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Comparative Study of Different Configurations of Fuel Oil Heat Exchanger

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Abstract- Fuel Oil heat exchanger used in aircraft's fuel system in order to prevent the formation of ice due to residual water in fuel is a shell-tube heat exchanger. This paper is a comparative study of shell and tube heat exchanger with segmented baffles and helical baffles to obtain maximum heat transfer characteristics. The Cold fluid used in the FOHE is the Jet-a fuel. 3D model and flow volume extraction was done using CATIA for the two different baffles. Since we are comparing the performance of segmented and helical baffles, we have simplified the analysis model and compared with only cold fluid domain and applied the temperature of the hot fluid to the hot pipe walls. For the given mass flow rate of the cold fluid, heat transfer rate and pressure drop were analyzed for the segmented and helical baffles and reported in this article. Analysis results from Ansys Fluent showed that the pressure drop is less with better heat transfer in helical baffles than the segmented baffles.

Keywords- *FOHE (Fuel Oil Heat Exchanger), Shell Tube Heat Exchanger, Segmented baffles, Helical baffles, Ansys Fluent*

I. INTRODUCTION

In many industrial applications heat has to be transferred from one flowing fluid to another through a solid barrier separating these fluids. The equipments used for this purpose are called Heat Exchangers. Shell and tube type is the most popular arrangement. (1)A number of small bore pipes are fitted between two tube plates and one fluid flows through these tubes. The tube bundle is placed inside a shell and other fluid flows through the shell and over the surface of the tube. Compact arrangement is possible with this type. Baffles are often included inside the shell to increase the velocity and turbulence of the shell side (4) fluid and thereby increasing the heat transfer.

A typical heat exchanger, usually for higher pressure applications up to 552 bars, is the shell and tube heat exchanger. Shell and tube type heat exchanger, indirect contact type heat exchanger. It consists of a (8) series of tubes, through which one of the fluids runs. A shell is the most commonly used due to its low cost and simplicity, and has the highest log-mean temperature-difference (LMTD) correction factor. In addition, industrial applications often include end plate baffles so that the tube side fluid makes more than one pass through the tube bundle. (9)This involves greater tube side pumping losses but results in an increase in the overall heat transfer coefficient. This can result in a smaller heat exchanger for the same capacity.

The Helical Baffle heat Exchanger is otherwise known as a Helix changer solution that removes many of the deficiencies of Segmental Baffle Heat Exchanger. Helical flow provides the necessary characteristics to reduce (14) flow dispersion and generate near plug flow conditions. The shell side flow configuration offers a very high conversion of pressure drop to heat transfer.

The major Drawback of shell and Tube Heat Exchanger first it cause a larger Pressure Drop secondly it result in a dead zone in each Component between two adjacent Baffles leading to an increase of Fouling Resistance and the Dramatic Zigzag flow cause a high risk of vibration (15)failure on tube bundle. The Helical baffle depends on the helix angle which determines the Pressure drop on shell side. Segmental baffles in a heat exchanger have some limitations in a shell side flow path is wasteful cause a Excessive Pressure loss while recovering less heat transfer These type of arrangements of baffle limits maximum thermal effectiveness. In this study work done on the analysis of Segmental (16) and Helical baffle in a heat exchanger and they shows the higher heat transfer and lower Pressure drop is achieved in a helical baffle compare to segmental baffle.

