HEAT EXCHANGERS

INTRODUCTION

The devices that are used to facilitate heat transfer between two or more fluids at different temperatures are known as heat exchangers.

Different types and sizes of heat exchangers are used in steam power plants, chemical processing units, building heating and air conditioning, house hold refrigerators, car radiators, radiators for space vehicles etc.

This chapter deals with classification of heat exchangers, the overall heat transfer coefficient, LMTD, NTU method and Effectiveness of heat exchangers.

CLASSIFICATION OF HEAT EXCHANGERS

Heat exchangers are broadly classified based on the following considerations.

1. Classification based on Transfer Process

Based on heat transfer process heat exchangers are classified as direct contact and indirect contact

a) Direct contact

In direct contact heat exchangers, heat transfer takes place between two immiscible fluids like a gas and a liquid coming into direct contact.

e.g.: Cooling towers, jet condensers for water vapour, and other vapors utilizing water spray.

b) Indirect contact

In indirect - contact type of heat exchangers the hot and cold fluids are separated by an impervious surface. There is no mixing of the two fluids and these heat exchangers are also known as surface heat exchangers.

e.g: Automobile radiators.

2. Classification based on Compactness

The ratio of the heat transfer surface area on one side of the heat exchanger to the volume is used as a measure of compactness. The heat exchanger having a surface area density on anyone side greater than about 700 m2/m3 is known as a compact heat exchanger.

e.g.: Automobile radiators (1100 m2/m3),Gas turbine engines (6600 m2/m3), Human lungs (20,000 m2/m3)

3. Classification based on type of construction

Based on the type of construction heat exchangers are classified as follows.

a) Tubular heat exchangers

Tubular heat exchangers are available in many sizes, flow arrangements and types. They can withstand a wide range of operating pressures and temperatures.

A commonly used design is shell-and-tube heat exchanger which consists of round tubes mounted on cylindrical shells with their axes parallel to that of the shell.

The combination of fluids may be liquid-to-liquid, liquid-to -gas or gas-to-gas.

b) Plate heat exchangers

In these types thin plates are used to affect heat transfer. The plates may be either smooth or corrugated.

These heat exchangers are suitable only for moderate temperature or pressure as the plate geometry restricts the use of high pressure and temperature differentials.

The compactness factor for plate exchangers ranges from 120 to 230 m2/m3.

c) Plate fin heat exchangers

These heat exchangers use louvered or corrugated fins separated by flat plates. Fins can be arranged on each side of the plate to get cross-flow, counter-flow or parallel-flow arrangements.

These heat exchangers are used for gas-to-gas applications at low pressures (10 atm.) and temperatures not exceeding 800°C.

They also find use in cryogenic applications. The compactness factor for these heat exchangers is upto 6000 m2/m3.

d) Tube-fin heat exchangers

Such heat exchanges are used when a high operating pressure or an extended surface is needed on one side. The tubes may be either round or flat.

Tube-fin heat exchangers are used in gas- 252 Heat and Mass Transfer turbine, nuclear, fuel cell, automobile, airplane, heat pump, refrigeration, Cryogenics etc.

The operating pressure is about 30 atm. and the operating temperature ranges from low cryogenic temperatures to about 870 Dc.

The maximum compactness ratio is about 330 m2/m3

e) Regenerative heat exchangers

Regenerative heat exchangers may be either static type or dynamic type.

The static type has no moving parts and consists of a porous mass like balls, pebbles, powders etc. through which hot and cold fluids pass alternatively.

e.g.: air preheaters used in coke manufacturing and glass melting plants.

In dynamic type regenerators, the matrix is arranged in the form of a drum which rotates about an axis in such a manner that a given portion of the matrix passes periodically through the hot stream and then through the cold stream.

The heat absorbed by the matrix from the hot stream is transferred to the cold stream during its run.

4. Classification based on flow Arrangement

Based on flow arrangement heat exchangers are classified into the following principal types.

a) Parallel-flow

In this heat exchanger, the hot and the cold fluids enter at the same end of the heat exchanger and flow through in the same direction and leave together at the other end as shown in Fig 5(a).

b) Counter flow
In this heat exchanger hot and cold fluids enter in the opposite ends of the heat

exchanger and flow in opposite directions as shown in Fig 5(b).

c) Cross flow

In this heat exchanger, the two fluids flow at right angles to each other as shown in Fig 5 (c).
In this arrangement the flow may be mixed or unmixed.

In general, in a cross flow exchanger, three idealized flow arrangements are possible

1. The fluids are unmixed
2. One fluid is mixed, and the other is unmixed
3. Both fluids are mixed.

d) Multipass flow
Since multi passing increases the overall effectiveness over individual effectiveness they are frequently used in heat exchanger design.

