ISSN : 2455-9679
SJIF Impact Factor : 6.008

IJRTSM

INTERNATIONAL JOURNAL OF RECENT TECHNOLOGY SCIENCE & MANAGEMENT

"A STUDY ON THERMAL LOSSES IN HEAT EXCHANGER"

***Sujeet Kumar* [1], *Yogesh Kumar Tembhurne* [2]**

[1] M.Tech Scholar, Department of Mechanical Engineering , Bhabha university Bhopal, MP, India
[2]Assistant Professor, Department of Mechanical Engineering , Bhabha university Bhopal, MP, India

---

ABSTRACT

This paper mainly deals with the study of thermal modeling of heat exchanger. Heat exchanger is a device that is used to transfer thermal energy (enthalpy) between two or more fluids, at different temperatures and in thermal contact. In this problem of heat transfer involved the condition where different constructional parameters are changed for getting the performance review under different condition. In tubes under laminar or turbulent flow conditions with a variety of nanofluids, high heating transfer rates were routinely observed in investigations.The increase in the thermal transfer of the nanofluid depends on particle content, the thermal conductivity of Nano in particular and the mass flow rate

Key Words: *Heat Exchanger, Thermal Power Plant, Fluids, Refrigeration..*

I. INTRODUCTION

Nanotechnology has interested many researchers since its inception, who have recently begun to use nano-fluids in together experimental and theoretical work. Thermo transmitting properties of nanoparticles also contributed to the usage of their respective fields of nanoparticles of industry such as solar Synthesis, gas sensing, biological sensing, nuclear reactors and the petroleum industry to enhance the heat transmission ability of conventional fluids.Over the last decade the science of nanofluid has grown quite constantly. Although the results were contradictory and the method of heat transfer of nanofluids could not be comprehensible, it emerged as a capable thermal transfer fluid. In the continuity of nanofluid science researchers have also recently attempted to use hybrid nanoparticles, which are built to suspend various nanoparticles in combination or a composite form. The aim of the use of hybrid nanofluids is to improve thermal transmission properties further by improving the pressure drop compensation ratios, enhancing the thermal network and the synergistic impact of nanomaterials on individual suspension benefits and disadvantages.

Heat exchanger is a piece of equipment built for efficient heat transfer from one medium to another. They are widely used in space heating, refrigeration, air conditioning, power plants, chemical plants, petrochemical plants, petroleum refineries, natural gas processing and sewage treatment. Heat exchangers are one of the most common pieces of equipment found in all plants. Heat Exchangers are components that allow the transfer of heat from one fluid (liquid or gas) to another fluid. In a heat exchanger there is no direct contact between the two fluids. The heat is transferred from the hot fluid to the metal isolating the two fluids and then to the cooler fluid. The mechanical design of a heat exchanger depends on the operating pressure and temperature

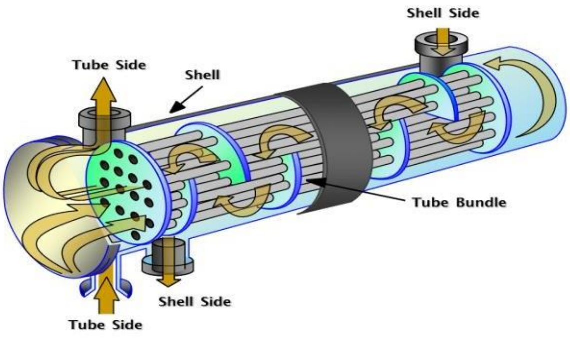

Fig.1 Shell and Tube Heat Exchanger

II. DESIGN METHOD

Shell and tube heat exchangers are designed normally by using either Kern's method or Bell-Delaware method. Kern's method is mostly used for the preliminary design and provides conservative results whereas; the Bell-Delaware method is more accurate method and can provide detailed results. It can predict and estimate pressure drop and heat transfer coefficient with better accuracy. In this paper we have described Kern's method of designing in detail. The steps of designing are described as follows:

1) To find out the values of some unknown temperature first we consider the energy balance. In this energy balance certain some inputs like hot fluid inlet and outlet temperatures, cold fluid inlet temperature, mass flow rates of the two fluids are needed to serve the purpose. The equation may be given as :

Some contents under this heading have been cited from Wolverine Tube Heat Transfer Data Book.