II. METHODS OF HEAT EXCHANGER CALCULATION

The central variables in any heat exchanger analysis are the heat transfer rate q [W], heat transfer area A [m2], heat capacity rates $C(=mcp)$ [W/K], (10)and the overall heat transfer coefficient U. On the basis of these variables and the fluid temperatures, we can write two (11) basic equations for the heat transfer rate; first, for heat transfer rate it must hold that

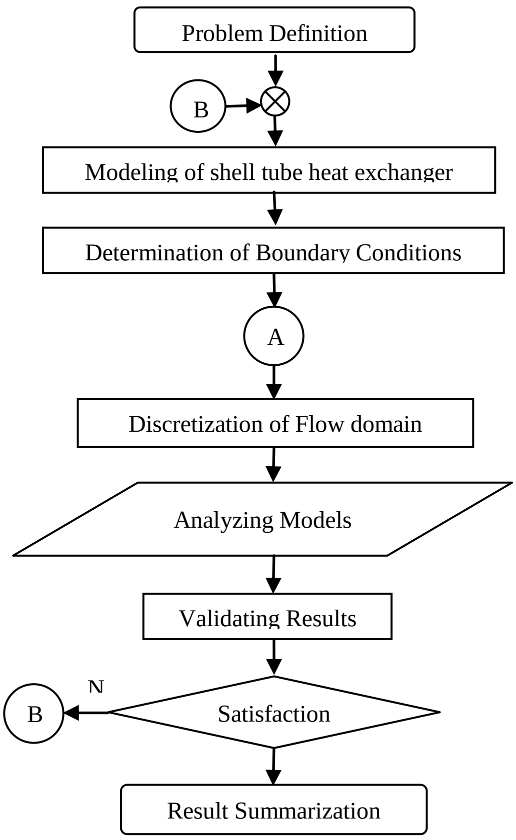
$$q = U A \Delta Tm \quad (1)$$

Where ΔTm is the average (mean) temperature difference of the two fluids in the heat exchanger, and the area A in equation the heat transfer area, meaning the contact area between one of the fluids, and the surface of the wall that separates the fluid. If the areas are different on each sides of the wall, the larger area is the one to be used in above equation as the heat transfer area. (5)The areas are typically significantly different from each other in the case in tubular or extended-surface heat exchangers. Sometimes the term UA of equation is written simply as G [W/K], or conductance of the heat exchanger. Second, on the basis of 1st law of thermodynamics, the heat transfer rate *q* must also equal the rate of heat lost by the hot fluid stream and gained by the cold fluid stream:

$$q = C_{hot} (T_{hot, in} - T_{hot, out}) = C_{cold} (T_{cold, out} - T_{cold, in}) \quad (2)$$

For a sizing problem, where one must define the required area of a heat exchanger in order to achieve the desired outlet temperatures and/or heat transfer rate *q*, the main parts of the problem can in very general terms be said to consist of two parts: finding the value of (6) overall heat transfer coefficient *U* for the type of heat exchanger) finding the correct way to get to the required heat transfer area given the *U* value, selected type of (8) heat exchanger and it's flow patterns, and required heat transfer rate and/or fluid outlet temperatures.

III. METHODOLOGY



A. Modelling of FOHE

Three different configurations of FOHE are being modeled using CATIA V5, namely

Case: 1- FOHE without baffles

Case: 2- FOHE with Segmental baffles

Case: 3- FOHE with helical baffles

The three cases of models are shown below:

