Review on Tube and Shell Type Heat Exchanger

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Abstract— A heat exchanger design is the procedure of satisfying a design of heat transfer rate and heat transfer area and checking the assumed design satisfying (with trial and error method)consider parameter or not the purpose of this paper is to design the shell and tube type heat exchanger with use of various type of fluids to fluid or air heat transfer the general design and consideration and design procedure is written in this paper in this calculation we calculate heat transfer rate and area with the given temperature requirement of hot fluid and cold fluids.

Key words: Heat Exchanger, Heat Transfer Rate, LMTD (Logarithmic Mean Temperature Difference)

I. Introduction

Heat exchangers are utilized for controlling heat energy heat exchanger are device that regulate efficient heat transfer from one fluid to another at different temperature heat exchanger are used un large variety of engineering application like waste heat recovery, in intercooler , boiler, pre- heater , condenser inside the power plant ,air-conditioning, refrigeration etc. Heat exchanger are classified according to following criteria

1) Recuperative and Regenerative.
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.

Flow arrangement: parallel, counter and cross flows.

A. *Basic Concept of Specific Heat:*

Specific Heat: Is defined as the amount of heat energy needed to raise 1 gram of a substance 1°C in temperature.

$$Q = m.Cp. (T2 – T1)$$

Where:
Q = heat energy (Joules);
m = mass of the substance (kilograms);
Cp = specific heat of the substance (J/kg°C)
(T2 – T1) = is the change in temperature (°C)

The higher the specific heat, the more energy is required to cause a change in temperature. Substances with higher specific heats require more of heat energy to lower temperature than do substances

B. *Heat Exchangers Calculations:*

The main basic Heat Exchanger equation is:

$$Q = U \text{ x } A \text{ x } \Delta Tm =$$

The log mean temperature difference ΔTm is:

$$\Delta Tm = (T1 – t2) – (T2 – t1) = °c$$

Where:
T1 = Inlet tube side fluid temperature;
t2 = Outlet shell side fluid temperature;
T2 = Outlet tube side fluid temperature;
t1 = Inlet shell side fluid temperature.

Note: When used as a design equation to calculate the required heat transfer surface area, the equation can be rearranged to become:

$$A = Q/ (U \text{ x } \Delta Tm) =$$

Where:
A = Heat transfer area (m²)
Q = Heat transfer rate (kJ/h)
U = Overall heat transfer coefficient (kJ/h.m².°C)
ΔTm = Log mean temperature difference (°C)
And:
Ct = Liquid specific heat, tube side (kJ/kg°K)
Cs = Liquid specific heat, shell side (kJ/kg°K)
The Overall Design Process:

1) Here is a set of steps for the process. Design of a heat exchanger is an iterative (trial & error) process:
2) Calculate the required heat transfer rate, Q, in Btu/hr from specified information about fluid flow rates and temperatures.
3) Make an initial estimate of the overall heat transfer coefficient, U, based on the fluids involved.
4) Calculate the log mean temperature difference, ΔTm, from the inlet and outlet temperatures of the two fluids.
5) Calculate the estimated heat transfer area required, using: A = Q/(U ΔTm).
6) Select a preliminary heat exchanger configuration.
7) Make a more detailed estimate of the overall heat transfer coefficient, U, based on the preliminary heat exchanger configuration.
8) Estimate the pressure drop across the heat exchanger. If it is too high, revise the heat exchanger configuration until the pressure drop is acceptable.
9) If the new estimate of U is different than the previous estimate, repeat steps 4 through 7 as many times as necessary until the two estimates are the same to the desired degree of accuracy.

