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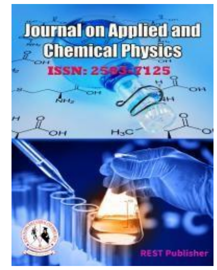

Review on Factors Affecting Efficiency of Shell and Tube Heat Exchanger

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Abstract: *Heat exchanger is one amongst promising thermal device in which heat transfer takes place between hot fluid and cold fluid. Among various classifications of warmth exchangers, the main focus was shown by researchers on indirect contact type compact heat exchangers. Among them the shell and tube device belongs to fluid to fluid type heat transfer device. Main applications of shell and tube device feed device in process industries, refineries, chemical plants and power plants. Usually the analysis of shell and tube heat exchangers are divided into two parts namely shell side and tube side analysis. Shell side analysis is easy and doesn't involve much modification. Whereas the tube side analysis is complex and it's done by varying baffle design and elevation with regard to arrangements of tubes. The most disadvantage of shell and tube device is pressure drop which occur at the end of tubes. To overcome this problem, drilled cylindrical copper block has been introduced to switch the tube part through which the new fluid flows and therefore the cold fluid is circulated through the shell. With this design modification, the effectiveness, mass rate, overall heat transfer co efficient are simulated and analysed.*

Keywords: *Refineries, Chemical plants, Baffle design, Cylindrical copper block, Effectiveness.*

1. INTRODUCTION

The shell and tube device is formed from a bundle of tubes is placed with baffle and placed into a shell. The warmth exchange always takes place between hot and cold fluid. In this type of heat exchanger, hot fluid passes through tube and cold fluid passes through shell. The operating fluid may be of single or two phase and flow in either a very parallel or a cross/counter flow arrangement. The selection of shell and tube device configuration affects the general heat transfer coefficient and thus also affects the heat transfer rate. The tube surfaces are also a vital concern to ponder upon to have awfully high heat transfer rate.

2. Operating Parameters

Investigations made on the effect of baffle spacing, shell diameter and tube length on heat transfer coefficient and pressure drop for shell side with both triangular and square pitches. Fouling rates are used to reduce the heat transfer rate on both shell and tube side. Heat transfer coefficient increases 3% with increasing shell diameter 0.05m [1].

Baffle design and arrangement: Baffle plates are used in shell and tube heat exchanger in order to hold the tubes in position and to directing the flow of working fluids in proper manner to have the enhanced efficiency. The study on thermal augmentation of trefoil baffles conducted using ANSYS FLUENT. In this study, structural modification is investigated for better thermo hydraulic performance and the effects of baffle design. Pressure loss on the small size heat exchanger is decreased by 21% and thermo hydraulic performance increased by 21.9% as the effect of such baffle design. In addition the convection heat transfer co-efficient on the shell is decreased monotonically with decrement of the baffle number [2]. The thermal performance and pressure drop are depended on the path of fluid flow and types of baffles in different orientation. By increasing the complicity of baffles enhances heat transfer which also results in higher pumping power required and it reduce the system efficiency. Three types of baffles were used on the experiment such as single baffle, double baffle and helical baffles. Among those, the helical baffles resulted in decreasing the dead zone and in better heat transfer compare to others [3]. In order to block the triangular leakage zones in original heat exchanger with helical baffle, ladder type fold baffle is proposed. The numerical results of the proposed model showed that improved heat exchange is more uniform and axial short circuit is eliminated. The experiment also resulted in the shell side and overall heat transfer coefficient improved by 22.3-32.6% and 18.1-22.5% respectively [4]. Investigation was made on comparison between conventional plate baffle and flower baffle plate heat exchanger [5]. Hence the result showed that overall performance of conventional model is more efficient than segmental baffle design heat exchanger. In an experimental study [6], shell & tube heat exchanger with shell diameter 30 mm and the transverse baffle with a 25% baffle cut were used. Shell side Reynolds number range from 250 to 2500. While tube side Reynolds number is 5900. Total pressure drop results were minimized in channel shell and tube heat exchange was 2.3 times higher than in the macro tube exchanger as the effect of transverse baffle.

Tube design and arrangements: As shell side modification can be easily made, effect of tube modification on efficiency enhancement also vital to consider. Kallannavar et al. carried out a comprehensive study on the effect of tube layout on the performance of STHX. In this study, performance of 4 different tube layouts having degrees of 30°,45°,60° & 90° were examined which resulted that tube layout with 45° as more efficient [7]. Shirvin.et.al proposed a novel design of cosine wave structured design for tubes in STHX. Investigation on such design leads to determine the effect of wavy surface characteristics leaded to the heat transfer enhancement in STHX [8]. Non uniformity in flow distribution can also reduce the efficiency of the heat exchange process. Numerical study carried out by Labbadilla.et.al on the arrangements of tube layout of different angle types. Among those arrangements, it is concluded that flow distribution of 60° arrangement is better uniformity compared to conventional arrangement by 21% and flow distribution in 45◦ gives good uniformity of pressure distribution compared to all other arrangements [9]. The experiments made by Marzouk.et.al [10] on heat exchanger with wired-nails circular cut inserts in tube sides of STHX. The performance of such configurations of wired-nails circular–cut rod inserts with different numbers of nails, varied space between them, and five different configurations of insert distribution in tubes. The arrangements resulted in augmentation on U, NTU, ε, and energy efficiency of about 210-280%, 132-149%, 185-224% & 130-210% respectively than conventional design of STHE.