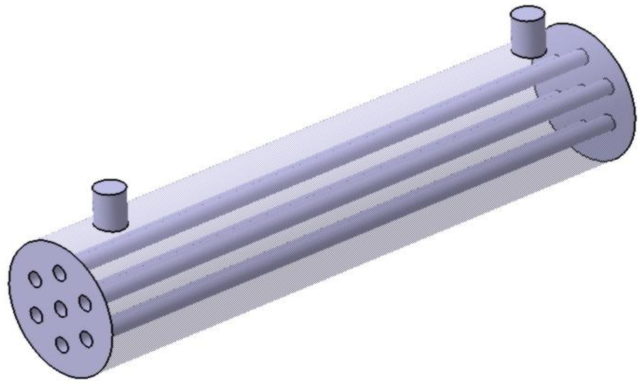


Figure 1. FOHE without baffles

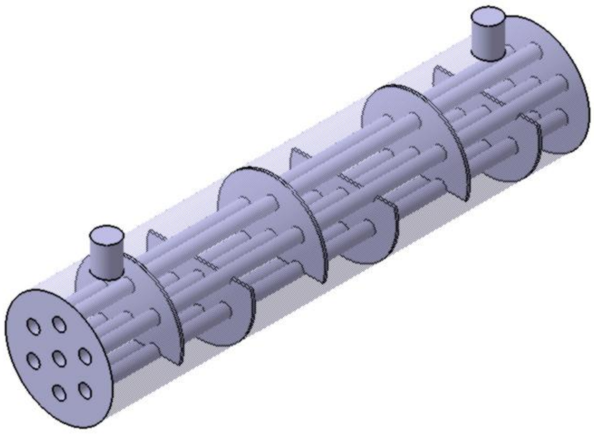


Figure 2. FOHE with Segmental baffles

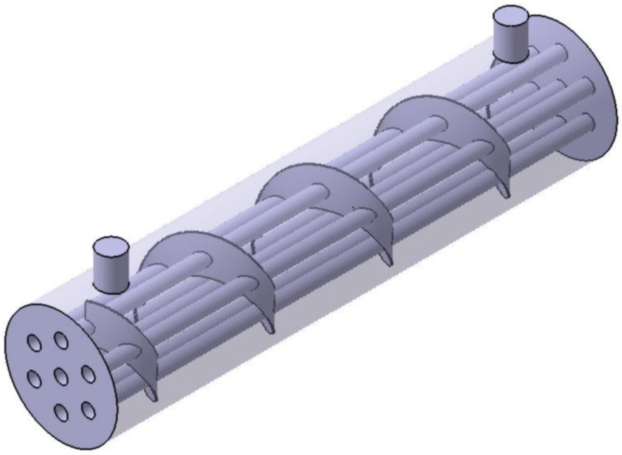


Figure 3. FOHE with Helical baffles

Apart from the various tube configurations, to maximize the heat transfer rate baffle plates are used. Following dimensions are used to create the FOHE.

TABLE I. NOMENCLATURE

Shell inside diameter	88mm
Shell outside Diameter	90mm
Baffle diameter	86mm
Number of Tubes	7
Cold inlet/ outlet diameter	20mm
Tube diameter	10mm
Helix angle	0^0
No of segments	6
No of Revolutions	4

B. *Problem setup and Boundary conditions*

Simulation was carried out in ANSYS® FLUENT. In the Fluent solver Pressure Based type was selected, absolute velocity formation and steady time was selected for the simulation. In the model option energy calculation was on and the viscous was set as standard k-e, standard wall function (k-epsilon 2 eqn).

TABLE II. BOUNDARY CONDITIONS

Cold Fluid	jet-A
Cold fluid Temperature	288K
Hot flow Temperature	353K
Mass flow rate	$1kg/s^2$
Solid Material	Copper
Density	$840kg/m^3$

IV. RESULTS AND DISSCUSSION

A. *Temperature variation for all cases*

The convergence of Simulation is required to get the parameters of the Fuel oil heat exchanger in outlet. It also gives accurate value of parameters for the requirement of heat transfer rate. The temperature Contours plots across the cross section at different configuration of FOHE shown in Figure 4, 5, 6.The temperature Contours plots across the mid-plane section at different kinds of baffle along the length of heat exchanger will give an idea of the flow in detail. Three different plots of temperature profile are taken in comparison with the different baffle sections.

B. *Velocity distribution for all cases*

Velocity distribution across the three different configurations of FOHE is shown in Figure 7, 8, 9. The Velocity distribution in a FOHE with helical baffles is high compared to others. Obviously, the temperature is also high compared to other configuration.