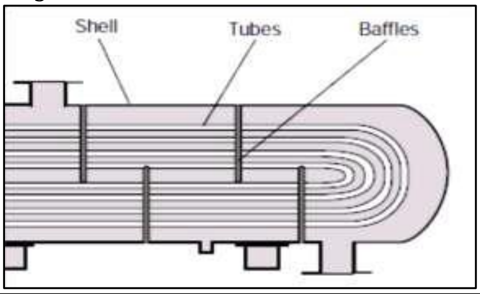
Input information needed. In order to start the heat exchanger design process, several items of information are needed as follows:

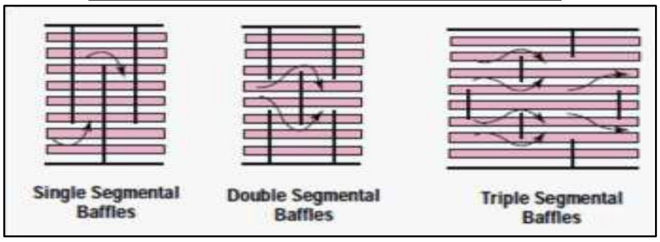
- The two fluids involved need to be identified;
- The heat capacity of each fluid is needed;
- The required initial and final temperatures for one of the fluids are needed;
- The design value of the initial temperature for the other fluid is needed;
- An initial estimate for the value of the Overall Heat Transfer Coefficient, U, is needed

C. *Baffle Design - Definitions:*

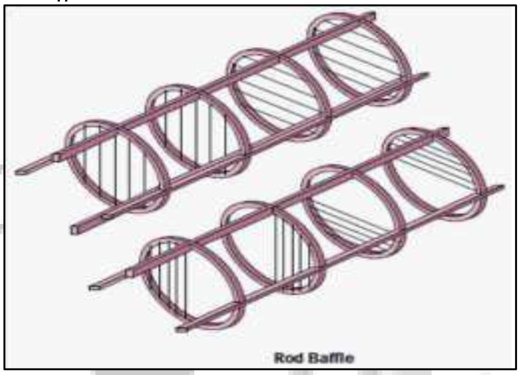
Baffles: are used to support tubes and enable a desirable velocity for the fluid to be maintained at the shell side, and prevent failure of tubes due to flow-induced vibration. There are two types of baffles; plate and rod.

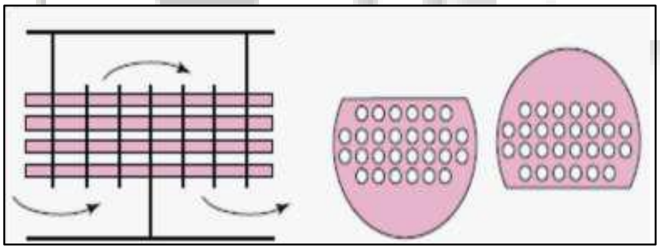
1) *Plate baffles may be single-segmental, double-segmental, or triple-segmental:*





2) *Rod Baffles:*





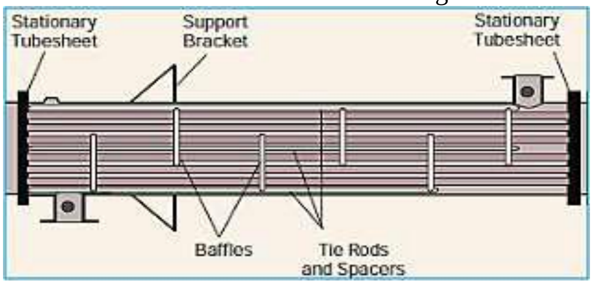
– The minimum spacing (pitch) of baffles normally should not be closer than 1/5 of shell diameter (ID) or 2 inches whichever is greater.

– The maximum spacing (pitch) spacing does not normally exceed the shell diameter. Tube support plate spacing determined by mechanical considerations, e.g. strength and vibration.

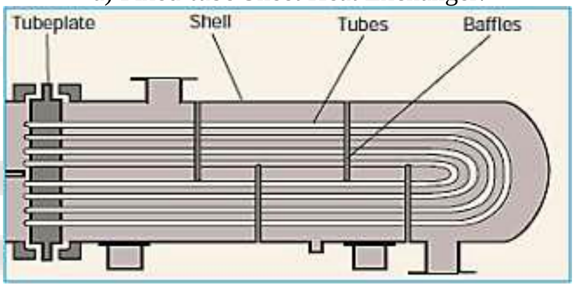
D. *Heat Exchanger Bundles:*

Tube bundles are also known as tube stacks are designed for applications according to customer requirements, including direct replacements for existing units. There are two types of tube bundles:

1) Fixed Tube Sheet. A fixed-tube sheet heat exchanger has straight tubes that are secured at both ends by tube sheets welded to the shell.
2) U-Tube. As the name implies, the tubes of a U-tube heat exchanger are bent in the shape of a U and there is only one tube sheet in a U-tube heat exchanger.



a) Fixed-tube Sheet Heat Exchanger.



b) U-Tube Heat Exchanger.

