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Studies on Shell and Tube Heat Exchanger Analysis: A Review

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Abstract

Heat exchanger (HX), a device used for transferring energy in the form of heat among two or more fluids of varying temperatures that are in contact thermally with each other. Most adopted heat transfer devices in industries are Shell and Tube Heat Exchangers(S&T HXs) therefore they are most common in many industrial applications such as HVAC, air treatment, refrigeration, and space heating and are also used in power plants, chemical plants, and Process Industries. This paper presents an analysis of research on shell and tube type HX, various correlations of its performance analysis, and improving heat transfer by changing various parameters, such as the effect of the diameter of the Shell, length of the tube, pitch, tube passage, baffle clearance, baffle cut, on the heat transfer coefficient (htc), loss of pressure on the side of the shell with the triangular, square pitch.

Keywords- *Baffle spacing, Heat exchanger, Pressure loss, Shell diameter*

1. INTRODUCTION

In S&T HX, a fluid flows in the tube, other fluid flows above the tubes in the Shell for heat transfer which is a pressure vessel of bigger size having tube bundles in it. Many configurations are possible with different design variables to improve the performance of the S&T HX. We can vary the types of baffles. Different baffle types and baffle angles provide a good scope for research. For cooling the oil, the S&T HX effectively uses the two passes of tube and one pass of shell. The oil temperature is decreased by up to 32%. The heat transfer and stability are improved by using the Nanofluids, it reduces pump power, minimizes clogging, miniaturizes the system, and saves cost and energy. Due to the large surface area of S&T HX for transferring the heat, it is used in the HVAC industry, especially in chillers. As a result, the material used and the heat transferability of the surface influence the cooler design. Hence, the role played by baffles in improving heat transfer performance is of importance. Heat exchanger design and modeling were modelled PTC CREO Software and CFD analysis was done ANSYS Fluent software taking copper, aluminium, and steel as materials. The analysis shows that copper worked better than aluminium or steel when using the minimum baffle spacing. Tube diameters, tube lengths, and shell types can only be used in specific sizes and shapes. Usually, a trial and error process is used for designing an S&T HX. In this process, the heat transfer area is estimated in this method, and a different combination of design variables is tested to increase the heat transfer coefficient.

2. PREVIOUS RESEARCH ON S&T HXS

Ali et al. [1] explained that the larger the diameter of the shell, the greater the coefficient of heat transfer and pressure drop. Maybe the best choice for increasing the heat transfer coefficient is the use of a Triangular pitch pull-through head. Whereas to reduce the coefficient of heat transfer, increasing baffle space and cutting space are suggested. The fouling factor has a greater impact on heat transfer on the shell side than on the tube side. So, reducing, the fouling factor on the shell side becomes important.

Fares et al. [2] described graphene nanofluid's effects on convective heat transfer in vertical S&T HXs. Using graphite foam made from sugar, graphene flakes are prepared. Prepared graphene flakes characterization is done by the use of microscopes of electron scanning and atomic force types and also by the diffraction of X-Rays and by Raman's method of spectroscopy. For improving heat performance, nanofluid of graphene is utilized in the HX's tube side. The effects of various parameters such as concentration, temperature at the inlet and flow rate over heat transfer coefficient, and thermal efficiency have been studied. As a result, it is seen that the using graphene or nanofluids based on water, the heat transfer abilities of S&T heat exchangers with vertical orientation can be improved and it also increases the coefficient of heat transfer and the mean heat transfer efficiency.

Srinivasan et al. [3] the DMAIC Six Sigma method has been introduced to kiln manufacturers to reduce the exhaust gas thermal energy that greatly affects the kiln efficiency. DMAIC has also emerged as the optimal solution for S&T HXs by mounting circular fins on bare tubes to enhance the heat transfer coefficient and reduce the exhaust fume's heat energy.

Durgesh et al. [4] have developed an Excel program by changing various parameters that simplify calculations and produce results. Tube diameters, lengths of the tube, shell types, etc. can be used in specific shapes and sizes. Hence for designing S&T HXs, the trial and error process has been used. In this process, for a particular design variable combination, the heat transfer area has been calculated and for raise in the heat transfer coefficient, another combination is tried.

Vahdat et al. [5] used alumina nanofluids to improve heat exchanger efficiency but reduce overall cost and energy consumption. Alumina nanofluids increase the Nu number and increase the heat transfer coefficient of S&T HXs. Increasing the heat transfer coefficient reduces required tube length and reduces the overall pressure drop of the HX and also reduces the velocity of flow. As a result, the total cost of heat exchangers has been reduced. The results are usage of nanofluids for the enhancement of the HX's efficiency and this technique usage, for a practical process designed to be efficient in designing S&T HXs.

