International Journal of Engineering Management Science

VOLUME-2 ISSUE-1
ISSN : 2799-18

IMPLENTATION OF SHELL AND TUBE EXCHANGER

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ABSTRACT
Heat exchangers have always been an important part to the lifecycle and operation of many systems. A heat exchanger is a device built for efficient heat transfer from one medium to another in order to carry and process energy. Typically one medium is cooled while the other is heated. They are widely used in petroleum refineries, chemical plants, and petrochemical plants**.** The purpose of this thesis work is to design an Oil Cooler, especially for shell and tube heat exchange which is the majority type of liquid to liquid heat exchanger with baffle for induced turbulence and higher heat transfer coefficient. Modeling is done by using PRO-Engineer, and analysis carried out in Ansys soft ware 14.5. General design consideration and design procedure are also illustrated in this thesis in design calculation; the Ansys soft ware 14.5 and HTRI software are used. Within the project work the analysis are done for heat exchanger with baffle and without baffle also used four material for tubes (brass, nickel, carbon steel ,stainless steel) and observed the heat transfer rate is increased for heat exchanger with baffle and when we used brass material.

I. INTRODUCTION

Tube sheets are welded to shell to form a box. Inside of the tubes may be mechanically cleaned after removing the channel cover, but because the tube bundle cannot be removed, cleaning of the outside tubes can only be achieved by chemical means. The combination of the thermal expansion coefficient of the shell tubes and Transfer of heat from one fluid to another is an important operation from most of the chemical industries. The most common application of heat transfer is in designing of heat transfer equipment for exchanging heat from one fluid to another fluid. Such devices for efficient transfer of heat are generally called heat exchangers.

A 'heat exchanger' may be defined as an equipment which transfers the energy from a hot fluid to a cold fluid, with maximum rate and minimum investment and running costs. In heat exchanger the temperature of each fluid changes as it passes through the exchangers, and hence the temperature of the dividing wall between the fluids also changes along the length of the exchanger. One of the important processes in engineering is the heat exchanger between flowing fluids, and many types of heat exchangers are employed in various types of installations, as petro-chemical plants, process industries, pressurised water reactor power plants, nuclear power stations and refrigeration systems. On the basis of design tubular or shell and tube type of heat exchangers are widely in use. The shell and tube heat exchangers are the one in which one of the fluids flows through a bundle of tubes enclosed by a shell. The other fluid is forced through the shell and it flows over the outside surface of the tubes. Such an arrangement is employed where reliability and heat transfer effectiveness are important. With the use of multiple tubes heat transfer rate is amply improved due to increased surface area. These heat exchanger's larger heat transfer surface area-to-volume ratios than the most of common types of heat exchangers, and they are manufactured easily for a large variety of sizes and flow configurations. They can operate at high pressures, and their construction facilities disassembly for periodic maintenance and cleaning.

Shell-and-tube heat exchangers are the most versatile type of heat exchanger. They are used in many industrial areas, such as power plant, chemical engineering, petroleum refining, petrochemicals industries, food processing, paper industries, etc. Shell and tube heat exchangers provide relatively large ratios of heat transfer area to volume and weight and they can be easily cleaned. They have greater flexibility to meet any service requirement. Shell and tube heat exchangers can be designed for high pressures relative to the environment and high pressure differences between fluid streams [2].

II. LITERATURE SURVEY

There were many works previously carried out on the Shell and tube heat exchangers. Some of them are enlisted here:

A. Experimental performance comparison of shell side heat transfer for shell-and-tube heat exchangers with middle-overlapped helical baffles & segmental baffles-Jian-Fei Zhang et-al

Presented in this paper are experimental test and comparison for several shell-and-tube heat

VOLUME-2 ISSUE-1
ISSN : 2799-18

exchangers, one with segmental baffles and four with helical baffles at helix angles of 20◦, 30◦, 40◦ and 50◦, respectively. The orientation of the segmental baffles are kept constant that is 90o vertical.[1]

B. Experimental investigation of shell-and-tube heat exchanger with different type of baffles-Pooja J. Pawar et al

This paper focus on the experimental investigation of shell and tube heat exchanger with different type of baffles. The shell and tube heat exchanger with segmental baffles and flower baffles are designed, fabricated and tested.The heat exchanger with flower baffle gives more efficient overall performance up to 25-32% than segmental baffles heat exchanger. Also the pressure drop gets reduced in flower baffle heat exchanger up to 20-28% than segmental baffles heat exchanger. [2]

C. Design and Performance Study of Shell and Tube Heat Exchanger with Single Segmental Baffle Having Perpendicular & Parallel-Cut Orientation.-Swarup S Deshpande et al

