

Heat exchanger

- These are devices used to transferring heat energy from one fluid(hot gas or steam) to another fluid (liquid) through a metal wall.
- Heat exchanger can be **classified** on the basis of :
 - 1. Type of fluid flow arrangement
 - 2. Method of heat transfer.
- 1. **Type of fluid flow arrangement :**
 - **Parallel flow heat exchangers**
 - **Counter flow heat exchanger**
 - **Cross flow heat exchangers.**

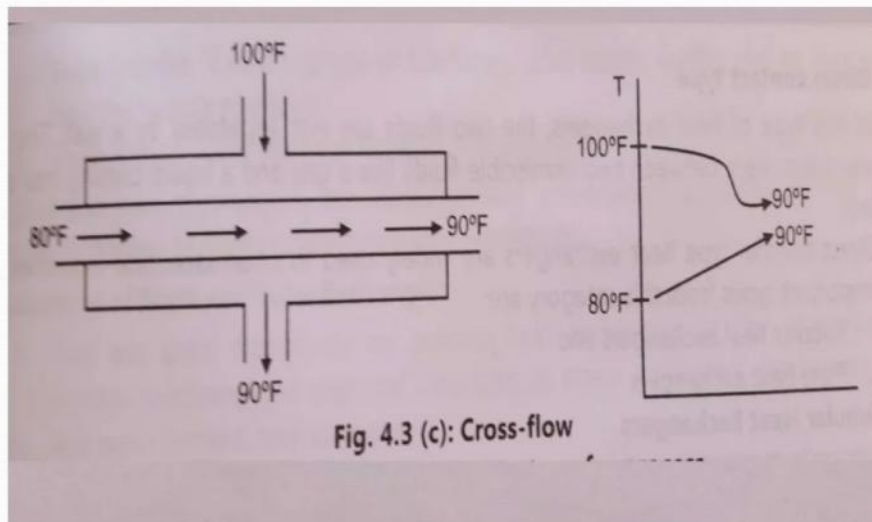
Parallel flow heat exchanger

- It is also referred as **cocurrent or parallel stream exchanger**.
- The hot and cold fluid streams enter together at one end, flow parallel to each other in the same direction, and leave together at other end.
- With parallel flow the temperature difference between the two fluid is large at the entrance end, but it becomes small at the exit end .
- The overall measure of the heat transfer driving force , the log mean temp difference is less than for counter flow, so the heat exchanger surface area requirement will be larger than for counter flow heat exchanger with same inlet and outlet temp for hot and cold fluid.

Counter flow heat exchanger

- It is also known as **counter current exchanger**.
- in this type hot and cold fluid flow parallel but in opposite directions.
- The hot fluid entering at one end of the heat exchanger flow path and the cold fluid entering at other end of the flow path.
- **Advantage:**
- It is thermodynamically superior to any other flow arrangement.
- It produces highest temperature change in each fluid .

Cross flow heat exchanger



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- In cross flow type , one fluid flows perpendicular to the second fluid , i.e one fluid flow through tube and second fluid passes around the tube at right angle.
- Cross flow arrangement , mixing of either fluid stream may or may not occur.
- These heat exchanger are typically used for heat transfer between a gas and a liquid .

Classification of heat exchanger according to transfer process.

- According to transfer process heat exchanger can be divided into two major categories:
 - ☐ Indirect contact type
 - ☐ Direct contact type

I. Indirect contact type :

- These are also referred to as **surface heat exchanger**.
- In this type ,fluid streams remain separate , and the heat transfer takes place continuously through **separating wall**.
- There are **no direct mixing of the fluid** because each fluid flows in separate fluid passages .

Classification of indirect contact type

- A. Direct transfer type
- B. Storage type.
- C. Fluidised bed exchanger

❑ A. Direct transfer type:

In this type, the hot and cold fluid flow simultaneously through the device and heat is transferred through a wall separating the fluids.

