

# Review on Analysis of Shell-And-Tube Heat Exchangers with Various Design Aspects

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**Abstract-** Shell and tube heat exchangers have played a vital role in almost any application, be it oil and gas, process, refrigeration, air-conditioning or pharmaceutical industry and more. The three different tube pattern is adopted for the study i.e. Square, Rotated Square and Triangular pattern tube arrangement. A comparative study has been carried out among all the three tube patterns. Numerical simulations are carried out to investigate the comparison in between three tube arrangement on the basis of thermo-hydraulic performance of shell-and-tube heat exchangers.

The objective of the study is to review of the performance analysis of different design (tube arrangement) shell and tube heat exchanger basis on previous research papers.

**Index Terms-** Shell and tube heat exchanger, Square Pattern tube, Rotated Square pattern tube Triangular pattern tube, LMTD.

## I. INTRODUCTION

### 1.1 Heat Exchanger

A heat exchanger is a contraption that is used to exchange thermal energy (enthalpy) between no less than two liquids, between a strong surface and a fluid, or between strong particulates and a fluid at various temperatures and in thermal contact. In heat exchangers, there are typically no outer heat and work cooperation. Commonplace applications include heating or cooling of a liquid stream of concern and vanishing or buildup of single-or multicomponent liquid streams. In different applications, the goal might be to recuperate or dismiss heat, or sterilize, sanitize, fractionate, distil, think, take shape, or control a procedure liquid. In a couple of heat exchangers, the fluids trading heat are in coordinate contact.

In most heat exchangers, heat transfer between fluids happens through an isolating divider or into and out of a divider in a transient way. In numerous heat exchangers, the fluids are isolated by a heat transfer surface, and in a perfect world, they don't blend or break. Such exchangers are alluded to as immediate transfer write, or just recovers. Interestingly, exchangers in which there is irregular heat trade between the hot and chilly fluids—by means of thermal energy stockpiling and discharge through the exchanger surface or framework are alluded to as aberrant transfer write, or just regenerators. Such exchangers more often than not have liquid spillage from one liquid stream to the next, because of weight contrasts and framework revolution/valve exchanging.

Essential instances of heat exchangers are shell-and-tube exchangers, vehicle radiators, condensers, evaporators, air preheaters, and cooling towers. In the event that no stage change happens in any of the fluids in the exchanger, it is once in a while alluded to as a sensible heat exchanger. There could be inward thermal energy sources in the exchangers, for example, in electric heaters and atomic fuel components.

### Direct Contact Type Heat Exchangers

In this type, heat transfers ceaselessly from the hot fluid to the chilly fluid through an isolating divider. In spite of the fact that a concurrent flow of (at least two) fluids is required in the exchanger, there is no direct blending of the (at least two) fluids on the grounds that each fluid flows in independent fluid sections. When all is said in done, there are no moving parts in most such heat exchangers. This type of exchanger is assigned as a recuperative heat exchanger or essentially as a recuperator. A few cases

of direct transfer type heat exchangers are tubular, plate-type, and expanded surface exchangers.

The term recuperator isn't normally utilized as a part of the procedure business for shell-and-tube and plate heat exchangers, in spite of the fact that they are likewise considered as recuperators. Recuperators are further sub-classified as prime surface exchangers and broadened surface exchangers. Prime surface exchangers don't utilize fins or expanded surfaces on any fluid side.

### 1.2.2 Classification of Heat Exchanger by Construction Type

Heat exchangers also can be classified according to their construction features. For example, there are tubular, plate, plate-fin, tube-fin, and regenerative exchangers. An important performance factor for all heat exchangers is the amount of heat transfer surface area within the volume of the heat exchanger. This is called its compactness factor and is measured in square meters per cubic meter.

#### Tubular Heat Exchangers

Tubular exchangers are generally utilized, and they are fabricated in numerous sizes, flow courses of action, and types. They can suit an extensive variety of working weights and temperatures. The simplicity of assembling and their moderately minimal effort have been the main explanation behind their across the board use in designing applications. A generally utilized outline, called the shell-and-tube exchanger, comprises of round tubes mounted on a cylindrical shell with their tomahawks parallel to that of the shell.