$Q = m\,h\,C_{ph}\,(Th_1 - Th_2) = mc\,C_{pc}\,(Tc_2 - Tc_1)$

2) Then we consider the LMTD equation to find its value:

$$LMTD = \frac{(\Delta T1 - \Delta T2)}{\ln(\frac{\Delta T1}{\Delta T2})}$$

Where, $\Delta T1 = T_{h1} - T_{c2}$ and $\Delta T2 = T_{h2} - T_{c1}$

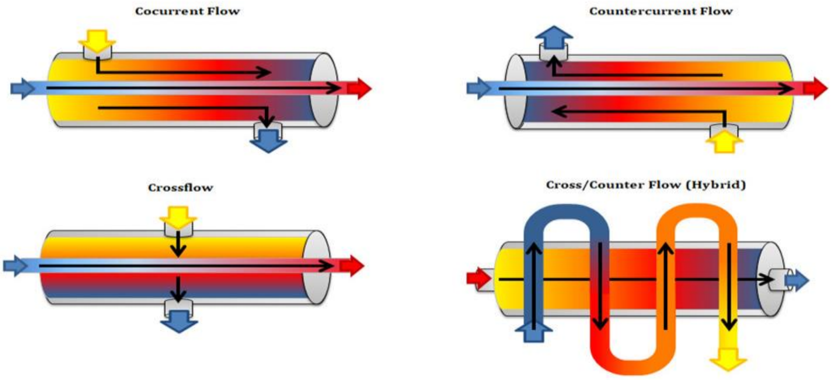

Figure 2 Categorization on the basis of flow direction.

III. LITERATURE REVIEW

While reviewing the works of renowned scholars it has been seen that significant amount of works has been done in field of STHE. Some important works have been described in detail as under:

Shuvam Mohanty et al [2020] In this investigation, a comprehensive approach is established in detail to analyse the effectiveness of the shell and tube heat exchanger (STE) with 50% baffle cuts (Bc) with varying number of baffles. CFD simulations were conducted on a single pass and single tube heat exchanger(HE) using water as working fluid. A counterflow technique is implemented for this simulation study. Based on different approaches made on design analysis for a heat exchanger, here, a mini shell and tube exchanger (STE) computational model is developed. Commercial CFD software package ANSYS-Fluent 14.0 was used for computational analysis and comparison with existing literature in the view of certain variables; in particular, baffle cut, baffle spacing, the outcome of shell and tube diameter on the pressure drop and heat transfer coefficient. However, the simulation results are more circumscribed with the applied turbulence models such as Spalart-Allmaras, k-ε standard and k-ε realizable. For determining the best among the turbulence models, the computational results are validated with the existing literature. The proposed study portrays an in-depth outlook and visualization of heat transfer coefficient and pressure drop along the length of the heat exchanger(HE). The modified design of the heat exchanger yields a maximum of 44% pressure drop reduction and an increment of 60.66% in heat transfer.[1]

Nada SA et al [2018] In the present study, a CFD analysis using ANSYS-FLUENT 14.5 CFD package is used to investigate the characteristics of heat transfer of laminar flow in annulus formed by multi tubes in tube helically coiled heat exchanger. The numerical results are validated by comparison with previous experimental data and fair agreements were existed. The influences of the design and operation parameters such as heat flux, Reynolds numbers and annulus geometry on the heat transfer characteristics are investigated. Different annulus of different numbers of inner tubes, specifically 1, 2, 3, 4 and 5 tubes, are tested. The Results showed that for all the studied annulus, the heat flux has no effect on the Nusselt number and compactness parameter. The annulus formed by using five inner tubes showed the best heat transfer performance and compactness parameter. Correlation of predicting Nusselt number in terms of Reynolds number and number of inner tubes are presented.[2]