This paper primarily focuses on the design and comparative analysis of Single segmental Shell and tube Heat Exchanger with perpendicular & parallel baffle cut orientation. For designing Kern Method is used. It predicts heat transfer coefficient, Pressure drop of both arrangements. This method gives us clear idea that rate of heat transfer is greater in Perpendicular-cut baffle orientation than Parallel-cut, Pressure drop approximately remaining same. [3]

D. Shell side CFD analysis of a small shell-and-tube heat exchanger - Ender Ozden et al

The author portrays that the heat transfer coefficient and the pressure dropare dependent of thebaffle spacing, baffle cut and shell diameter. This is investigated by numerically modelling a small heat exchanger. The flow and temperature fields inside the shell are resolved using a commercial CFD package. A set of CFD simulations is performed for a single shell and single tube pass heat exchanger with a variable number of baffles and turbulent flow. The results are observed to be sensitive to the turbulence model selection. The best turbulence model among the ones considered is determined by comparing the CFD results of heat transfer coefficient, outlet temperature and pressure drop with the Bell–Delaware method results. For two baffle cut values, the effect of the baffle spacing to shell diameter ratio on the heat exchanger performance is investigated by varying flow rate. [4]

E. An experimental investigation of heat transfer enhancement for a shell-and-tube heat exchanger-Simin Wang et al

For the purpose of heat transfer enhancement, the configuration of a shell-and-tube heat exchanger was improved through the installation of sealers in the shell-side. The gaps between the baffle plates and shell is blocked by the sealers, which effectively decreases the short-circuit flow in the shell-side. The results of heat transfer experiments show that the shell-side heat transfer coefficient of the improved heat exchanger increased by 18.2–25.5% .the overall coefficient of heat transfer increased by 15.6–19.7% and Pressure losses increased by 44.6–48.8% with the sealer installation, but the increment of required pump power can be neglected compared with the increment of heat flux. [5]

III. THERE ARE MAINLY THREE TYPES OF SHELL AND TUBE HEAT EXCHANGERS

Fixed tube sheet type: temperature during service may cause a differential expansion between them, which if excessive **U-tube type:** U-tube type heat exchanger has only one tube sheet and as each tube is free to move with respect to shell, the problem of the differential movement is eliminated. Tubes can be cleaned mechanically, in applications where the tube side fluid is virtually non-fouling fluid. The advantage of Utube heat exchanger is, as one end is free the bundle can expand or contract in response to the stress differentials.

Floating head type: The floating head type heat exchanger is the most versatile type of heat exchanger. In this type of heat exchanger one tube sheet is fixed relative to the shell, while the other is free to float thus permitting differential movement between shell and tube and also complete tube bundle withdrawal for easy cleaning. Although this type of exchanger is widely used, it has an internal joint at the floating head and careful design is asserted to prevent the leakage of one fluid to another.

A. Description Of Oil Cooler

Tubes: Heat exchanger tubes are available in variety of materials, which include both ferrous and non-ferrous materials such as carbon steel, stainless steel, copper, admiralty brass, 90-10 copper-nickel, etc. They are available in a number of wall thickness defined by BWG. The tubes are made with the strict

VOLUME-2 ISSUE-1
ISSN : 2799-18

tolerance on the outside diameter and as per specification of ASME, BS, IS standards.

Tube Pitch: The tube pitch is the shortest distance between two adjacent tubes. Tube holes cannot be drilled very close together since too small width of metal between the adjacent tubes structurally weakens the tube sheet as shown in Fig.1. The shortest distance between the two tube holes is the clearance.

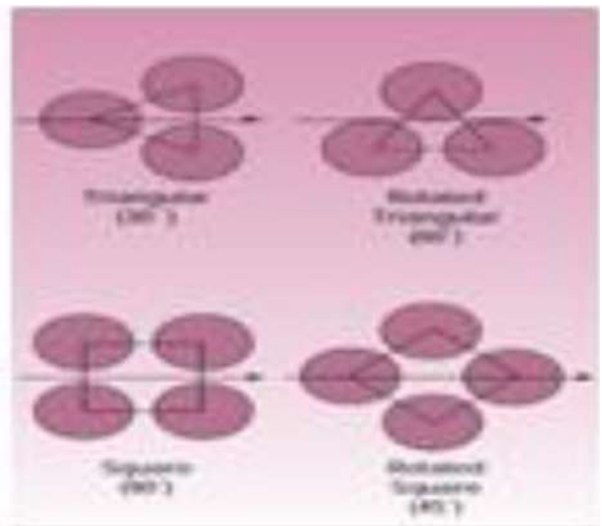

Fig.1. Tube layouts.

Tube Sheet: They are used to hold the tubes at the ends. A tube sheet is generally a circular metal plate with holes drilled through for the desired tube pattern, holes for the tie rods, grooves for the gaskets and bolt holes for flanges to the shell and channel.

