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Analysis of Shell and Tube Heat Exchanger with Square and Triangular Cross-Sectional Geometry of Tubes: A Review

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***Abstract*—*Heat exchanger is a gear used transfer thermal energy from one medium to another. This medium can either be liquid or gas. This paper is representing the study of shell and tube heat exchanger with the literature review of several researchers. The cross sections of the tube containing geometry square, triangle influence the thermal analysis due to variations of the surface area. When the circular surface gets replaced by flat surface increases the area of contact of fluid with its boundary which in result enhances the heat transfer rate. Analysis with different geometries of the tube in shell and tube heat exchanger and by providing different orientations to the tubes. Using water both as hot and cold fluid. Comparing the analysis result of flat surface geometry with the results of circular tubes by using ANSYS software as a tool..*

***Keywords*— *Shell and tube heat exchanger, CFD- computational fluid dynamics, tube geometries-Square and triangular*.

I. INTRODUCTION

It is almost impossible to imagine a plant without heat exchanger, as it plays vital role for energy transfer. A heat exchanger is a stuff that transfers energy from one fluid to another across a solid surface by convection and conduction. Heat exchangers have its much application in following areas such as power plants, nuclear reactors, refrigeration and air conditioning systems, automotive industries, heat recovery systems, chemical processing, food industries etc. A heat exchanger is equipment which transfers the energy from a hot fluid to a cold fluid, with maximum rate and minimum investment and running costs. There are various types of heat exchangers which are available in industry. But shell and tube type heat exchanger is the most widely used heat exchanger. Shell and tube heat exchanger (STHE) has its own importance in the process industries. Shell and tube heat exchanger is most common type of heat exchanger used in various industrial process and application. STHE is widely used in petrochemical industry, power generation, and energy conservation and manufacturing industries.

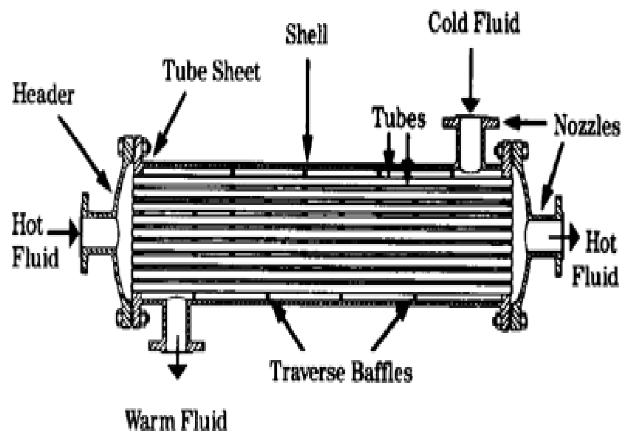

Fig. 1. Shell and tube heat exchanger.

II. LITERATURE REVIEW

1. J. Bala Bhaskara Rao and V. Ramachandra Raju, has carried out the experimental and numerical simulation for single shell and multi-pass tube heat exchanger with elliptical and circular tube geometries with different tube orientations and with different baffle arrangements. The numerically obtained data with elliptical tubes and compared with that of experimental data of circular tube with varying Reynolds number and fluid temperatures. As a result, it is found that the heat transfer coefficient using elliptical tubes is 10% higher as compare to the circular tubes with low pressure drop.
2. Jundika C. Kurniaa, Agus P. Sasmitob, Saad Akhtar, Tariq Shamimc and Arun S. Mujumdar, has numerically evaluate and compare the heat transfer performance of coiled tubes with that of straight tube. Both the tubes have had square cross section area and identical length. The coiled tubes are arranged in three configurations i.e.in-plane, helical and conical with large temperature differences. As the wall temperature of tubes increases, results in higher heat transfer rate.
3. Timothy J.Rennie, Vijaya G.S.Raghavan, has modeled a double-pipe heat exchanger, in which two different tubes with different diameters were used for laminar fluid and heat transfer under different fluid flow rates. This results in the greatest thermal resistance in the annular region.
4. D.G.Prabhanjan, G.S.V.Raghavan, T.J.Rennie, the researchers in this study found the advantages of changing the geometry of heat exchanger i.e. by comparing the helically

coiled heat exchanger with straight tube heat exchanger. The study has an odd one out difference i.e. the boundary conditions for the helical coil as compare to other & focused on fluid to fluid heat transfer.