Figure 1.1 illustrates the main features of a shell-and-tube exchanger having one fluid flowing inside the tubes and the other flowing outside the tubes. The principle components of this type of heat exchanger are the tube bundle, shell, front and rear end headers, and baffles. The baffles are used to support the tubes, to direct the fluid flow approximately normal to the tubes, and to increase the turbulence of the shell fluid. There are various types of baffles, and the choice of baffle type, spacing, and geometry depends on the flow rate allowable shell-side pressure drop, tube support requirement, and the flow-induced vibrations. Many variations of shell-and-tube exchanger are available; the differences lie in the arrangement of flow configurations and in the details of construction.

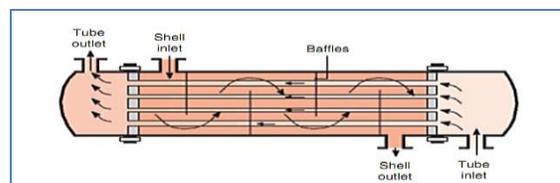


Figure 1.1 A shell-and-tube heat exchanger; one shell pass and one tube pass

## II-LITERATURE REVIEW

Different analysts have been examine the plan and dimensional investigation in shell and tube heat exchangers. Some of them are

Two novel shell-and-tube heat exchangers with louver bewilders are imagined and outlined by Yonggang Lei et al; 2017 for energy protection. A specific sum louver confounds at the tendency edge between shell side stream direction and louver perplex are prepared in shell side to help tube packs. Numerical reproductions are completed to explore the thermo-water powered execution of the two improved shell-and-tube heat exchangers with louver perplexes. For examination, a shell-and-tube heat exchanger with traditional segmental confuses additionally contemplated in the paper. Liquid stream structures and temperature appropriations are displayed for the examination of the physical conduct of liquid stream and heat transfer.

Slanted stream is created in the shell side of the shell-and-tube heat exchangers with louver perplexes that reduction and wipe out the dead spaces and expand the neighborhood heat transfer. Contrasted and the shell-and-tube heat exchanger with segmental bewilders, unexpected difference in liquid stream is kept away from that decline the weight drop in the shell side. The numerical outcomes demonstrated that the heat transfer coefficient per weight drop of both the shell-and-tube heat exchangers with louver puzzles are higher than that of the shell-and-tube heat exchanger with segmental confuses. This infers at a similar heat transfer amount, the directing intensity of the shell-and-tube heat exchangers with louver astounds is lower than that of the shell-and-tube heat exchanger with regular segmental confounds.

One of the worries with respect to these heat exchangers is to upgrade the heat transfer and enhance their productivity. Different analysts and researcher did there think about concerning it. The

overview and explores had been completed in a huge way to enhance the heat transfer improvements. Some of them are as “*Arithmetic Mean Temperature Difference and the Concept of Heat Exchanger Efficiency*”, by Ahmad Fakheri, *Proceedings of HT2003, ASME Summer Heat Transfer Conference, July 21-23, 2003, Las Vegas, Nevada, USA*

In this paper, it is demonstrated that the Arithmetic Mean Temperature Difference, which is the distinction between the normal temperatures of hot and chilly fluids, can be utilized rather than the Log Mean Temperature Difference (LMTD) in heat exchanger investigation. For a given estimation of AMTD, there exists an ideal heat transfer rate,  $Q_{opt}$ , given by the result of UA and AMTD with the end goal that the rate of heat transfer in the heat exchanger is constantly not as much as this ideal esteem. The ideal heat transfer rate happens in an adjusted counter stream heat exchanger and by utilizing this ideal rate of heat transfer, the idea of heat exchanger proficiency is presented as the proportion of the genuine to ideal heat transfer rate. A general mathematical articulation and also a diagram is introduced for the assurance of the proficiency and in this manner the rate of heat transfer for parallel stream, counter stream, single stream, and also shell and tube heat exchangers with any number of shells and considerably number of tube passes per shell. Notwithstanding being more natural, the utilization of AMTD and the heat exchanger productivity permit the direct examination of the distinctive types of heat exchangers.