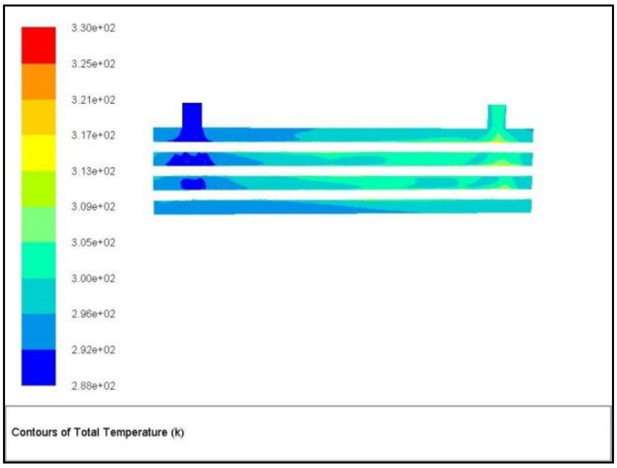


Figure 4. Temperature Variation in FOHE without baffles

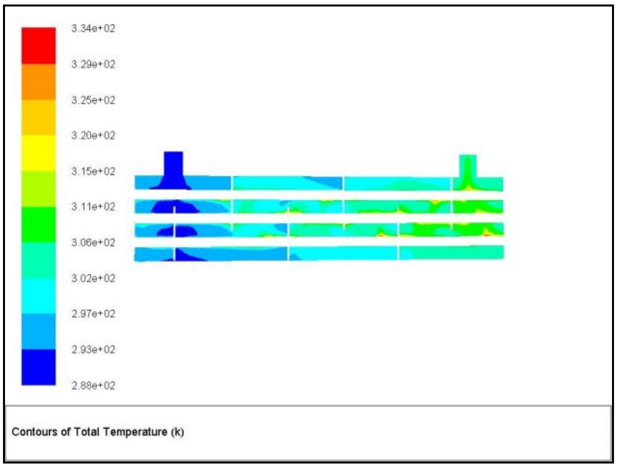


Figure 5. Temperature Variation in FOHE with segmental baffles

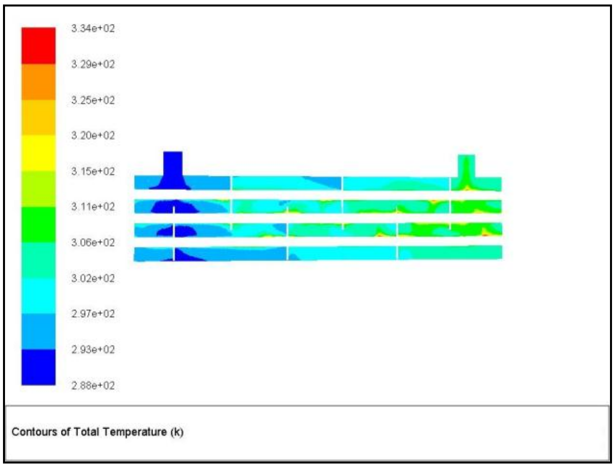


Figure 6. Temperature Variation in FOHE with helical baffles

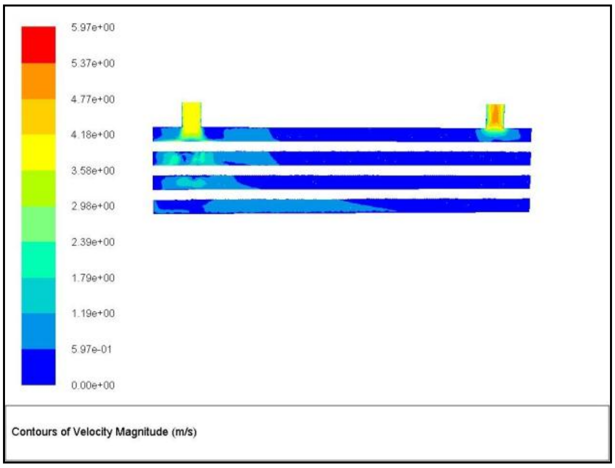


Figure 7. Velocity Distribution in FOHE without baffles

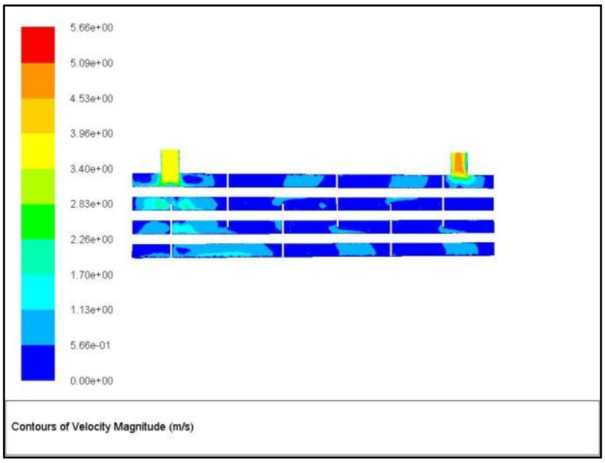


