Design and Fabrication of Shell and Tube Type Heat Exchanger and Performance Analysis

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ABSTRACT

Shell and Tube heat exchangers are having special importance in boilers, oil coolers, condensers, pre-heaters. They are also widely used in process applications as well as the refrigeration and air conditioning industry. The robustness and medium weighted shape of Shell and Tube heat exchangers make them well suited for high pressure operations.

Heat exchangers are commonly used in practice in a wide range of applications, from heating and air-conditioning systems in a household, to chemical processing and power production in large plants.

Key words: *Shell and Tube heat exchanger, Performance analysis, Optimization, mass flow rate, baffles spacing, pressure drop, and heat transfer coefficient.*

INTRODUCTION

Heat Exchanger is a device which provides a flow of thermal energy between two or more fluids at different temperatures. Heat exchangers are used in a wide variety of engineering applications like power generation, waste heat recovery, manufacturing industry, air-conditioning, refrigeration, space applications, petrochemical industries etc. Heat exchanger may be classified according to the following main criteria.

1. Recuperators and Regenerators.

2. Transfer process: Direct contact and Indirect contact.

3. Geometry of construction: tubes, plates and extended surfaces.

4. Heat transfer mechanisms: single phase and two phase.

5. Flow arrangements: parallel, counter and cross flows.

Shell and tube heat exchangers are most versatile type of heat exchanger; they are used in process industries, in conventional and nuclear power station as condenser, in steam generators in pressurized water reactor power plants, in feed water heaters and in some air conditioning refrigeration systems. Shell and tube heat exchanger provide relatively large ratio of heat transfer area to volume and weight. Shell and tube heat exchanger offer great flexibility to meet almost any service requirement. Shell and tube heat exchanger can be designed for high pressure relative to the environment and high pressure difference between the fluid streams.

Problem Statement

The thermal performance of a heat exchanger depends upon so many factors. Some of them are thermal conductivities of involved fluids and materials, velocity of flow, turbulence, Quality and quantity of the insulation provided, ambient Conditions flow conditions, construction etc. To make any exact prediction about the performance of heat exchanger under a set of loading conditions is always a tough job. However by certain testing and experience predictions up to a certain level can be made.

Basic Components of Shell and Tube Heat Exchanger:

Shell and tube heat exchanger are built of round tubes mounted in a cylindrical shell with the tubes parallel to the shell. One fluid flow inside the tubes, while the other fluid flows across and along the axis of the exchanger, the major components of this exchanger are tubes (tube bundles), shell, front end head, rear end head, fins and tube sheets. Typical parts and their arrangement are show in figure 1.

Fig 1: Schematic diagram of component of shell and tube type heat exchanger.

There are various types of STHE, but most of process industries and chemical industries mostly use fixed tube sheet shell and tube type heat exchanger because of its low cost, simple construction and low maintenance cost. From industrial point of view it is necessary to operate shell and tube heat exchanger at optimal condition thus it reduce an operating and maintenance cost.

OBJECTIVES

- To design the shell and tube heat exchanger.
- To study different materials for heat exchanger.
- To fabricate the shell and tube heat exchanger.
- To analysis performance of heat exchanger.
- To determine the size of heat exchanger.
- Operate shell and tube heat exchanger varying steam flow.
- Determine the outside overall heat transfer coefficient (Uo).
- Determine shell side heat transfer (Qss).
- Determine tube side heat transfer (Qts).
- Try to resolve the problem of design team and manufacturing.
- Plan of action for solving real time problem.

LITERATURE REVIEW RELATED TO DESIGN OF STHE:

Su Thet Mon Than, Khin Aung Lin, MiSandar Mon: [1] In this paper data is evaluated for heat transfer area and pressure drop and checking whether the assumed design satisfies all requirement or not. The primary aim of this design is to obtain a high heat transfer rate without exceeding the allowable pressure drop.

Rajiv Mukharji; [2] explains the basics of exchanger thermal design, covering such topics as: THE 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.

Yusuf Ali Kara, Ozbilen Guraras: [3] Prepared a computer based design model for preliminary design of shell and tube heat exchangers with single phase fluid flow both on shell and tube side. The program determines the overall dimensions of the shell, the tube bundle, and optimum heat transfer surface area required to meet the specified heat transfer duty by calculating minimum or allowable shell side pressure drop. He concluded that circulating cold fluid in shell-side has some advantages on hot fluid as shell stream since the former causes lower shell-side pressure drop and requires smaller heat transfer area than the latter and thus it is better to put the stream with lower mass flow rate on the shell side because of the baffled space.

2] LITERATURE REVIEW RELATED TO EXPERIMENTAL AND METHOD FOR EVALUATING SHELL SIDE HEAT TRANSFER COEFFICIENT:

Zahid H. Ayub: [4] A new chart method is presented to calculate single-phase shell side heat transfer coefficient in a typical TEMA style single segmental shell and tube heat exchanger. A case study of rating water-to-water exchanger is shown to indicate the result from this method with the more established procedures and software's available in the market. The results show that this new method is reliable and comparable to the most widely known HTRI software.

R. Husseini, A. Hosseini-Ghaffar, M. Soltani:[5] experimentally obtained the heat transfer coefficient and pressure drop on the shell side of a shell-and-tube heat exchanger for three different types of copper tubes (smooth, corrugated and with micro-fins). Also, experimental data has been compared with theoretical data available. Experimental work shows higher Nusselt number and pressure drops with respect to theoretical correlation based on Bell's method. The optimum condition for flow rate (for the lowest increase of pressure drop) in replacing the existing smooth tube with similar micro-finned tube bundle was obtained for the oil cooler of the transformer under investigation.

