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"Performance Analysis of Triple Concentric Tube Heat exchanger with Ribs-A Review "

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Abstract— Heat exchanger is a device which is used to transfer heat between a solid object and a fluid, or between two or more fluids separated by a wall to prevent mixing of the fluid. The performance of the heat exchanger generally depends on the various physical characteristics of the fluid and the material. In order to achieve the maximum efficiency of heat exchanger, many researchers have put their effort to maximize the performance along with reduced cost and size. There are several kinds of heat exchangers are used in industry such as plate type heat exchanger, shell and tube heat exchanger, double pipe heat exchanger, helical tube heat exchanger etc. Double tube heat exchanger is conventionally used because of its cheaper cost and simple construction. But it occupies more space. To resolve this problem a new heat exchanger was introduced i.e. triple tube heat exchanger. It provides additional flow passage with compact design and greater heat transfer area per unit length of heat exchanger as compared to the double pipe heat exchanger. To study the temperature distribution along the length of heat exchanger two combinations of the heat exchanger are used for this purpose, the first one named (N–H–C) which means that the normal water flows through the innermost pipe, hot water flows through the inner annulus and the cold water flows through the outer annulus. The second combination used is named as (C–H–N) where the cold water and normal water interchange between each other while hot water flow remains same as in (N– H–C) configuration. This paper presents a review on performance analysis of triple tube heat exchanger.

Keywords- Heat exchangers, Triple concentric tube heat exchanger, Double tube heat exchanger (N-H-C) ,(C-H-N) .

1. Introduction

Heat exchangers (HX) are used in all process and industrial purpose worldwide. Heat exchanger equipment transfers heat from a hot fluid to a cold fluid. Here in both fluids are separated by means of a solid wall. Typically, most heat exchangers are two-fluid heat exchangers, although three fluid heat exchangers are becoming more popular. Heat exchangers can be classified in terms of flow and construction. In terms of flow, heat exchangers can be classified as parallel flow, counter flow and cross flow (figure 1, & 2). In terms of construction, they can be classified as shell and tube, concentric tube and finned tube heat exchangers. The choice of a heat exchanger for a given application is dependent on the application itself, available resources, space, existing connections in the field, etc. Whatever may be the choice of a heat exchanger, it is very essential that a heat exchanger be designed such that it delivers the required heat transfer while occupying less space, being light weight, and yet be priced competitively.

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Concentric tube heat exchanger plays a major role in fulfilling the needs of heat exchanger in food industry. The most commonly used heat exchanger is double pipe heat exchanger which consists of one pipe inside another pipe placed concentrically. It is used in different products such as dairy, food, beverage and pharmaceutical industries. There are some disadvantages of this exchanger and to overcome this, there is need to enhance the performance of double pipe heat exchanger. Adding an intermediate tube to a double pipe heat exchanger converts it to a triple pipe heat exchanger. Triple concentric tube heat exchanger (figure 3) has better heat transfer efficiencies and performs better as compared to double pipe heat exchanger. It has larger area per unit length for heat transfer and better overall heat transfer coefficient due to higher fluid velocities in the annular regions. To study the temperature distribution along the length of heat exchanger with ribs two combinations of the heat exchanger are used for this purpose, the first one named (N–H–C) which means that the normal water flows through the innermost pipe, hot water flows through the inner annulus and the cold water flows through the outer annulus. The second combination used is named as (C–H–N) where the cold water and normal water interchange between each other while hot water flow remains same as in (N– H–C) configuration.

