3.6 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 exchangers, the temperature of each fluid changes as it passes through the exchangers, and hence the temperature of the dividing wall between the fluids changes along the length of the exchanger.

Examples of heat exchangers:

(i) Intercoolers and pre heaters;

(ii) Condensers and boilers in steam plant;

(iii) Condensers and evaporators in refrigerator.

(iv) Automobile radiators;

(v) Oil coolers of heat engine;

(vi) Milk chiller of a pasteurising plant

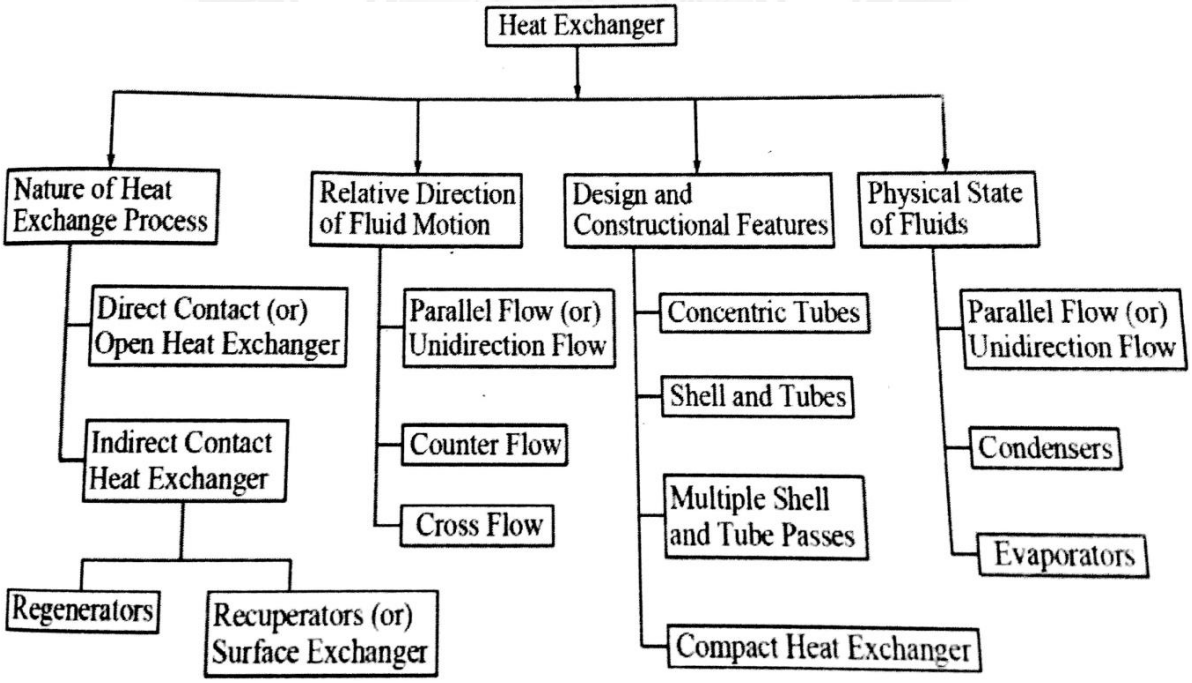

Fig-3.6.1 Types of Heat Exchangers

Types of Heat Exchangers

1. Nature of heat exchange process

Heat exchangers, based on nature of heat exchange process, are classified as follows:

i) Direct contact (or open) heat exchangers.

ii) Indirect contact heat exchangers

i) Direct contact heat exchangers

In a direct contact or open heat exchanger, the exchange of heat takes place by direct mixing of hot and cold fluids and transfer of heat mass takes place simultaneously.The use of such units is made under conditions where mixing of two fluids is either harmless or desirable.

Ex: Cooling towers, Jet condensers, Direct contact feed heaters.