3] LITERATURE REVIEW RELATED TO DIFFERENT OPTIMIZATION TECHNIQUES:

Resat Selbas, Onder Kızılkan, Marcus Reppich:[6] Applied genetic algorithms (GA) for the optimal design of shell-and-tube heat exchanger by varying the design variables: outer tube diameter, tube layout, number of tube passes, outer shell diameter, baffle spacing and baffle cut. From this study it was concluded that the combinatorial algorithms such as GA provide significant improvement in the optimal designs compared to the traditional designs. GA application for determining the global minimum heat exchanger cost is significantly faster and has an advantage over other methods in obtaining multiple solutions of same quality.

Sepehr Sanaye, Hassan Hajabdollahi: [7] considered seven design parameters namely tube arrangement, tube diameter, tube pitch ratio, tube length, tube number, baffle spacing ratio as well as baffle cut ratio. Fast and elitist non-dominated sorting genetic algorithm with continuous and discrete variables was applied to obtain the maximum effectiveness (heat recovery) and the minimum total cost as two objective functions.

V.K. Patel, R.V. Rao: [8] explores 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

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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.

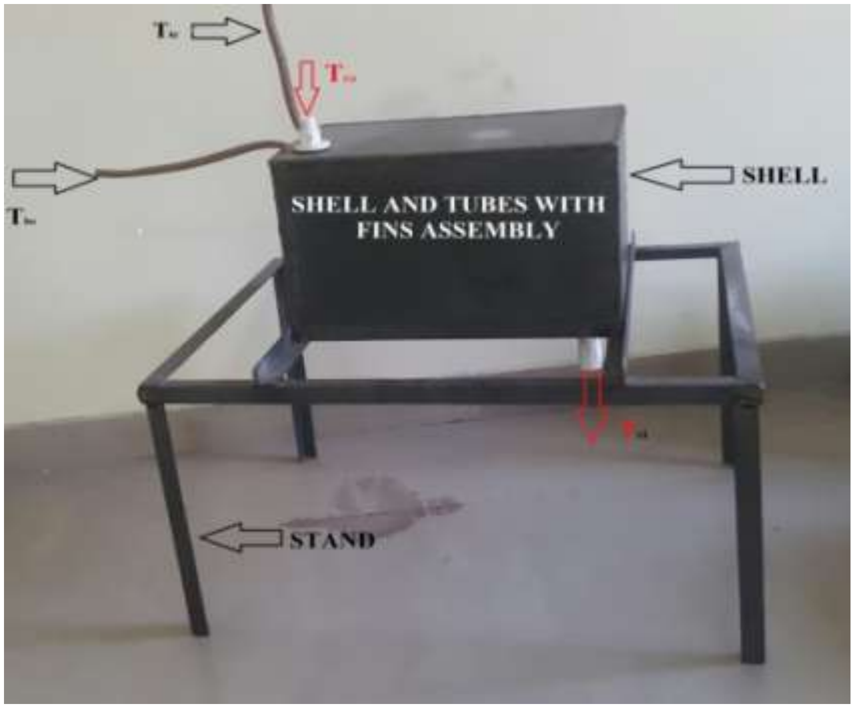

Figure show: shell &Tube HX

WORKING

Two fluids, of different starting temperatures, flow through the heat exchanger. One flows through the tubes (the tube side) and the other flows outside the tubes but inside the shell (the shell side). Heat is transferred from one fluid to the other through the tube walls, either from tube side to shell side or vice versa. The fluids can be either liquid or gases on either the shell or the tube side. In order to transfer heat efficiently, a large heat transfer area should be used, leading to the use of many tubes. In this way, waste heat can be put to use. This is an efficient way to conserve energy.

Heat exchangers with only one phase (liquid or gas) on each side can be called one-phase or single-phase heat exchangers. Two-phase heat exchangers can be used to heat a liquid to boil it into a gas (vapour), sometimes called boilers, or cool a vapour to condense it into a liquid (called condenser), with the phase change usually occurring on the shell side. Boilers in steam engine locomotives are typically large, usually cylindrically-shaped shell-and-tube heat exchangers. In large power plants with steam-driven turbines, shell-and-tube surface condenser are used to condense the exhaust steam exiting the turbine into condensate water which is recycled back to be turned into steam in the steam generator.

MANUFACTURED PARTS

1. Shell

    Dimensions=700*600mm

    Thickness=1.5mm

    Material - Mild Steel

2. Tube

    Dimensions=Ø12.5mm

    Material – copper

    Number of Tube-16

    In 1st column=8

    In 2nd column=8

3. Fins

    Dimensions=0.4mm (thickness)

    Material – Stainless Steel

    Fin Geometry-Flat-Rippled Edges

4. Heater

    Quantity-1

    Capacity-2000 watt

CONCLUSION

- The design of a finned shell and tube heat exchanger is successfully optimized using LMTD with the objective functions of maximizing heat transfer rate and minimizing total cost.

- There is increase in pressure drop with increase in fluid flow rate in shell and tube heat exchanger which increases pumping power.
- Tube pitch ratio, tube length, tube layout as well as fins spacing ratio was found to be important design parameters which has a direct effect on pressure drop and causes a conflict between the effectiveness and total.

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