Examples are – Tubular , plate –type, and extended surface exchangers

❑ B. Storage type.

These are also referred as regenerative heat exchanger.

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- This type of heat exchanger has a heat transfer surface (flow passage) which is generally **cellular in structure** and is referred to as **Matrix** or it is porous solid material.
- In this , both fluid flow alternatively through the same flow passages.
- When hot gas flows over the matrix, the thermal energy from hot gas is stored in the matrix wall, and thus hot gas is being cooled during matrix heating period .
- When cold gas flows through same matrix, the matrix wall gives up thermal energy , which is absorbed by the cold fluid.
- Thus, in this type , the corresponding thermal energy is alternatively stored and released by the matrix wall.

❑ C. Fluidised bed exchanger

- In fluidised –bed heat exchanger , one side of a two-fluid exchanger is immersed in bed of sand or coal particles.
- At optimum fluid velocity , the bed particles floats and the condition is referred to as fluidized condition .
- Under this condition very high heat transfer coefficients are achieved.
- **Application:** In drying, mixing, adsorption, reactor engineering, coal combustion.

II. Direct contact type

- Two fluids are not separated by a wall. The heat transfer takes place between two immiscible fluids like gas and liquid coming into direct contact.

Direct transfer type

- **Direct transfer type** heat exchangers are widely used in industries. Two important types
- **Types**
- **A. Tubular heat exchanger**
- **B. Plate heat exchanger**
- **A. Tubular heat exchanger :**
 - Shell and tube exchanger
 - Double pipe heat exchanger.

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A. Tubular heat exchanger

- Shell and tube heater is the simplest form of a tubular heater(heat exchanger).
- **Shell and tube exchanger :**
- **Construction :**
- Tubular heater consists of a bundle of parallel tubes inside the cylindrical shell.
- Two distribution chambers, D1 and D2 are provided at each end of the casing C.
- Fluid inlet is provided at chamber D2 and outlet at D1.
- Steam or other vapour is introduced by connection ,F.
- Provision for escape the non-condensable vapour K and condensed vapour to drain at G.

Two fluids can exchange heat ,one fluid flows over the outside of tube while second fluid flows inside tubes.

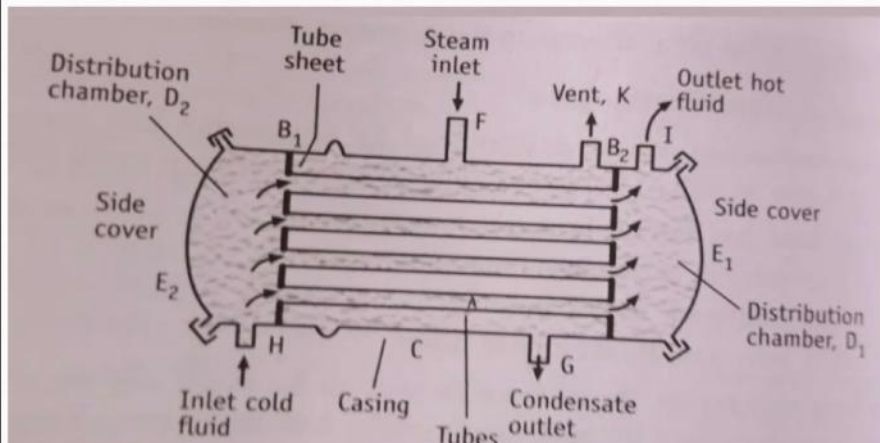


Figure 5-11. Construction of single-pass tubular heater.

Working :

- Steam or any vapour is introduced through a steam inlet F into space surrounding the tube.
- The steam flows down the tubes. In this process, the tube gets heated rapidly due to high value of steam film coefficient.
- The condensed vapour drain through condensed outlet at G.
- Non-condensable gases ,if any, escape through vent K .
- The fluid to be heated is pumped through the cold fluid inlet H into distributing chamber D₂.
- The fluid flows through tubes.
- The fluid in tube get heated due to heat transfer by conduction through metal wall , followed by stagnant layer and finally by convection. Thus enhanced rate of heat transfer.
- Heated fluid reaches distributing chamber D₁ and leaves the hot fluid outlet ,I.

