"REVIEW ON EXPERIMENTATION ON SHELL AND TUBE HEAT EXCHANGERS WITH HELICAL BAFFLE PLATES"

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ABSTRACT: *In this project, experimentation is being carried out on STHXs. The helical baffle plates are given an inclination of 45^o to study the pressure drop at shell side and tube side of HXs and to determine the change in its efficiency. In experimentation single phase fluid and cross-flow is provided. Readings are being taken at different voltage viz. 50V, 100V, 150V, 200V & 250V. STHXs with Helical Baffle plates are more efficient that STHXs with Segmental Baffle plates because of low pressure drop inside the shell and tube sides. Baffles are used to support the tubes for structural rigidity, preventing tube vibration and sagging and to divert the flow across the bundle to obtain a higher heat transfer coefficient. The Numerical Experimentation is calculated on ANSYS Software. STHXs are widely used in process industries, nuclear power plants, in steam generators, etc.*

Keywords: Heat transfer coefficient, helical baffle, helix angle, pressure drop, shell & tube heat exchanger.

1. INTRODUCTION

1.1. Heat exchangers

Heat Exchangers are one of the mostly used equipment in the process industries. Heat exchangers are used to transfer heat between two process streams. One can realize their usage that any process which involve cooling, heating, condensation, boiling or evaporation will require a heat exchanger for these purpose. Process fluids, usually are heated or cooled before the process or undergo a phase change. Different heat exchangers are named according to their application. For example**,** heat exchangers being used to condense are known as condensers, similarly heat exchanger for boiling purposes are called boilers.

1.2. Shell and Tube Heat Exchangers

Shell and Tube Type heat exchanger is probably the most used and widespread type of the heat exchanger's classification. It is used most widely in various fields such as oil refineries, thermal power plants, chemical industries and many more. This high degree of acceptance is due to the comparatively large ratio of heat transfer area to volume and weight, easy cleaning methods, easily replaceable parts etc. Shell and tube type heat exchanger consists of a number of tubes through which one fluid flows. Another fluid flows through the shell which encloses the tubes and other supporting items like baffles, tube header sheets, gaskets etc. The heat exchange between the two fluids takes through the wall of the tubes.

1.3. Baffle Plates

Baffles are used to support the tubes for structural rigidity, preventing tube vibration and sagging and to divert the flow across the bundle to obtain a higher heat transfer coefficient. Baffle spacing is the centre line distance between two adjacent baffles. Baffle cut can vary between 15 % and 45 % of the shell inside diameter. In general, conventional shell and tube heat exchangers result in high shell-side pressure drop and formation of recirculation zones near the baffles.

Basically two types of baffle plates are used:

a) Segmental Baffle Plates
b) Helical Baffle Plates

Most of the researches now a day are carried on helical baffles, which give better performance then single segmental baffles but they involve high manufacturing cost, installation cost and maintenance cost.

2. LITERATURE REVIEW

2.1. Shell-side heat transfer enhancement for shell-and-tube heat exchangers by helical baffles by Qiuwang Wang[1] Guidong Chen, Min Zeng, Qiuyang Chen, Botao Peng, Dongjie Zhang, Laqin Luo concludes that: (1) The heat exchanger with continuous helical baffles is superior to the heat exchangers with segmental baffles or overlapped helical baffles. (2) The combined helical baffled STHXs in single shell-pass have higher heat transfer coefficient than the segmental baffled STHXs. (3) Compared with the heat exchangers with segmental baffles, the combined multiple shell-pass heat exchangers with helical baffles can enhance the comprehensive heat transfer performance. (4)Meanwhile, the combined single shell-pass and combined multiple shell-pass heat exchangers with helical baffles can simplify the manufacture and installation of heat exchangers.

2.2. From literature review given by Sandeep K. Patel, Professor Alkesh M. Mavanit[2], it can be concluded that:

• There is increase in pressure drop with increase in fluid flow rate in shell and tube heat exchanger which increases pumping power.

• Genetic algorithm provide significant improvement in the optimal designs compared to the traditional designs. Genetic algorithm 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. Thus, providing more flexibility to the designer.

• It also reveals that the harmony search algorithm can converge to optimum solution with higher accuracy in comparison with genetic algorithm.