Optimization of design parameters: Arani.et.al[11], presented an experimental analysis on optimization of baffle and tube arrangement by using disc baffle and combined segmental-disc baffle in circular ribbed and triangular ribbed tube configurations under mass flow rate 2 kg/sec. Solid works flow simulation analysis resulted in average value of shell side heat transfer coefficient of disc baffle triangular and combined segmental disc baffle triangular are 26.6% and 31.95% higher than disc baffle circular and combined segmental disc baffle circular. Sun.et.al introduced a new approach for optimal heat exchanger network synthesis based on pinch technology considering multi pass heat exchanger. This proposed the relationship between the number of passes of shell and tubes and pinch character are analyzed by using modified composite curves [12]. Xinting.et.al presented an optimization study to simply the fabrication of STHX. In which STHX-ST, STHX-SG & STHX-CH were compared on their performance based on parameters like baffle cut, number of baffles and staggered angle. Using TOPSIS technique, it is proved that the STHX-ST, with α=0.45, β=79◦ and n=11 is the optimal solution in the view of heat transfer enhancement [13].

3. Numerical analysis

Bechri.et.al[14] presented an analytical solution to evaluate the influence of pertinent parameters like natural convection, outer tube radius and tube length, HTF flow rate of shell and tube storage unit during the melting of PCM. The proposed solution is validated numerically and resulted in significant reduction in calculation time and to avoid the weakness of the numerical simulations. Many researchers interest on the role of nano-fluids on heat exchange leads to breakthrough in enhancement of efficiency. Esfahani.et.al[15] dealt with characteristics of one of such nano-fluids namely graphene oxide. The energy analysis showed that utilizing graphene oxide resulted in weight concentration of 0.01 wt% to 0.1 wt% augmented the thermal conductivity up to 8.7% to 18.9%.

As the efficiency of STHX reduces with deviation in flow distribution it is indeed ponder upon. In order to improve the flow distribution in the rectangular header, novel approach called Double tube-passes in STHX (DTP-STHX) was introduced by Shao.et.al. It is evident that the second tube flow distribution is more uniform than conventional header configuration to use in practice. The first tube flow distribution is uneven with Es=0.157 and R_v = 2.21. After using the novel header configuration the flow distribution of the rest of tubes has been improved dramatically as compared to the conventional header configuration. The standard flow deviation (E_s) and ratio of maximum to minimum velocity (R_v) were decreased by 56.7% and 42.1% respectively [16]. A new type of hexagon clamping baffles is designed by Chulin Yu.et.al[17] to overcome anti-vibration of baffle in shell and tube heat exchanger. The flow and its heat transfer characteristic on shell side were numerically analyzed by using CFD method. The effect of several factors such as velocity, baffle distance and baffle layout on thermal hydraulic performance is investigated in full developed turbulence region with Reynolds number range in 10849 to 32547. The analysis concluded that HCB (Helical Clamping Baffle) has a better heat transfer enhancement but a poorer overall performance than CRB (Curved-Rod Baffle) Three dimensional conjugate heat transfer method has been used in numerical investigation process where the heat transfer rate heat transfer coefficient and overall heat transfer coefficient was investigated by Waqas Mughal.et.al. [18]. These parameters are numerically investigated by using 10 to 50kg Hr^{-1} mass flow rates. Inlet temperature of melt as 200ºc and oil temperature was 160ºc, 170ºc and 190ºc. Experiment was 10, 30, 50 kg Hr^{-1} mass flow rate and homogeneous temperature distribution is taken from 10 to 20 kg Hr^{-1}. The experimented resulted that the overall heat transfer coefficient increases with increasing mass flow rate. Parikshit.et.al developed a simple method to calculate the shell side pressure drop prediction on the STHX using finite element method. This method of predictions extended to the cases of no tubes in window region also which remained as the restriction in earlier prediction methods [19]..

4. CFD Analysis

It is inevitable to understand the performance detriments with respect to design and performance. Being experimental analysis as a complicate method, an object oriented dynamic model is developed at CIEMAT-PSA (the public research centre for energy, environment and technological research, owned by the Spanish government). The objective of this stimulated model is to evaluate the heat exchange between molten salt and different kinds of heat transfer fluids. The performance and detriment in a multi-pass shell and tube heat exchanger was noticed in the simulation results that help for manufacturer of such heat exchanger [20].

5. CONCLUSION

Researches discussed so far resulted in following conclusions

1. Shell and tube heat exchangers capable of transferring effective heat with reduced area occupied are still in demand.

2. An optimal design of shell and tube heat exchanger converting input to effective output is under recent study by many researchers.

3. Micro channel type shell and tube heat exchanger with effective and competitive heat transfer rate in comparison with normal channel heat exchangers is trending research gap.

4. Changes in core tube configuration, baffle configurations, using nano-fluids, using inserts inside core tube may also increase heat transfer rate in heat exchangers.

5. Right selection of innovative materials (i.e. for both shell and tube arrangements), innovative flow pattern through tubes, innovative baffle designs, research on innovative inserts which produces less pressure drop were also been focused by researchers of recent days.

6. Automation of any industrial process equipment's is a major challenge for recent researchers by industry 4.0.

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