“*Heat Exchanger Efficiency*” by Ahmad Fakheri, *Article in Journal of Heat Transfer · September 2007, DOI: 10.1115/1.2739620*

This paper gives the answer for the issue of characterizing thermal proficiency for heat exchangers in view of the second law of thermodynamics. It is demonstrated that relating to each genuine heat exchanger, there is a perfect heat exchanger that is an adjusted counter-stream heat exchanger. The perfect heat exchanger has the same UA, a similar number juggling mean temperature distinction, and a similar chilly to hot liquid delta temperature proportion. The perfect heat exchanger's heat limit rates are equivalent to the base heat limit rate of the real heat exchanger. The perfect heat exchanger transfers the greatest measure of heat, equivalent to the result of UA and number juggling

mean temperature contrast, and produces the base measure of entropy, making it the most proficient and slightest irreversible heat exchanger. The heat exchanger productivity is characterized as the proportion of the heat transferred in the genuine heat exchanger to the heat that would be transferred in the perfect heat exchanger. The idea of heat exchanger proficiency gives another path to the outline and investigation of heat exchangers and heat exchanger systems.

“*Design of Shell and Tube Heat Exchanger Using Computational Fluid Dynamics Tools*” by Arjun K.S. and Gopu K.B., 2014, *Research Journal of Engineering Sciences*, ISSN 2278 – 9472 Vol. 3(7), 8-16, July (2014) *Res. J. Engineering Sci.*

At the point when the helix edge was shifted from 00 to 200 for the heat exchanger containing 7 tubes of external distance across 20 mm and a 600 mm long shell of internal breadth 90 mm, the recreation demonstrates how the weight change in shell because of various helix edge and stream rate. The heat transfer coefficient when recorded demonstrated a high esteem when the weight inside the heat exchanger enlisted a decay esteem and this incremental climb was observed to be profoundly huge in the present investigation. This may be expected to the rotational and helical nature of stream design following the geometry change by the presentation of nonstop helical perplexes in the shell side of the heat exchanger. The reproduction comes about acquired with Computational liquid elements instruments for the confound slice given to the altered heat exchanger are used for the count of different parameters like the weight decay, wanted perplex tendency edge and mass stream rate, outlet temperature at the shell side and distribution at confuse side for the specific geometry of the heat exchanger. Little corners at variable points of the fluid stream are the aftereffect of presentation of segmental confounds which enhances heat transfer and enormous decrease in weight in this way expanding the fouling obstruction. This recorded a successful heat transfer climb by the effect of helical astound. The most alluring heat transfer coefficient of the most astounding request and weight decrease of the least request are the outcome created in heat exchanger. Along these lines, the present investigation decisively enhanced the execution of the heat exchanger by the utilization of helical

astound instead of segmental confound from the numerical experimentation comes about.

*"A Review on Performance of Heat Exchangers with Different Configurations"* by T.Venkateshan, Dr. M. Eswaramoorthi, *International Journal for Research in Applied Science & Engineering Technology (IJRASET)*, Volume 3 Issue VII, July 2015 IC Value: 13.98 ISSN: 2321-9653

The necessity of the momentum assembling and generation ventures directs the analysts in finding an elective framework which ought to be powerful in the most effective way. This empowers us to focus on the field of heat exchangers where the energy preparing occurs from the waste outlet. The investigation of heat exchangers is a pushed zone as it is an eco-design display. The idea of heat exchangers assumes a noteworthy part in the refrigeration and cooling framework. An endeavor is made in this paper to survey the writing identified with the heat exchangers and changes made to enhance the efficiencies. Catchphrases: heat transfer upgrade, heat exchanger setups, minimal heat exchangers, nano-fluids

*"An Investigation of Heat Transfer for Two-Phase Flow (Air-Water) in Shell and Tubes Heat Exchanger"* by Ahmed A. Maraie, Ali Ahmed M. Hassan, Mohamed Salah Hassan, Taha Ebrahim M. Farrag and Mamdouh M. Nassar, *International Journal of Innovative Research in Science, Engineering and Technology*, 2016

General Heat transfer coefficients were assessed for two-stage stream in shell and tubes heat exchanger for various stream designs. A two-stage heat transfer exploratory setup was worked for this examination and an aggregate of 44 two-stage heat transfer information with various stream designs were acquired. For these information, the shallow Reynolds number went around between (650-4,000) and (27,000-170,000) for the fluid (ReSL) in first and second heat exchangers separately and ran roughly between (2,600-11,000) and (87,000-162,000) for the gas (ReSG) in the first and second heat exchanger individually. Results show to the general heat transfer coefficient (U) and weight drop) increments with ReSG increments for a settled ReSL. General heat transfer coefficient (U) increment for low ReSL with increment ReSG in which extended between (2-8%) and (3-21%) for first and second heat exchanger individually, yet for high ReSL the general heat transfer coefficient is expanded continuously when

increment ReSG for both heat exchangers in the range between 0.5-1% and from 10 to 14% for first and second heat exchangers separately. Accordingly the execution of shell and tubes heat exchanger is more effective and enhanced for two-stage stream in tubes than one stage, that prompting more productive modern applications.