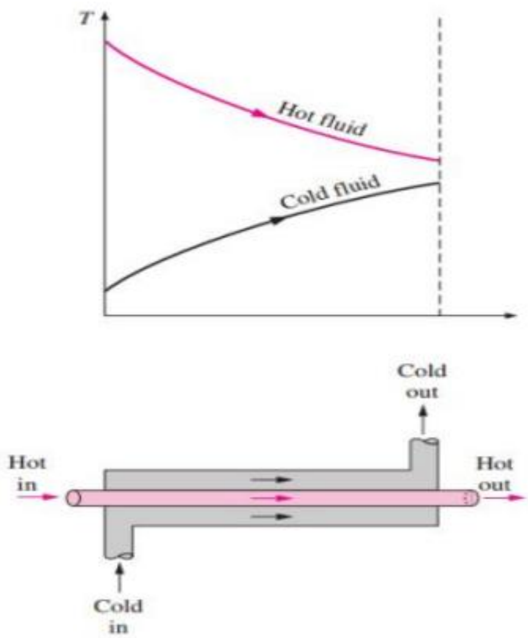

Fig 1: Parallel flow

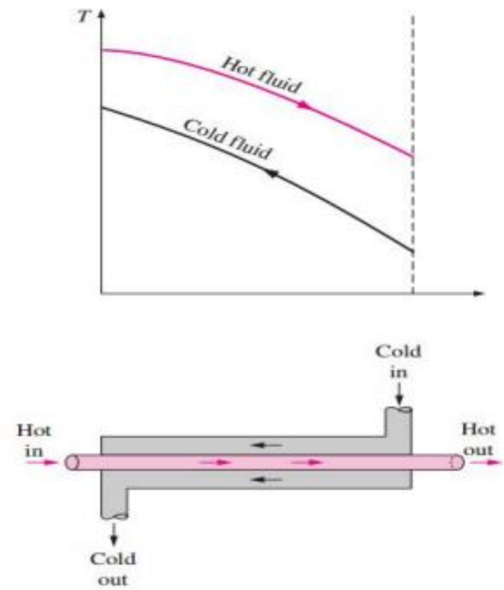

Fig 2: Counter flow

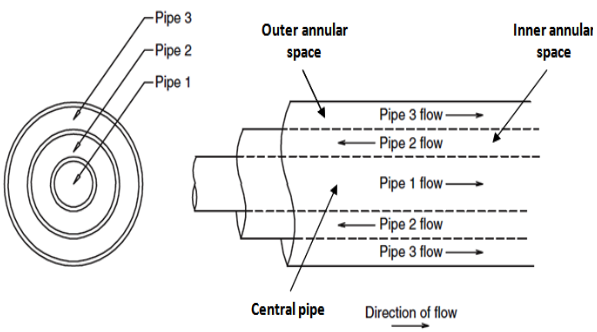

Fig 3: Triple concentric pipes [5]

2. LITERATURE REVIEW

Quadir et. al. [1] studied triple concentric tube heat exchanger experimentally under steady state conditions for two different flow arrangements, called N-H-C and C-H-N, and for insulated as well as non-insulated conditions of the heat exchanger. Under N-H-C arrangement, normal water flows in the innermost pipe, hot water flows in the inner annulus, and the cold water flows in the outer annulus. Under C-H-N arrangement normal and cold water flow passages are interchanged while that for hot water remains unchanged. The results are presented in terms of temperature distribution of the three fluids along the length of the heat exchanger under co-current parallel flow, both insulated as well as non-insulated conditions, and for different fluid flow rates. The heat transfer between the three fluids considered is more effective in N–H–C arrangement of the heat exchanger as compared to that in C–H–N arrangement. Further, normal water is heated more in N–H–C arrangement than in C–H–N arrangement. The crossover point occurs between hot and normal water for insulated as well as non-insulated conditions under N–H–C arrangement.

Sahoo et. al. [2] carried out experiment for helical triple concentric tube heat exchanger with different flow arrangements i.e. N-H-C and C-H-N with parallel and counter flow types. The temperature distribution of fluids w.r.t. length of the heat exchanger was observed. Effectiveness calculated for parallel and counter flow in N-H-C and C-H-N arrangements. The triple concentric helical tube heat exchanger proved to be effective and of compact design for heat exchange between the fluids.

Dilpak et. al. [3] carried out CFD analysis of triple concentric tube heat exchanger by using previous research's mathematical model, experimental model and correlation . Here mainly focused on two conditions, $V_n = V_h = V_c = 35$ l/min and V_h=20 l/min; V_n=V_c=35 l/min. The flow analyzed was co current parallel flow with N-H-C arrangement. Tolerating small difference, CFD results are close to the experimental results.

Pravin et. al. [4] Carried out experiment for the heat transfer performance and pressure drop of triple concentric pipe heat exchanger. The mass flow rate of hot water in the inner annulus and normal water in the inner pipe are varied during experiment. Effect of mass flow rate on heat transfer characteristics and pressure drop are considered. With increase in hot water Reynolds number, both normal and cold side overall heat transfer coefficient increases.

Ganesh et. al. [5] Carried out experiment on performance analysis of Triple Tube Heat Exchanger with dimple tubing. He found that for the same Reynolds number effectiveness of triple tube heat exchanger is 60% more than double tube heat exchanger. Friction factor on hot fluid side is decreases as 'Re' increases and hence pumping power is reduced.

Tejas et. al. [6] studied sizing of triple concentric pipe heat exchanger. It involves the sizing of triple concentric pipes heat exchanger where in two cold water streams flow through the central tube and outer annular space at same mass flow rates and same inlet temperatures in co-current direction while hot water flows through inner annular space in counter-current direction. He proposes a basic procedure for calculating overall heat transfer coefficients and length of triple concentric pipes heat exchanger. Length of triple pipe heat exchanger is computed for a required temperature drop of hot water with available dimensions of three pipes by LMTD method. Overall heat transfer coefficient and length of the equivalent double pipe heat exchanger are compared with that of the triple pipe heat exchanger. The theoretical analysis shows that introducing an intermediate pipe to the double pipe heat exchanger reduces effective length of heat exchanger, which results in savings in material and space.