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2.3. Sunil S. Shinde, Samir S. Joshi, Dr. S. Pavithran[3] in their research paper on Single Phase HXs said that the performance of tubular heat exchanger can be improved by helical baffles instead of conventional segmental baffles. Use of helical baffles in heat exchanger reduces shell side pressure drop, pumping cost, size, weight, fouling etc. as compare to segmental baffle for new installations. For the helical baffle heat exchangers, the ratios of heat transfer coefficient to pressure drop are higher than those of a conventional segmental heat exchanger. This means that the heat exchangers with helical baffles will have a higher heat transfer coefficient when consuming the same pumping power. It can be concluded that proper baffle inclination angle will provide an optimal performance of heat exchangers.

2.4. Sunil S. Shinde, Samir S. Joshi, Dr. S. Pavithran[4] after doing next research paper on the thermal analysis on turbulent, transition and laminar flow it was observed that:

1. For the helical baffle heat exchangers, the ratios of heat transfer coefficient to pressure drop were higher than those of a conventional segmental heat exchanger. This means that the heat exchangers with helical baffles will have a higher heat transfer coefficient when consuming the same pumping power for the same pressure drop.
2. With constant flow rate and Reynolds number and varying helix angle, the heat transfer coefficient & pressure drop decreased slowly for helix angle less than 40 degrees.
3. The optimum helix inclination angle depended on the Reynolds number of the working fluid on the shell side of heat exchanger.
4. Proper baffle inclination angle provided an optimal performance of heat exchanger.

3. COMPONENT DETAILS

Some of the very basic components of a shell and tube type heat exchangers are as given below:

3.1. Tubes

The tubes are the basic components of a shell and tube type heat exchanger. The outer surfaces of the tubes are the boundary along which heat transfer takes place. It is recommended that the tubes materials should be highly thermal conductive otherwise proper heat transfer will not occur. The tubes of Copper, Aluminum and other thermally conductive materials are commonly used.

3.2. Shell

The shell is simply the container for the shell side fluid, and the nozzles are the inlet and exit ports. The shell normally has a circular cross section and is commonly made by rolling a metal plate of the appropriate dimensions into a cylinder and welding the longitudinal joint (“rolled shells”).

3.3. Baffles

Baffles serve two functions; Most importantly, they support the tubes in the proper position during assembly and operation and prevent vibration of the tubes caused by flow induced eddies, and secondly, they guide the shell side flow back and forth across the tube field, increasing the velocity and heat transfer coefficient.

3.4. Thermocouples

A thermocouple is a sensor used to measure temperature. Here, five thermocouples are used to indicate inlet and outlet temperatures of shell and tube and ambient temperature.

3.5. Channel covers

The channel covers are round plates that bolt to the channel flanges and can be removed for the tube inspection without disturbing the tube side piping. In smaller heat exchangers, bonnets with flanged nozzles or threaded connections for the tube side piping are often used instead of channel and channel covers.

4. DESIGN OF STHXS

The design of STHE involves a large number of geometric and operating variables as a part of the search for an exchanger geometry that meets the heat duty requirement and a given set of design constrains. Usually a reference geometric configuration of the equipment is chosen at first and an allowable pressure drop value is fixed. Then, the values of the design variables are defined based on the design specifications and the assumption of several mechanical and thermodynamic parameters in order to have a satisfactory heat transfer coefficient leading to a suitable utilization of the heat exchange surface.

4.1. Part A-Thermal Design

The thermal design of STHE includes:
1) Consideration of process fluids in both shell and tube;
2) Selection of required temperature specifications;
3) Limiting the shell and tube side pressure drop;
4) Setting shell and tube side velocity limits;
5) Finding heat transfer area including fouling factor.

4.2. Part B—Mechanical Design

The mechanical design of STHE includes:

1) Selection of tube parameters such as size, thickness, layout, pitch, material;
2) Selection of shell side parameters such as material, baffle spacing;
3) Thermal conductivity of tube material;
4) Setting design limits of tube diameter and number of baffle plates.

Design of Support: Leg Support

5. DESIGN SPECIFICATIONS AND DIAGRAM

Shell Specifications:

1. Shell Material:- Cast Iron (Allowable temp.= 200C, Allowable bpress.=8.6bar)
2. Shell OD= 318mm.
3. Shell ID= 280mm.
4. Shell Thickness= 19mm.