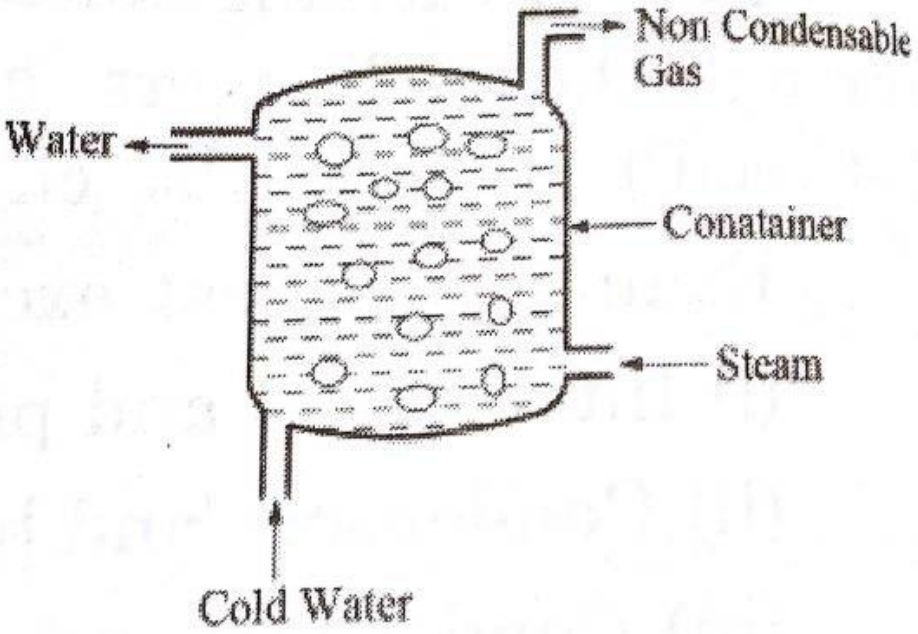

Fig-3.6.2- Heat Exchangers

ii) Indirect contact heat exchangers

In this type of heat exchangers, the heat transfer between two fluids could be carried out by transmission through wall, which separates the two fluids. This type includes the following:

a) Regenerators

b) Surface exchangers

a) Regenerators

In a regenerator type of heat exchanger, the hot and cold fluids pass alternately through a space containing solid particles (matrix), these particles providing alternately a sink and a source for heat flow.

Ex: I.C. engines and gas turbines, open hearth and glass melting furnaces, air heaters of blast furnaces.

The performance of these regenerators is affected by the following parameters:

i) Heat capacity of regenerating material.

ii) The rate of absorption, and

iii) The release of heat.

b) Recuperators

Recuperator is the most important type of heat exchanger in which the flowing fluids exchanging heat are on either side of dividing wall (in the form of pipes or tubes generally). These heat exchangers are used when two fluids cannot be allowed to mix i.e., when the mixing is undesirable.

Ex: Automobile radiators, Oil coolers, Intercoolers.

2. Relative direction of fluid motion

According to the relative directions of two fluid streams, the heat exchangers are classified into the following three categories:

i) Parallel – flow (or) uni-direction flow.

ii) Counter – flow

iii) Cross – flow

i) Parallel- flow heat exchangers

In a parallel-flow exchanger, as the name suggests, the two fluid streams (hot and cold) travel in the same direction. The two steams enter at one end and leave at the other end. Since this type of heat exchanger needs a large area of heat transfer, therefore, it is rarely used in practice.

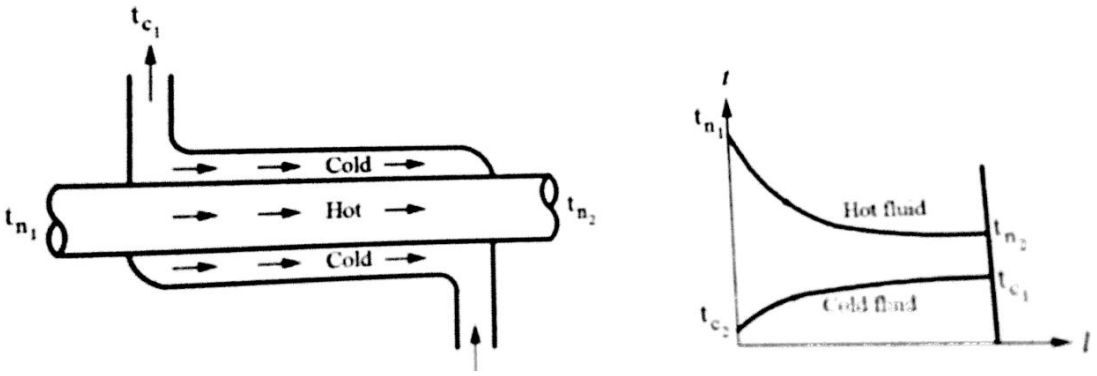

Fig-3.6.3- Parallel- flow heat exchangers

Ex: Oil coolers, oil heaters, water heaters etc.

As a wall separates the two fluids, this type of heat exchanger may be called parallel-flow recuperator or surface heat exchanger.

ii) Counter-flow heat exchangers

In a counter flow heat exchanger, the two fluids flow in opposite directions. The hot and cold fluids enter at the opposite ends. Due to counter flow, gives maximum rate of heat transfer for a given surface area. Hence, such heat exchangers are most favoured for heating and cooling of fluids.