D. P. Sekulic et al. [7] offered in detail a review on thermal design theory of three fluid heat exchanger, where they have allowed for third fluid temperature to vary according to main thermal communication while neglecting interaction with ambient. He used effectiveness- NTU (number of heat transfer units) approach and corresponding rating and sizing problems for the determination of the effectiveness or NTU for a three-fluid heat exchanger.

Quadir et. al. [8] studied performance of a triple concentric pipe heat exchanger numerically using finite element method (FEM) under steady state conditions for different flow arrangements and for insulated as well as non-insulated conditions of the heat exchanger. The three fluids being considered are hot water, cold water and the normal tap water. The results are presented in the form of the dimensionless temperature variations of the three fluids along the length of the heat exchanger for their different flow rates. He found that the numerical predictions of the temperature variations of the three fluids by using FEM follow closely to those obtained from experiments both in magnitude and trend provided correct overall heat transfer coefficients are used. Parametric studies are also carried out to show the effect of the individual design parameter on the performance of the heat exchanger.

Ahmet Unal et. al.[9] in his first part developed a mathematical model, consisting the derivation and possible solutions of the governing equations for both counter-flow and parallel-flow arrangements. The equations derived in this study can be used for both design calculations and performance calculations, besides they can be used for the determination of bulk temperature variation along the exchanger.

Ahmet Unal et. al.[10] in his second part conducted several case studies for counter-flow arrangement in his second part based on the solution obtained in the first part. It has been demonstrated that the relative sizes of the tubes (the tube radii) play a very important role on the exchanger performance and/or on the exchanger length and optimizing triple tube heat exchanger effectiveness provides a considerable amount of increase in the exchanger performance.

3. CONCLUSION

The outline of above literature review is that a triple concentric tube heat exchanger performs better than double pipe heat exchanger . The heat transfer between the three fluids considered is more effective in N–H–C arrangement of the heat exchanger as compared to that in C–H–N arrangement. Further, normal water is heated more in N–H–C arrangement than in C–H–N arrangement. With increase in hot water Reynolds number, both normal and cold side overall heat transfer coefficient increases. Effectiveness of triple tube heat exchanger with dimpling is 60% more than double tube heat exchanger.

4. REFRENCES

1. G.A. Quadir , N. J. Salman Ahmed, Irfan Anjum Badruddin, (2013), Experimental investigation of the performance of a triple concentric pipe heat exchanger, International Journal of Heat and Mass Transfer, 62, 2014, 562-566.
2. M.Sahoo , V.M. Behera , S.N.Das , H.C.Das , (2016) "Experimental investigation and performance analysis of triple concentric helical tube heat exchanger " International Journal of Engineering and Technology (IJET) Vol 8 No 5 Oct-Nov 2016.
3. Dilpak Saurabh P., Harshal Khond and Mandar M. Lele , (2016) CFD Analysis of a Triple Concentric Tube Heat Exchanger having water flowing at three different temperatures INPRESSCO IJCET Special Issue-4 (March 2016)
4. Pravin M. Linge, B. Korane, V. N. Kapatkar (2016) Performance Study of Triple Concentric Pipe Heat Exchanger , International Engineering Research Journal (IERJ) Special Issue Page 629-634, June 2016
5. Mr. Ganesh V. Wafelkar , Dr. L. V. Kamble "Experimental performance analysis of triple tube heat exchanger with dimple tubing " INPRESSCO IJCET Special Issue-5 (June 2016)
6. Tejas M. Ghiwala, Dr. V. K. Matawala, (2014), Sizing of triple concentric pipe heat exchanger, International Journal of Engineering Development and Research, 02, 1683-1692.
7. D.P.Sekulic, R.K.Shah, "Thermal design theory of three fluid heat exchangers", Advances in Heat Transfer, 1995, 26, 219-328.
8. G.A. Quadir , N. J. Salman Ahmed, Irfan Anjum Badruddin, (2014) Numerical investigation of the performance of a triple concentric pipe heat exchanger.
9. Ahmet Unal, "Theoretical analysis of triple concentric-tube heat exchanger Part-1 Mathematical modeling", International Communication Heat Mass Transfer, 1998, 25, 949-958.
10. Ahmet Unal, "Theoretical analysis of triple concentric-tube heat exchanger Part-2 Case studies", International Communication Heat Mass Transfer, 2001, 28, 243-256.