5. Jose Fernandez-Seara, Carolina Pineiro-Pontevedra, J.Alberto Dopazo, these researchers developed the numerical model to predict the heat transfer and pressure drop in vertical helical coil heat exchanger ,uses water as the working fluid. An increase in Nusselt number and larger ratio between heat transfer rate to pressure drop is obtained by increasing the tube diameter. The model was used to evaluate the geometrical parameters based on heat transfer coefficient and pressure drop.

6. A.Zachar has numerically calculated steady heat transfer enhancement in helical coil tube heat exchanger to examine various geometrical parameters, impact of fluid flow & thermal boundary conditions for laminar and transition flow. As well as discussed the Comparison of flow and temperature fields of common helical tube and the coil with spirally corrugated wall configuration. Heat exchanger coil with helically coiled corrugated wall configuration results in 80-100% increase for the inner side heat transfer rate due to additionally developed swirling motion and the relative pressure drop is 10-600% larger as compared to the common helically coiled heat exchanger.

7. Amarjit singh, Satbir S.Sehgal, has performed an experimental analysis on shell and tube heat exchanger. The shell and tube heat exchanger contains the segmental baffles having different orientations are analysed for different range of Reynolds number between 303-1516, hence the flow is laminar flow. The purpose of using the segmental baffles is to increase the heat transfer rate in shell and tube heat exchanger. With the varying Reynolds number for different orientations result in variations in Log mean temperature difference, heat transfer coefficient, Nusselt number & pressure drop.

8. Panida Seemawute,Smith Eiamsa-ard, has performed an experiment with peripherally-cut twisted tape with alternate axis(PTA), peripherally-cut twisted tape(PT) and typically twisted tape are compared with plain tube in heat exchanger, with varying Reynolds number from 5000 to20000.Using water as working fluid in a turbulent tube. This results in enhanced rate of heat transfer up to 184% in peripherally –cut twisted tape with alternate axis, 102% in peripherally-cut twisted tape and 57% in typically twisted tape with respect to plane tubes of heat exchanger.

9. Zarko Stevanovic, to calculate the velocity, temperature distribution and the rate of heat transfer for three dimensional fluid flows in shell and tube heat exchanger has followed the iterative method. This method leads to the designing and modeling of shell and tube heat exchanger using computational fluid dynamics. In this model baffles and tube bundles were designed by use of porous media.

10. Zekeriya Altac, Ozge Altun has made the use of spiral tube coils in place of straight tubes of same length in heat exchanger. Kept the fluid flow laminar and at steady state conditions. The cold fluid flows from the innermost surface of the spiral tube coil. The spiral tube were used with different curvature ratios(Ro/Ri), tube pitch , Reynolds numbers, Prandtl numbers which reduces the friction factor as a result of which the heat transfer rate get increased. Using CFD software for designing and calculation.

11. Edward S Gaddis & Volker Gnielinski has developed the method on the correlation of the pressure for calculating the pressure drop in an ideal tube tank with equation for calculating the pressure drop in a window section by Delaware method. The pressure drop in an ideal tube tank is calculated with correction factor. This correction factor includes influence of leakage and by pass streams. The above results were checked by comparing experimental measurements available in literature with theoretical predictions.

12. Yonghua You, Aiwu Fan, has developed the porosity and permeability based numerical model to obtain the thermal performance on shell side of a shell and tube heat exchanger with using flower baffles. The numerical model is solved for highly turbulent flow conditions at shell side of heat exchanger. The model helps in analysing the velocity and temperature distribution with convective heat transfer.

13. P.C. Mukesh kumar has shown in its experiment that Al2O3/ the water nanofluids can replace the conventional fluid in helically coiled tube heat exchanger which in result enhances the thermal performance of exchanger with negligible pressure drop. The experimental setup has been carried out to perform the heat transfer and pressure drop analysis in shell and helical coiled tube heat exchanger by using the fluids at turbulent flow conditions.

14. Dr.B.Jayachandriah has made a comparative study of helical baffles with segmental baffles by using kern method. Kern method is an error and trial method used for the designing of shell and tube heat exchanger. Researcher has used CATIA V5 software for the comparative study. As a result of which an increased rate of heat transfer coefficient with helical baffles are obtained.

III. CONCLUSION

From all the literature survey it has been concluded than various numerical analyses are carried out for helical coil tubes and straight tube, and with various baffles geometries such as helical spiral etc in heat exchanger with different geometrical parameters under various conditions. This gives a new outcome than by changing the tube cross sectional geometries other than from circular (i.e. which contains more number of flat surfaces in cross section geometry) will influence the thermal performance due to variations of the surface area. Hence it is identified that by little change in shapes and orientations of tubes, performance of a heat exchanger can be improved.

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