*"Numerical investigation and optimization of heat transfer and exergy loss in shell and helical tube heat exchanger"* by Mir Majid Etghani, Seyed Amir Hosseini Baboli, 2017, *Applied Thermal Engineering* (2017)

In this exploration paper, numerical model of shell and helical tube heat exchanger is researched to evaluate heat transfer coefficient and exergy misfortune. Four design parameters including pitch loop, tube diameter, hot and cool stream rate, which are more noteworthy for the heat exchanger execution, were taken to thought. At that point, sixteen cases with assorted design parameters are demonstrated and broke down numerically. The outcomes are demonstrated that tube diameter and chilly stream rate are the most huge design parameters of heat transfer and exergy misfortune, individually. Besides, the most elevated Nusselt number are accomplished by more both cool and hot stream rates and additionally, heat transfer coefficient are decreased by expanding of pitch curl and by expanding of hot stream rate, the exergy misfortune increments. The ideal levels for heat transfer coefficient are: pitch 13 mm, tube diameter 12 mm, chilly and hot stream rate 4 LPM. Moreover, the ideal level for exergy misfortune are: pitch 13 mm, tube diameter 12 mm, cool and hot stream rate 1 LPM.

### III-CONCLUSION

In the present work; it can be conclude that comparison has been carried out on by the previous research papers the various parameters like Pressure drop, temperature difference, heat transfer coefficient, heat flux using LMTD analysis etc. The other geometrical parameters like Effective length, number of tubes, Layout pattern, Tube Pitch and material consideration can also be considered for future research.

### REFERENCES

- [1] Ahmad Fakheri, "Heat Exchanger Efficiency", and Article in Journal of Heat Transfer · September 2007, DOI: 10.1115/1.2739620
- [2] Ahmad Fakheri, "Arithmetic Mean Temperature Difference and the Concept of Heat Exchanger Efficiency", Proceedings of HT2003, ASME Summer Heat Transfer Conference, July 21-23, 2003, Las Vegas, Nevada, USA
- [3] Ahmed A. Maraie, Ali Ahmed M. Hassan, Mohamed Salah Hassan, Taha Ebrahim M. Farrag and Mamdouh M. Nassar, "An Investigation of Heat Transfer for Two-Phase Flow (Air-Water) in Shell and Tubes Heat Exchanger" International Journal of Innovative Research in Science, Engineering and Technology, 2016
- [4] Arjun K.S. and Gopu K.B., "Design of Shell and Tube Heat Exchanger Using Computational Fluid Dynamics Tools" 2014, Research Journal of Engineering Sciences, ISSN 2278 – 9472 Vol. 3(7), 8-16, July (2014) Res. J. Engineering Sci.
- [5] Ashkan Alimoradi, Farzad Veysi, "Optimal and critical values of geometrical parameters of shell and helically coiled tube heat exchangers", Case Studies in Thermal Engineering 10 (2017) 73–78
- [6] Dawit Bogale, "Design and Development of Shell and Tube Heat Exchanger for Harar Brewery Company Pasteurizer Application (Mechanical and Thermal Design)" 2014, American Journal of Engineering Research (AJER) e-ISSN: 2320-0847 p-ISSN: 2320-0936 Volume-03, Issue-10, pp-99-109
- [7] J. Fernández-Seara, F. J. Uhía, J. Sieres, and A. Campo, "A general review of the Wilson plot method and its modifications to determine convection coefficients in heat exchange devices," *Applied Thermal Engineering*, vol. 27, pp. 2745-2757, 12// 2007.
- [8] M. Thirumarimurugan, T.Kannadasan and E.Ramasamy, "Performance Analysis of Shell and Tube Heat Exchanger Using Miscible System" American Journal of Applied Sciences 5 (5): 548-552, 2008 ISSN 1546-9239
- [9] Mir Majid Etghani, Seyed Amir Hosseini Baboli "Numerical investigation and optimization of heat transfer and exergy loss in shell and helical tube heat exchanger" 2017, Applied Thermal Engineering (2017)