Pal E et al [2016] Shell-and-tube heat exchanger has been extensively used in industrial and research fronts for more than a century. However, most of its design procedures are based on empirical correlations extracted from experimental data of long length shell and tube heat exchanger. In this paper, an attempt has been made to investigate the complex flow and temperature pattern in such a short shell and tube type heat exchanger, with and without baffles in the shell side. Heat exchangers of length by hydraulic diameter ratio between for unbaffled and for baffled heat exchangers are analysed using CFD code OpenFOAM-2.2.0 for different mass flow rates. It was observed that, the cross flow near the nozzle region has a significant contribution towards the heat transfer, hence the conventional heat transfer correlations do not apply to these short heat exchangers. Furthermore, a sensitivity study of turbulence models was performed and it was observed that the standard model gives best results for the velocity profile as well as heat transfer, provided average of the first node adjacent to the heat transfer surface is maintained greater than 15. The commonly used boundary conditions at the exit are not realistic, as it tends to give either incorrect flow and temperature fields, or the solution was found to diverge. Through a sensitivity study of the exit length, it was found that exit length to shell side velocity ratio of 2.5 is required for proper convergence. Finally the effect of flow field on shell side heat transfer coefficient is presented and a comparison with analytical methods has been presented.[3]

Rambir Bhadouriya et al [2015] Heat transfer and friction factor characteristics of air flow in an annulus formed by an inner twisted square duct and an outer circular pipe is studied experimentally for Reynolds number range of 400–60,000. Experiments were conducted with air as working fluid. A uniform wall temperature at the inner wall of annulus was maintained while the outer pipe was kept insulated. Twist ratios (ratio of the pitch to outer width of twisted square duct) of 10.6 and 15 were used in the experiments. The transitional Reynolds number for laminar flow to turbulent flow was identified as 3000. Results were compared with the flow inside the annulus of an equivalent straight square duct in a circular pipe for identical pumping power. Results showed considerable enhancement in the heat transfer and pressure drop in both the laminar and turbulent flow regimes.[4]

Rajeev Mukherjee [1988] explains the basics of exchanger thermal design, covering such topics as: STHE components; classification of STHEs according to construction and according to service; data needed for thermal design; tube side design; shell side design, including tube layout, baffling, and shell side pressure drop; and mean temperature difference. The basic equations for tube side and shell side heat transfer and pressure drop. Correlations for optimal condition are also focused and explained with some tabulated data. This paper gives overall idea to design optimal shell and tube heat exchanger. The optimized thermal design can be done by sophisticated computer software however a good understanding of the underlying principles of exchanger designs needed to use this software effectively.[5]

V.K. Patel and R.V. Rao[2010] explore the use of a non-traditional optimization technique; called particle swarm optimization (PSO), for design optimization of shell-and-tube heat exchangers from economic view point. Minimization of total annual cost is considered as an objective function. Three design variables such as shell internal diameter, outer tube diameter and baffle spacing are considered for optimization. Two tube layouts viz. triangle and square are also considered for optimization. The presented PSO technique's ability is demonstrated using different literature case studies and the performance results are compared with those obtained by the previous researchers. PSO converges to optimum value of the objective function within quite few generations and this feature signifies the importance of PSO for heat exchanger optimization.[6]