Figure 8. Velocity Distribution in FOHE with segmental baffles

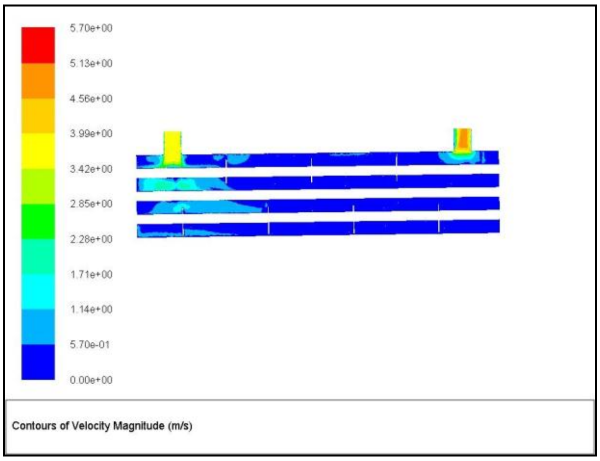


Figure 9. Velocity Distribution in FOHE with helical baffles

C. Pressure distribution for all cases

The Total pressure distribution for all configurations is shown in Figure 10, 11, 12.The pressure drop is less with helical baffles compared to other configuration. Inlet pressure obtained for all cases is different.