Bundle diameter, Db, can be estimated using constants shown:

$$D_b = d_o (N_t / K_1)^{1/n} =$$

Where:
do = Tube Outside Diameter;
Nt = Number of tubes.
K1 - n = see table below:

Triangular Pitch $p_t = 1.25\ d_o$					
Number Passes	1	2	4	6	8
K_1	0.319	0.249	0.175	0.0743	0.0365
n	2.142	2.207	2.285	2.499	2.675

Square Pitch $p_t = 1.25\ d_o$					
Number Passes	1	2	4	6	8
K_1	0.215	0.156	0.158	0.0402	0.0331
n	2.207	2.291	2.263	2.617	2.643

E. *Tube Diameters:*

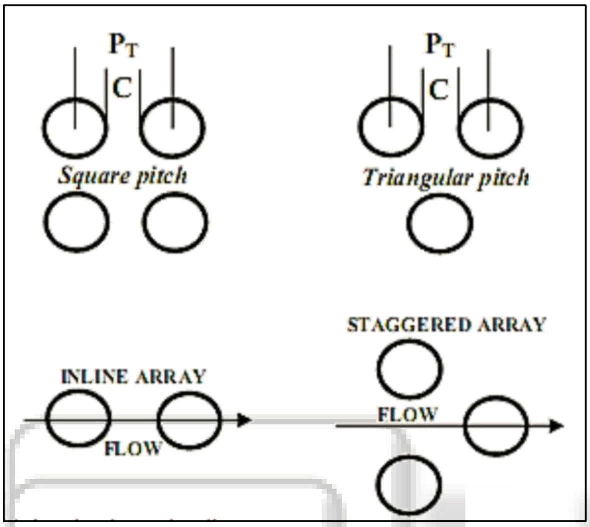
The most common sizes used are Ø3/4" and Ø1". Use the smallest diameter for greater heat transfer area with a minimum of Ø3/4" tube due to cleaning considerations and vibration. For shorter tube lengths say < 4ft can be used Ø1/2" tubes.

F. *Tube Quantity and Length:*

Select the quantity of tubes per side pass to give optimum velocity. For liquids 3-5 ft/s (0.9-1.52 m/s) can be used. Gas velocities are commonly used 50-100 ft/s (15-30 m/s). If the velocity cannot be achieved in a single pass consider increasing the number of passes. The tube length is determined constraints may require an increase in the number of tubes and/or a reduction in tube length. Long tube lengths with few tubes may carry shell side distribution problems.

G. Tube Arrangement:

Triangular pattern provides a more robust tube sheet construction.
Square pattern simplifies cleaning and has a lower shell side pressure drop.
Tube pitch is defined as:
PT = do+ C
PT = tube pitch
do = tube outside diameter

