaning is made simple. The shell of the unit denoted by E on the TEMA code is trivial from the specification of 1-shell pass. The Rear end denoted by L is selected based on justifications made for the front-end cover. Moreover, having similar covers on both ends allows access to tubes for cleaning purposes possible on both ends of the Heat Exchanger.

3. CONCLUSIONS

In this paper the numerical simulation is done on the Heat Exchanger to find the total heat transfer rate and the overall heat transfer coefficient for different Baffle inclination angles. This provides optimum helix angle for the heat transfer coefficient.

In the present work, an attempt has been made to use Helical Baffle plates instead of the segmental Baffle plates. The modified formula for the simulation of the Heat Exchanger gives the clear idea of the efficiency and the effectiveness.

The heat transfer and flow distribution is discussed in detail above. From CFD simulation results, for fixed tube wall and shell inlet temperatures, shell side heat transfer coefficient, pressure drop and heat transfer rate values are obtained. From the CFD result it is observed that the Heat Exchanger without any short circuited flow has greater heat transfer coefficient than the Heat Exchanger with leakage. It's found that the overall heat transfer coefficient increases by 9.89% if the sealers are installed inside the Shell and Tube Heat Exchanger. It is found that for 0.5 kg/s mass flow rate there is no much effect on outlet temperature of the tube even though the Baffle inclination is increased from 0^0

to 20^0 . However the shell-side pressure difference is decreased with increase in Baffle inclination angle i.e., as the inclination angle is increased from 0^0- 20^0. The pressure difference is decreased by 3%. Baffle cut is reduced in order to provide proper support to the centre row of tubes. It is noticed that for the 36% Baffle cut only 10^0 Baffle inclination angle is maximum. If the angle is beyond 20^0, the centre row of tubes is not supported. Hence the Baffle cut can't be used effectively. Also for the given geometry the mass flow rate must be below 2 kg/s, if it is increased beyond 2 kg/s the pressure drop increases rapidly with little variation in outlet temperature. Hence it can be concluded that Shell and Tube Heat Exchanger with 20^0 inclination angle and 25% Baffle cut results in better performance compared to 0^0 and 10^0 inclination angle.

ACKNOWLEDGEMENT

I would like to convey my sincere gratitude to my project internal supervisor Prof. M.C. NAVINDGI for his invaluable suggestions, constructive criticism, motivation and guidance for carrying out related experiments and for preparing the associated reports and presentations. His encouragement towards the current topic helped me a lot in this project work.

REFERENCES

- Diaper, A.D. and Hesler, L.E. Cross flow Pressure Drop and Flow Distributions within a Tube Bundle Using Computational Fluid Dynamic, Proc. Heat Transfer Conf., Israel, (1990), pp. 235- 240.

- Jian-Fei Zhang, Experimental performance comparison of shell-side heat transfer for shell-and-tube Heat Exchangers with middle-overlapped Helical Baffles and segmental Baffles, Chemical Engineering Science 64 (2009).

- DOW chemical company, 2010. DOWTHERM SR-1 and DOWFROST HD Heat Transfer Fluids In Thermal Energy Storage.

- Pooja J. Pawar, Experimental investigation of shell-andtube Heat Exchanger with different type of Baffles, International Journal of Current Engineering and Technology Accepted 15 June 2016, Available online 20 June 2016, Special Issue-5 (June 2016).

- Emerson, W.H. Shell-side pressure drop and heat transfer with turbulent flow in segmentally Baffled shell-tube Heat Exchangers, Int. J. Heat Mass Transfer, 6 (1963).

- Ghajar, W. & Tang, A., 1994. Comparison of Hydraulic and Thermal Performance of PA0 and Coolanol 25R Liquid Coolants. Washlngton, D.C., 6th AIANASME Joint Thermophysics and Heat Transfer Conference.

- Sinnott, R. K., 2005. Chemical engineering design. 4th ed. s.l.:Elsevier ButterworthHeinemann.

- Serth, R. W., 2007. Process heat transfer principles and application. s.l.:Elsevier Science & Technology Books.

- Usman, U. E. and Goteborg. Heat Transfer Optimization of Shell-and-Tube & Heat Exchanger through CFD, Master's Thesis, Sweden, 09 (2011).

- RevendraVerma ,A Comparative Analysis of Thermal Characteristics Between Experimental Value and FEM Value in Helical Coil Heat Exchanger, International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue 11, November - 2013