Arjun et al. [6] explained S&T HXs are very important in boilers, condensers, oil coolers, and pre-heaters. They described the evolution of Differential applications to achieve a design of optimal proportions for S&T HXs. The main purpose of designing an HX is to minimize the area of heat transfer required so that the total cost of the HX can be estimated. There is a possibility of different configurations by using different design variables like outer diameter, length of the tube, pitch, passes of tubes, cut in baffles, and more. Thus, for finding global minima, design engineers need an efficient strategy.

Aadil et al. [7], offer research backgrounds for S&T HXs. In industry, S&T HXs have been excellently used in heating and cooling purposes. For enhancing the performance of S&T HXs many successful efforts has been made for many years. These efforts including variations in types of baffles or angles of baffle provide an indispensable area to work on. Many configurations are included in the baffle that give rise to better results at various stages of their use.

Farelet al. [8] calculated the cooling oil effectiveness on the tube sideand the Research was conducted to judge NTU- ε of HX and experimental studies when water is used as a coolant flowing through a shell side. S&T HXs allows oil temperature to reduce by some percentage.

Songchai et al. [9] present 3D unsteady conditions for simulations for predicting the heat transfer in HXs as compared to experimental work. The hot water is used as a working fluid in the tube with some mass flow rate in liters per minute. From Simulation and Experimental analysis, it is obtained that the transfer of heat is from hot water to air that is cooler via an HX. Inlet temperature of hot water in an HX was set to some degrees and air flowing through the heat exchanger was set to some velocities. By assuming the outer diameter of the spiral tube and assuming the number of panels, a box was built taking some dimensions. As a result, when the temperature rises from the taken temperature from minimum to maximum and by taking some velocity of airflow through the HX, there is some increase in the temperature difference of air that passes through the HX. On the other hand, the flow velocity of air passing through the HX increases, then the air temperature difference decreases. The simulated heat transfer coefficient over the area of the HX was consistent with the data obtained from the Experimental study. It is obtained that as compared to the actual experimental analysis, the simulations can be achieved in the system.

Sangashetty et al. [10] found that, of all the methods, for calculating the coefficient of heat transfer and decrease in pressure on the side of shell of HX, Kern method is the easiest way. However, we cannot adequately use this method for finding a leakage in baffle-shell and tube-baffle. This experiment reveals that the calculation and analysis of coefficients of heat transfer and various thermal parameters are done with higher accuracy than other methods.

Rao et al. [11] performed experimental &numerical simulations using different shapes of tubes, in place of circular tubes, elliptical tubes are used for the single-shell and multiple pass HXs. The experiment was performed using a circular tube taking some tube orientation and a baffle cut, using a fluid of higher temperature on the side of tube and a fluid of lower temperature on the side of the shell. Coefficient for transfer of heat, drop in pressure is calculated by varying Renumbers. For numerical surveys Fluent software has been used by taking circular and elliptical tube shapes both in different directions. For numerical Analysis, 25% baffle cut, and baffle cut of mirror quarter configuration is also used to compare them against each other. Then Comparison has been done for the experimental values of coefficient of transfer of heat and drops in pressure on the side of shell and side of tube along the length of the S&T HX with the values obtained from the flow. They have been seen that the coefficient of transfer of heat and drop in pressure for baffle cut of mirror quarter with elliptical tubing is more than the current S&T HX.

Erica et al. [12] used CREO Parametric to model S&T HXs and analyzed them by using Ansys Fluent software. This analysis was performed after creating a simple model, taking into account the distance between the baffles. In Ansys Workbench window, taking Steady-state thermal, an experiment was performed using housings and baffles of different materials such as Copper (Cu), Stainless Steel (SS), and Aluminium (Al). Ebieto et al. [14] developed the correlation for the performance analysis of S&T HX. Nitheesh et al. [15] mentioned that it has the great advantages of being able to vary pressure and pressure drop over a wide range, being inexpensive to handle heat loads, and being relatively easy to clean and repair.

3. CONCLUSION

- Taking all research helps to choose the material of the S&T HX and the baffle spacing is an important parameter for analyzing the heat transfer rate. Copper shells & Copper baffles are made better compared to SS and Al. But copper is a costly material so we cannot use Cu for each part of S&T still we use it for baffles. Cu with moderate resistance towards corrosion but it has been discolored easily. In such cases, we can use Al as it is light, so it will be the best option.
- For the performance enhancement of S&T HX, total transfer of heat coefficient needs to be increased. Changes in pipe metallurgy are influenced by changing total transfer of heat coefficients. To increase the coefficient of heat transfer we have to select metallurgy in such a way that the material should have high thermal conductivity values. Because of the reduction in baffle spacing, no. of baffles increases due to which the Reynolds number on the shell side increases, and the overall increase of htc. However, it raises pressure drop at the same time. The htc rises to reduce the baffle spacing but at that condition, the pressure drop is the main concern. Changes can result in high operating costs in order to achieve better heat transfer through baffle spacing. Therefore, there should be a proper margin in pressure drop while selecting the baffle spacing.

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