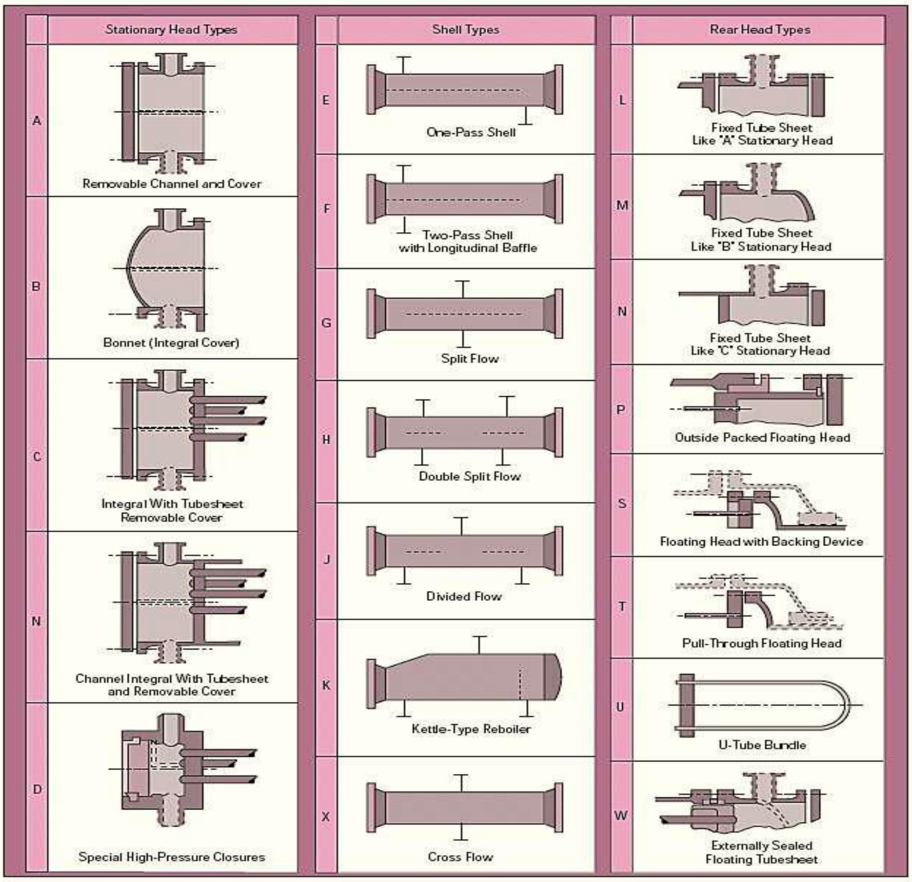


C = clearance

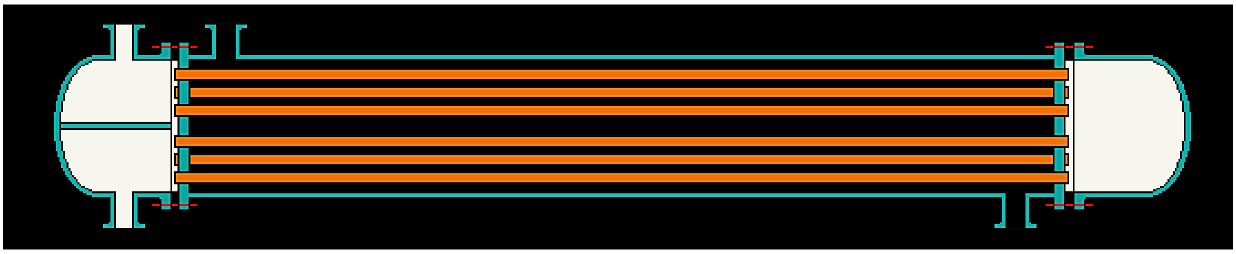
II. TYPES OF SHELL CONSTRUCTIONS

TEMA-E: This shell is the most common shell type, as it is most suitable for most industrial process cooling applications.
TEMA-F: This shell design provides for a longitudinal flow plate to be installed inside the tube bundle assembly. This plate causes the shell fluid to travel down one half of the tube bundle, then down the other half, in effect producing a counter-current flow pattern which is best for heat transfer.
TEMA-G and H: These shells are most suitable for phase change applications where the bypass around the longitudinal plate and counter-current flow is less important than even flow distribution.
TEMA-J: This shell is specified for phase change duties where significantly reduced shell side pressure drops are required. They are commonly used in stacked sets with the single nozzles used as the inlet and outlet. A special type of J-shell is used for flooded evaporation of shell side fluids.
TEMA-K: This shell, also termed as “kettle reboiler”, is specified when the shell side stream will undergo vaporization. The liquid level of a K shell design should just cover the tube bundle, which fills the smaller diameter end of the shell. This liquid level is controlled by the liquid flowing over a weir at the far end of the entrance nozzle.
TEMA-X: This shell, or cross flow shell is most commonly used in vapor condensing applications, though it can also be used effectively in low pressure gas cooling or heating. It produces a very low shell side pressure drop, and is therefore most suitable for vacuum service condensing.