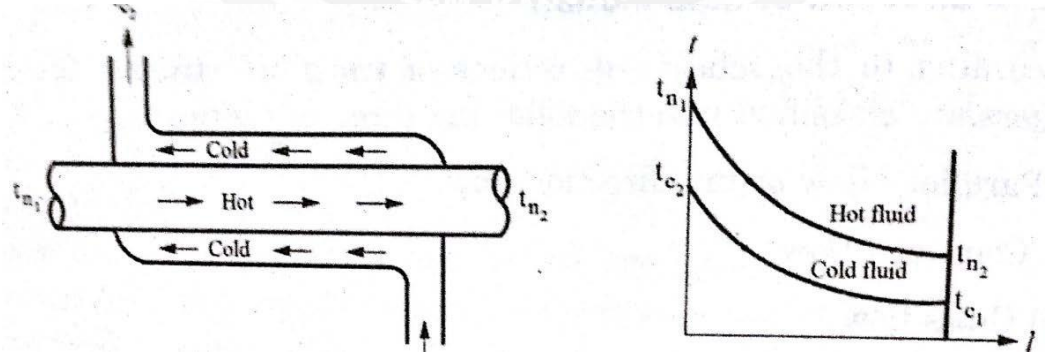

Fig-3.6.4- Counter-flow heat exchangers

i) Cross-flow heat exchangers

In cross-flow heat exchangers, the two fluids (hot and cold) cross one another in space, usually at right angles. Figure shows a schematic diagram of common arrangements of cross-flow heat exchangers.

Ex: The cooling unit of refrigeration system, automobile, radiators, etc.

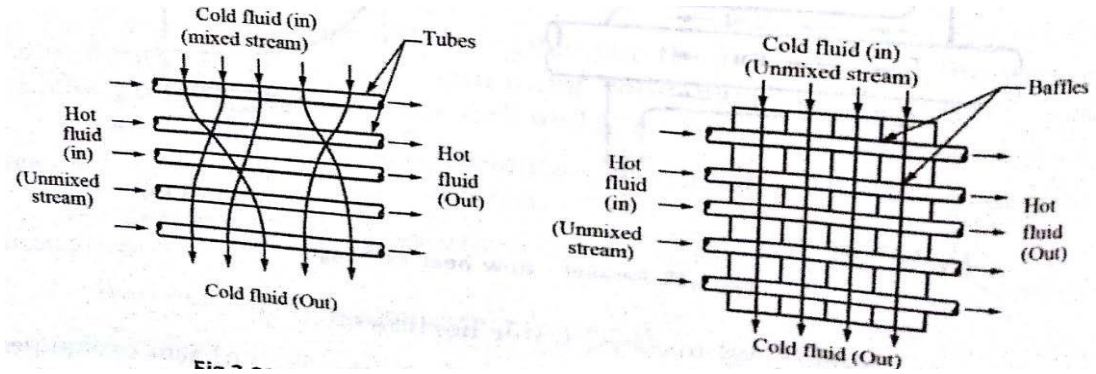

Fig-3.6.5- Cross-flow heat exchangers

3. Design and constructional features

Based on design and constructional features the heat exchangers are classified as under:

i) Concentric tubes

In this type, two concentric tubes are used, each carrying one of the fluids. This direction of flow may be parallel or counter as depicted in figure. The effectiveness of the heat exchanger is increased by using swirling flow.

ii) Shell and tube

In this type of heat exchanger, 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.