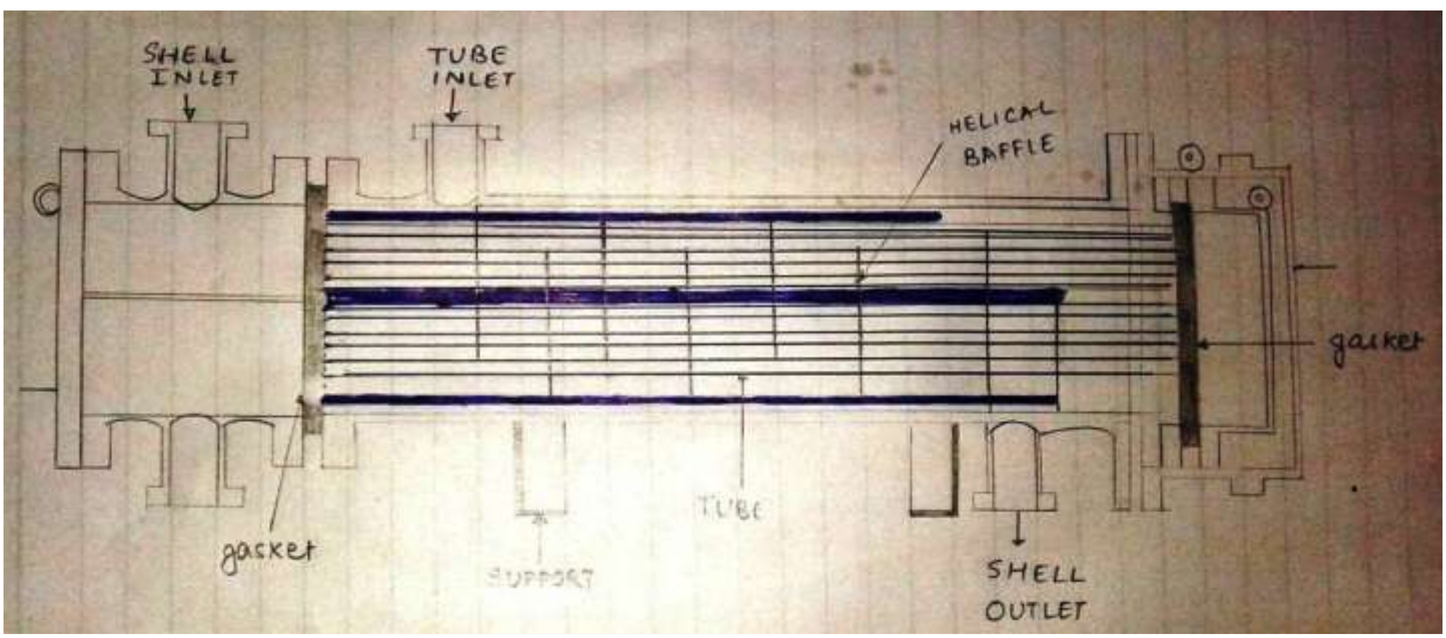
Flat Cover Specifications:-
1. Flat Cover Diameter= 350mm.
2. Flat Cover Thickness= 11mm.

Flange Specifications:-
1. Diameter of flange= 6 inches

Gasket Specifications:-
1. Gasket Material: Asbestos

Bolt Specifications:-
1. Bolt Material: Medium Carbon Steel
2. No. of Bolts= 4
3. Diameter of Bolts= 5/8 inches
4. Diameter of Bolts Holes= 0.75 inches
5. Bolt circle= 3.25 inches

Tube and Channel Specifications:-
1. Tube Material: Stainless Steel
2. Tube Sheet Thickness= 12mm
3. Tube Thickness= 2mm
4. Tube Diameter= 19mm(OD) and 15mm(ID)
5. Channel Thickness= 10mm



6. NOMENCLATURE

L Heat exchanger length
Di Shell inner diameter,
do Tube outer diameter
Nt Number of tubes,
Nb Number of baffles.
B Central baffle spacing
Θ Baffle inclination angle
Lt Length of tube
Nb Number of baffles

Nt Number of heat exchange tubes
Pr Prandtl number
Q Heat transfer rate

7. OBSERVATION TABLE

In observation table following parameters will be calculated:

Volts V	Current A	T1	T2	T3	T4	T5

Where,
T1= ambient temperature
T2= tube inlet temperature
T3= tube outlet temperature
T4= Shell outlet temperature
T5= Shell Inlet temperature

8. CALCULATIONS

8.1. $Q = (mCp)c\ (Tc_2 - Tc_1) = (mCp)h\ (Th_2 - Th_1)$

8.2. $LMTD = \Delta T1 - \Delta T2 \div \ln(\Delta T1 / \Delta T2)$
where, $\Delta T1 = th1 - tc2$ and $\Delta T2 = th2 - tc1$

8.3. $A = Q \div U\ \Delta T$

8.4. $Nt = A \div (\pi dt\ l)$

8.5. $Nu = 0.27\ (Re)^{0.63}\ (Pr)^{0.36}\ (Pr/Prw)^{0.23}$

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