III. SHELL CONSTRUCTIONS:

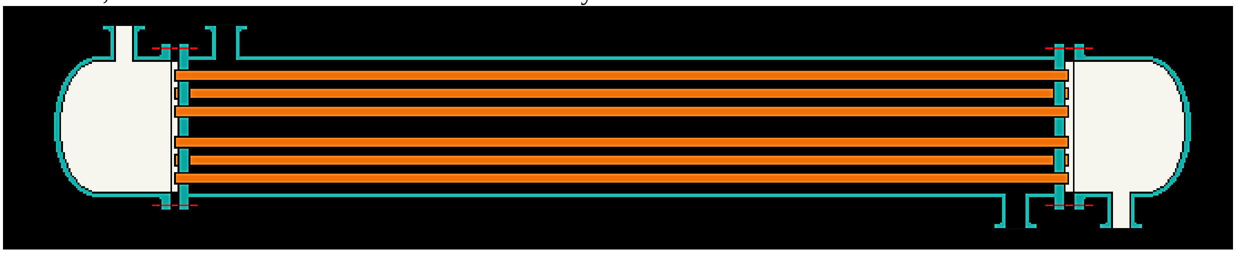


IV. EXAMPLES OF THE TEMA DESIGNATIONS



BEM: Bonnet (Integral Cover), One Pass Shell, Fixed Tubesheet Bonnet

Fixed tubesheet heat exchanger. Is a version with one shell pass and two tube passes and a very popular version as the heads can be removed to clean the inside of the tubes. The front head piping must be unbolted to allow the removal of the front head,if this is undesired this can be avoided by applying a type A front head. In that case only the cover needs to be removed. It is not possible to clean the outside surface of the tubes as these are inside the fixed part. Chemical cleaning can be used



BEM: This is the same type of heat exchanger as above, but with one tube pass.

V. LITERATURE SURVEY

Dawit Bogale [1]: He states that the heat exchanger is a device which is use to transfer thermal energy between two or more fluid or between solid perticulate and a fluid at defferent temprature s and in thermal contact thermal and mechanical design is run in order to optimize theb output temprature of cold fluid in heat exchanger. in thermal design part geometry optimization is done through trial and error method.

Sandeep K. Patel, 2 Alkesh M. Mavani: In this paper the author says that heat transfer area andpressure drop and checking wetherthe assumed design satisfies all requirement or not. the pupose of this paper is how to design the shell and tube exchanger which is majority type of liquid -to-liquid heat exchanger

Ahmad Fakheri [3]:this paper provides the solution to the problem of defining thermal efficiency of heat exchanger based on second law of thermodynamic. it is show that corresponding to each actual heat exchanger,there is an ideal heat exchanger that is balanced counter-flow heat exchanger.the concept of heat exchanger efficiency provides a new way for design and analysis of heat exchanger and heat ecxhanger network.

Ravi Kumar Banjare [4]: This paper concerned with the study of different types of reliable material used in heat exchanger. AURUBIS offers high-performance foil and strip of the finest quality and with the tightest tolerances for industrial heat exchangers. In material science ceramics and ceramic matrix composite open opportunities for new heat exchanger designs. In air-conditioning and energy-recovery applications, heat exchangers are very important to the overall efficiency, cost, and size of the system. Some research directed toward using ceramic materials for heat exchangers in other applications

Drilon Meha [5]: In this paper in which inside the flows water,but outside the tubes flows air aims toenable cooling of circulating water,which serve to cool the engine of machine . such exchanger find application in the automotive industry as well as heating and cooling equipment and HVAC system etc. the surface of heat exchanger by the air side always tends to much larger using surface fin in order to facilitate equalization of thermal resistance for both side of heat exchanger, beacause rate of transmission of heat from the water side is much geaeter.

Amol Niphade [6]: in this paper the design alternatives for the heat exchanger. the current need are met with shell and tube type heat exchangar with support offerd for volume of about five thousand liter of milk per day. the performance and efficincy can be measurad through the amount of heat transfer using least area of heat transfer and pressure drop.

Digvendra singh [7]: this paper is based on designing and performance evaluation of shell and tube heat exchanger using ansys (computational fluid dynamics) heat exchanger has a variepy of application in different in industries and in this study on such heat exchanger is taken in to account. The heat exchanger is designed as per commercial need of industries. The main objective of this research paper is to verify the heat exchanger design with the use of kern's technique.

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