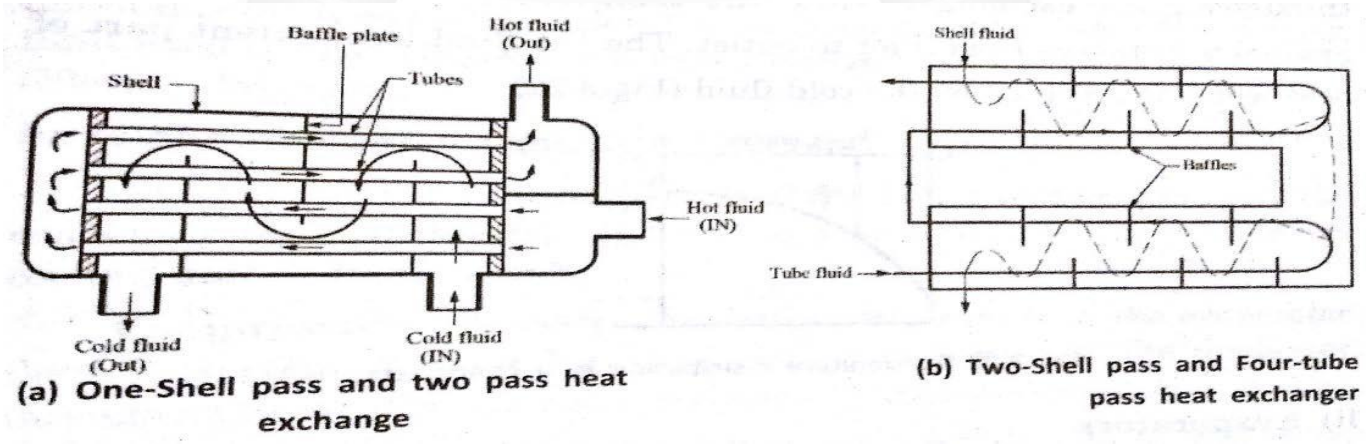

Fig-3.6.6- Shell and tube exchanger

i) Multiple shell and tube passes

Multiple shell and tube passes are used for enhancing the overall heat transfer. Multiple shell pass is possible where the fluid flowing through the shell is re-routed. The shell side fluid is forced to flow back and forth across the tubes by baffles. Multiple tube pass exchangers are those which re- route the fluid through tubes in the opposite direction.

ii) Compact heat exchangers

These are special purpose heat exchangers and have a very large transfer surface area per unit volume of the exchanger. They are generally employed when convective heat transfers sufficient associated with one of the fluids is much smaller than that associated with the other fluid.

Ex: Plate-fin, flattened fin tube exchangers etc.

4. Physical state of fluids

Depending upon the physical state of fluids the heat exchangers are classified as follows:

i) Condensers

ii) Evaporators

i) Condensers

In a condenser, the condensing fluid remains at constant temperature throughout the exchanger while the temperature of the colder fluid gradually increases from inlet to outlet. The hot fluid loses latent part of heat which is accepted by the cold fluid (figure).

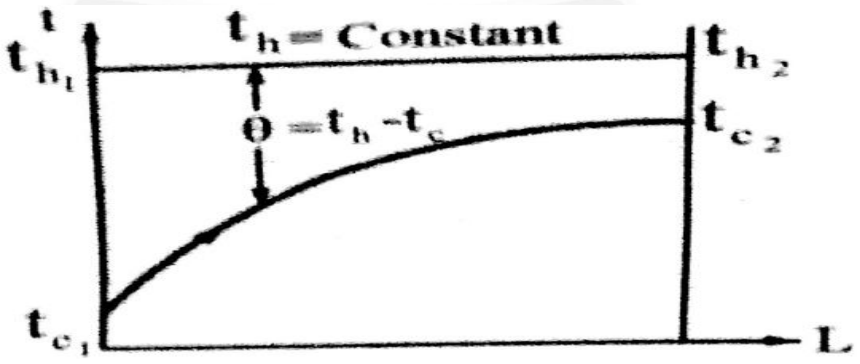

Fig-3.6.7- Condensers

i) Evaporators

In this case, the boiling fluid (cold fluid) remains at constant temperature while the

temperature of hot fluid gradually decreases from inlet to outlet (figure).

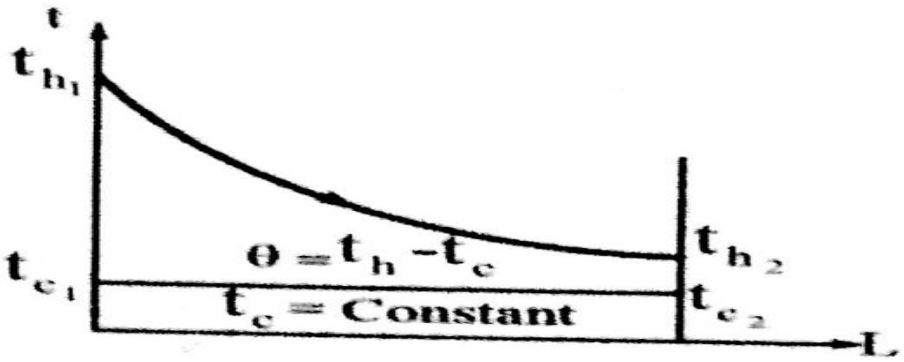

Fig-3.6.8- Evaporators