Hari Haran [2012] proposed a simplified model for the study of thermal analysis of shell and tube type heat exchangers of water and oil type is proposed. The robustness and medium weighted shape of Shell and Tube heat exchangers make them well suited for high pressure operations. This paper shows how to do the thermal analysis by using theoretical formulae and for this they have chosen a practical problem of counter flow shell and tube heat exchanger of water and oil type, by using the data that come from theoretical formulae they designed a model of shell and tube heat exchanger using Pro-E and done the thermal analysis by using ANSYS software and comparing the result that obtained from ANSYS software and theoretical formulae. For simplification of theoretical calculations they have also done a C code which is useful for calculating the thermal analysis of a counter flow of water-oil type shell and tube heat exchanger. The result after comparing both was that they were getting an error of 0.0274 in effectiveness.[]

IV. CONCLUSION

After the study and above discussion it is to be said that the shell and tube heat exchanger has been given the great respect among all the classes of heat exchanger due to their virtues like comparatively large ratios of heat transfer area to volume and weight and many more. And in this work An model will be developed to evaluate analysis of a Helical and Segmental Baffle Heat Exchanger as well as the Comparative analysis between the thermal Parameters between the Segmental and helical angle has been showed.

REFERENCES

[1] Shuvam Mohanty, R. Arora"CFD Analysis of a Shell and Tube Heat Exchanger with Single Segmental Baffles", International Journal of Automotive and Mechanical Engineering 17(2):7890-7901, july 2020
[2] Nada SA, Elattar HF, Fouda A, Refaey HA. Numerical investigation of heat transfer in annulus laminar flow of multi tubes- in-tube helical coil. Heat and Mass Transfer. ; 54(3):715-26, 2018.
[3] Pal E, Kumar I, Joshi JB, Maheshwari NK. CFD simulations of shell-side flow in a shell-and-tube type heat exchanger with and without baffles. Chemical engineering science. 2016; 143:314-40.2016.

[4] Bhadouriya R, Agrawal A, Prabhu SV. Experimental and numerical study of fluid flow and heat transfer in a twisted square duct. International Journal of Heat and Mass Transfer. 2015; 82:143-58

[5] Rajeev Mukharji, "Effective design of shell and tube heat exchanger", American Institute of Chemical Engineering, 1988.

[6] V.K. Patel, R.V. Rao, "Design optimization of shell and tube heat exchanger using particle swarm optimization technique", Applied Thermal Engineering 30 (2010) 1417-1425.

[7] Hari Haran, Ravindra Reddy and Sreehari, "Thermal Analysis of Shell and Tube Heat ExChanger Using C and Ansys", International Journal of Computer Trends and Technology (IJCTT) – volume 4 Issue 7–July 2013.

[8] A. Gopichand, A. V. N. L. Sharma, G. Vijay Kumar, A. Srividya, "Thermal Analysis of Shell and Tube Heat Exchanger Using MATLAB And FLOEFD Software", International Journal of Reasearch In Engineering And Technology (IJRET) – volume 1 Issue 3 - Nov 2012.

[9] Vindhya Vasiny Prasad Dubey,Raj Rajat Verma, Piyush shankar Verma, A. K. Srivastava, "Performance Analysis of Shell and Tube Type Heat Exchanger Under The Effect of Varied Operating Conditions", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) – volume 11 Issue 3 – May-June 2014.

[10] Sandeep k patel, Alkesh M. Mavani, "A New Optimization Method For Evaluating Thermal Parameters in a Single Segement Shell And Tube Heat Exchanger", International Journal of Engineering Trends in Engineering and Development – volume 2 Issue 3 – March 2013.

[11] Donald Q.Kern. 1965. Process Heat transfer (23rd printing 1986). McGraw-Hill companies.ISBN 0-07-Y85353-3.

[12] J. E. Hesselgreaves, 2001 Compact Heat Exchangers Selection, Design and Operation. Elsevier Science and Technology Books. ISBN 0080428398.

[13] Andrews Malcolm, Master Bashir (2005), Three Dimensional Modeling of Helixchanger heat exchanger using CFD, Heat Transfer engineering, vol.26.no.6. pp.22-31.

[14] Mukherjee.R, (1998), Effective Design of Shell and Tube Heat Exchanger, Chemical Engineering Progress, pp.1-8.

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