Different multipass flow arrangements are "One shell pass, two tube pass" known as "one - two" heat exchanger, "two shell pass, two tube pass", etc. as shown in Fig 6.

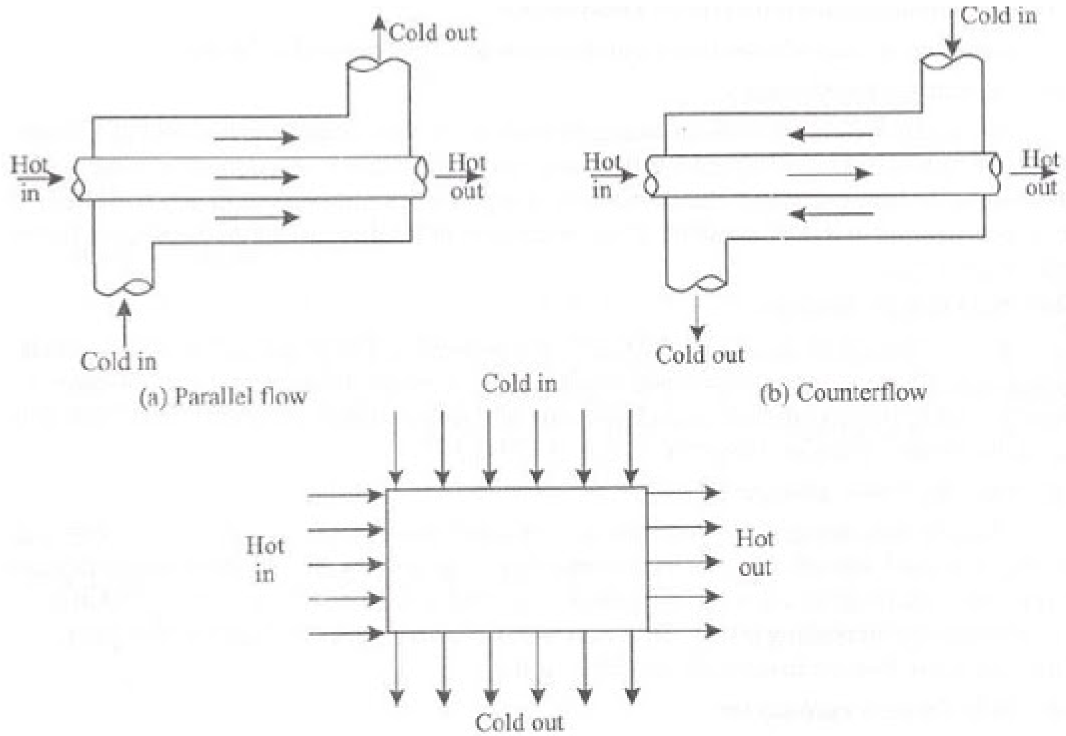

Fig. 5: Classification by flow arrangement

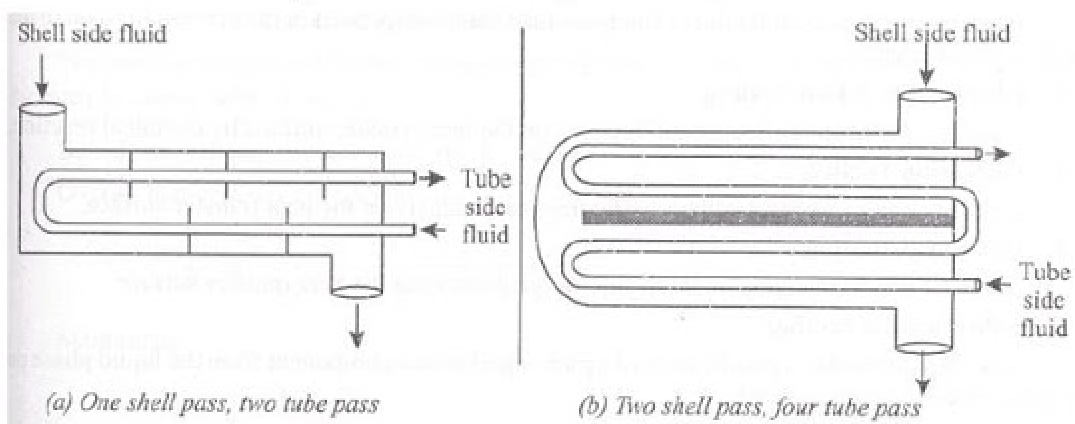

Fig. 6: Multi pass flow arrangement

5. Classification based on heat transfer mechanism

Heat exchangers are classified based on the following modes of heat transfer.

1. Single phase forced or free convection.

2. Phase change due to boiling and condensation.

3. Radiation or combined convection and radiation.

Source : http://mediatoget.blogspot.in/2011/10/heat-exchangers.html