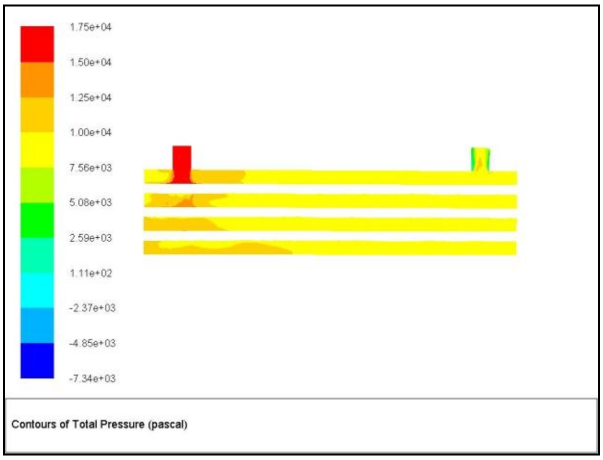


Figure 10. Total Pressure in FOHE without baffles

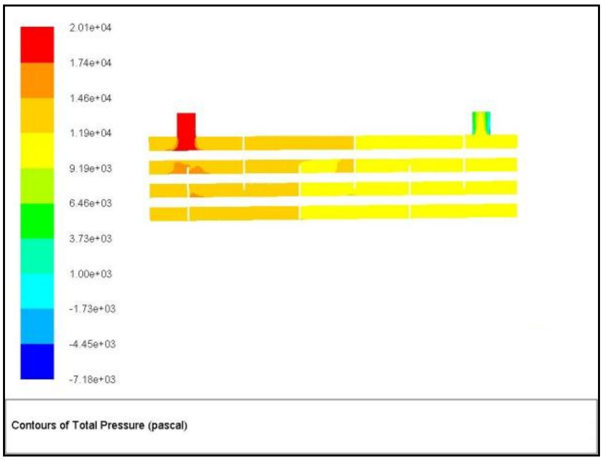


Figure 11. Total Pressure in FOHE with segmental baffles

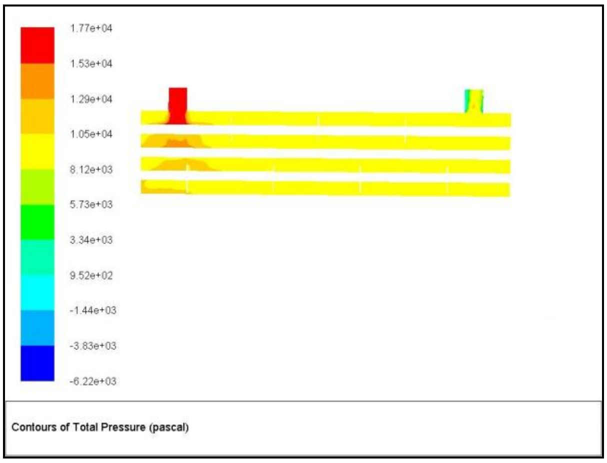


Figure 12. Total Pressure in FOHE with helical baffles

The result values for all the three configurations are tabulated in Table 3. The average values of Total temperature and pressure is mentioned.

TABLE III. RESULTS COMPARISION

Cases	Temperature (K)	Pressure (Pa)
Case-1	300.89	6895.25
Case-2	305.49	6740.74
Case-3	305.2	6808.17

D. Graphical representation

The temperature and pressure variations of different configurations of FOHE are presented graphically in figure 13 and 14.