Baffles: It is apparent that higher heat transfer coefficient results when the liquid is maintained in the state of turbulence. To induce turbulence outside the tube it is customary to employ baffles, which cause the liquid to flow through the shell at right angles to the exit of the tubes.

Baffles are used to support tubes, enable a desirable velocity to be maintained for the shell side fluid, and prevent failure of tubes due to flow-induced vibration.

Nozzles: The entrance and exit ports for the shell fluid and tube fluid are referred to as “Nozzles”. These nozzles are

pipes of constant cross section welded to the shell and channels. They are used to distribute or collect the fluid uniformly on shell and tube sides.

Front-End And Rear End Covers: They are containers for tube fluids for every pass. In many rear end head designs, a provision has been made to take care of thermal expansion of whole tube bundle. The front-end head is stationery while the rear end head could be either stationary or floating depending upon the thermal stresses between the tubes and shell.

Tie Rods And Spacers: Tie rods and spacers are other equivalent means of tying baffle system together. They should be provided to retain all transverse baffles and tube support plates securely in position. They serve two purposes; one to maintain the spacing between the baffles and second function is to reduce the fluid by-passing.

Shell: The cylindrical shell made of rolled carbon steel plate or pipe carries flanged connection for water inlet, water

outlet, plug and couplings for shell drain and vent. Suitable provisions are made for pressure and temperature measurement.

Water Chambers: Both the inlet and outlet and rear end water chambers are fabricated from rolled carbon steel plate or a pipe and are of adequate proportions to minimize pressure drop and turbulence. The inlet and outlet water

chamber carries water and inspection cover is divided internally into inlet and outlet chambers, each having a flanged connection. The rear end water chamber consists of a simple dished cover or a flat end cover. If the water passes are more than two it is divided accordingly.

Tube Plates: The tube plate material is selected depending on the type of cooling water application. Both the tube plates are drilled and tapped to receive the bolts securing water chamber. The tube holes are internally reamed to a finish suitable for the roller expansion into tube plates.

B. Design Methodology

In the present project, the methodology used in the design of the heat exchanger is studied and presented. The thermal design involves the calculation of shell side and tube side heat transfer coefficients, heat transfer surface area and pressure drops on the shell side and tube side. The mechanical design involves the calculations of thickness of pressure parts of the heat exchanger such as the shell, channel, tube etc. to evaluate the rigidity of part under design pressures. The design of the heat exchanger is then modeled in Pro-Engineer and finally analyzed using ANSYS software. In this system oil is taken as hot fluid and cold fluid is water. Where no phase change occurs.

Theoretical Calculation: Perform energy balance and find out the heat duty

VOLUME-2 ISSUE-1
ISSN : 2799-18

$$(Q).\ Q = m*cp*(t_2-t_1) = m*cp*(T_1-T_2)$$

Determine the Logarithmic mean temperature difference (LMTD).

$$LMTD = (\Delta T_1-\Delta T_2)/Ln\ (\Delta T_1/\Delta T_2).$$

CONCLUSION

In this analysis, numerical simulation for heat exchanger with different number of baffles, baffle cut, tube diameter and tube length are performed to reveal the effect of different baffle configuration on heat transfer and pressure drop characteristics. Also the effect of fin on heat transfer characteristics and pressure drop of heat exchanger are performed. The major findings are summarized as follows:

1. The increase in number of baffles leads to turbulence of fluid flow which causes increase in heat transfer characteristics but also leads to increase in pressure drop.

2. The flow profile of main fluid stream depends upon the number of baffles, their arrangement, height of baffle cut and tube length. In certain rage, the number of baffles, shortening the height of baffles and length of tube can decrease the pressure drop as well as increase the heat transfer coefficient effectively.

3. Also the diameter of tube influences the heat transfer characteristics. Since the surface area of smaller tubes is lesser, the heat transfer rate is also lower. Hence suitable diameter is to be chosen to increase the heat transfer rate.

4. The tubes with fin occupy more space inside the shell. Hence pressure drop of heat exchanger is higher than the normal heat exchanger. Also surface area of finned tube is larger which increase the heat transfer rate but reduces the heat transfer coefficient. Thus finned tubes are to be incorporated where higher heat transfer rate is of primary importance.

5. In this analysis, the new heat exchanger with reduced tube length with 10 baffles and 36% baffle cut shows the best performance. The length of such heat exchanger is kept as 1540 mm, baffle spacing is kept as 0.14 m and other dimensions are kept

6. In case heat exchanger with finned tube, the heat exchanger with 10 baffles and 36% baffle cut shows the best performance. For such heat exchanger the middle section and inlet & outlet section baffle spacing is kept as 0.165 m and 0.1675 m respectively. The other dimensions are kept same as

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