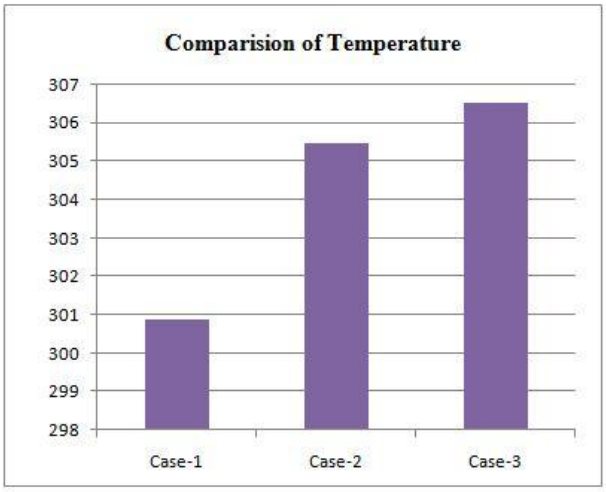


Figure 13. Temperature Comparision

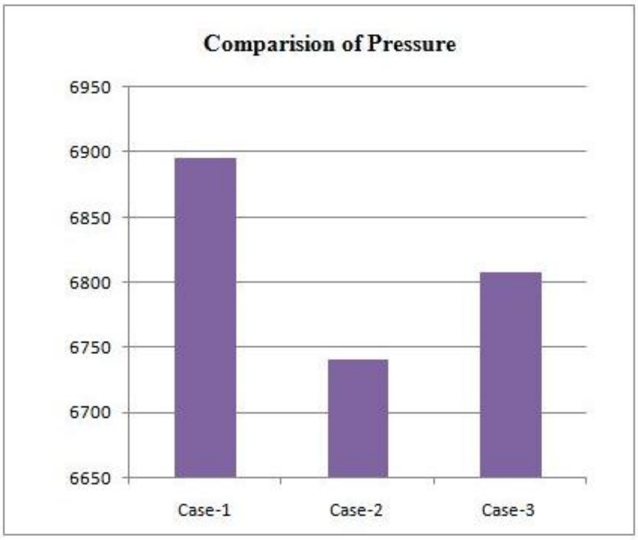


Figure 14. Pressure Comparision

V. CONCLUSION

In this work, analyze of two different baffles and without baffles in a Shell and Tube Heat Exchanger done by ANSYS FLUENT. Shell and tube heat exchanger has been widely used in many industrial applications. The segmental baffle forces the liquid in a Zigzag flow and improving heat transfer and a high pressure drop and Helical Baffle have an Effective Performance of increasing heat transfer performance. The desirable features of heat exchanger obtain a maximum heat transfer Coefficient and a lower pressure drop. In this work only the cold flow heat transfer is analyzed and hot flow heat transfer will analyze in future work.

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REFERENCES

[1] Emerson, W.H., “Shell-side pressure drop and heat transfer with turbulent flow in segmental baffled shell-tube heat exchangers”, Int. J. Heat Mass Transfer 6 ,1963, pp. 649–66.

[2] Haseler, L.E., Wadeker, V.V., Clarke, R.H., "Flow Distribution Effect in a Plate and Frame Heat Exchanger", IChemE Symposium Series, No. 129, 1992,pp. 361-367.

[3] Diaper, A.D. and Hesler, L.E.,"Cross flow Pressure Drop and Flow Distributions within a Tube Bundle Using Computational Fluid Dynamic", Proc. 9th Proc. 9th Heat Transfer Conf., Israel, 1990,pp.235-240.

[4] Jian-Fei Zhang, Ya-Ling He, Wen-Quan Tao, “3d numerical simulation of shell and tube heat exchanger with middle-overlapped helical baffle”, a journal, School of energy and power engineering, china.

[5] Li, H., Kottke, “Effect of baffle spacing on pressure drop and local heat transfer in shell and tube heat exchangers for staggered tube arrangement”, source book on Int.J. Heat Mass Transfer 41,1998, 10, pp. 1303–1311.

[6] Thirumarimurugan, M., Kannadasan, T., Ramasamy, E., Performance Analysis of Shell and Tube Heat Exchanger Using miscible System, American Journal of Applied Sciences 5,2008, pp. 548-552.

[7] Usman Ur Ehman , Goteborg, Sweden, Master’s Thesis 2011:09 on “Heat Transfer Optimization of Shell-and-Tube & Heat Exchanger through CFD”,2011.

[8] LAPPEENRANTA UNIVERSITY OF TECHNOLOGY, Faculty of Technology, LUT Energy, “Heat Exchanger Dimensioning”

[9] P.A.HILTON LTD, Experimental Operating and Maintenance Procedures Optional Shell and Tube Heat Exchanger, H101CM/E/1/001, MAY 04.

[10] Tubular Exchanger Manufacturers Association, “Standards of the Tubular Exchanger Manufacturers Association,” 7th ed., TEMA, New York ,1988.

[11] Mukherjee, R., “Don’t Let Baffling Baffle You,” Chem. Eng. Progress**,** 92 (4),Apr. 1996,pp. 72–79.

[12] Mukherjee, R., “Use Double- Segmental Baffles in Shell-and-Tube Heat Exchangers,”Chem. Eng. Progress, 88(11),Nov. 1992,pp. 47–52.

[13] Tinker, T**.,** “Shell side Characteristics of Shell-and-tube Heat Exchangers: A Simplified Rating System for Commercial Heat Exchangers,” *Trans. ASME,* 80**,**1958,pp. 36–52.

[14] Gang Yong Lei, Ya Ling He , Effects of Baffle inclination angle on flow and heat transfer of heat exchanger with helical baffle, Science Direct Chemical Engineering Processing,2008, pp.1-10.

[15] Bashir Master, K. Chunangad, “Fouling Mitigation using Helixchanger heat exchanger”, Fundamentals and Applications,2003,pp. 312-317.

[16] Kothandaraman C. P. “Fundamentals of Heat and Mass Transfer”,pp. 521.