Application :

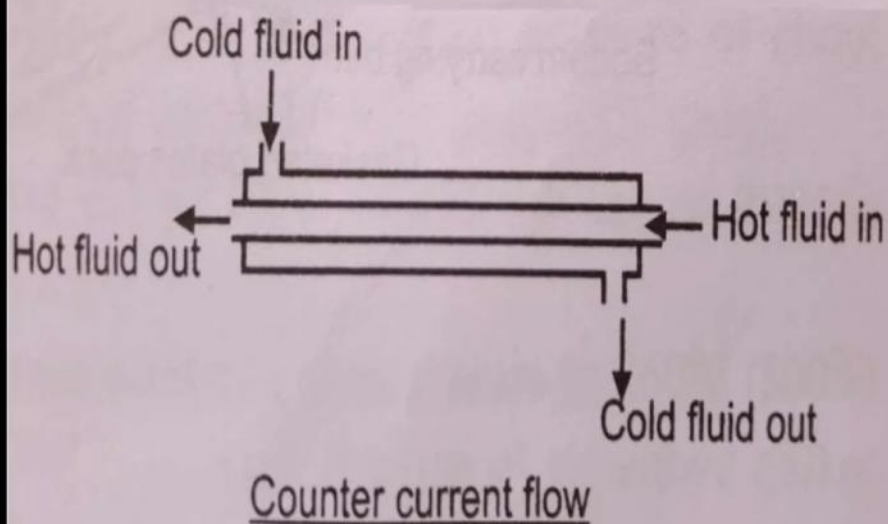
- Used in pharmaceutical petroleum –refining and chemical industries as a steam generators, condenser, boiler feed water heater.
- Used in air conditioning and refrigeration applications.

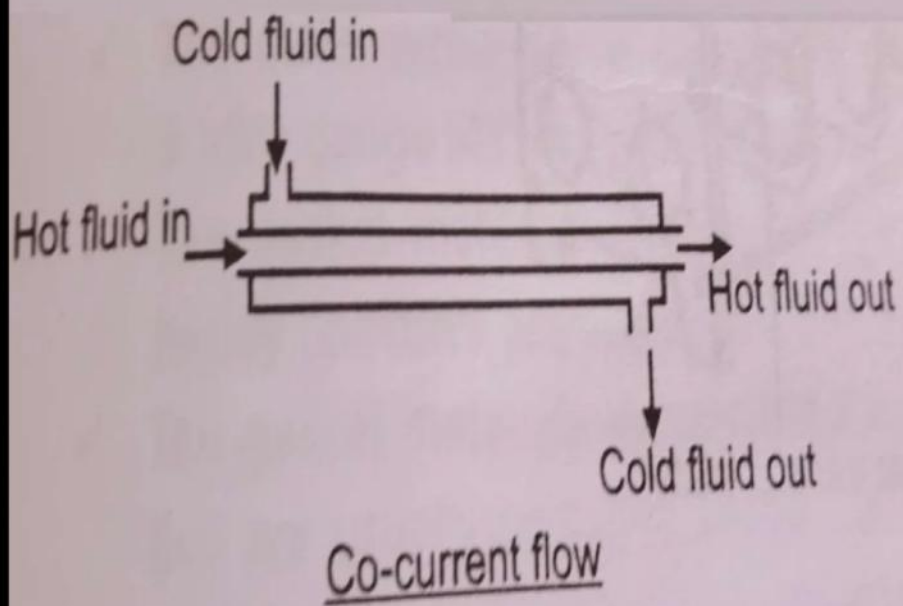
Advantages :

- They are most versatile exchangers , made from variety of metal and non-metal material.
- The tubes are replaceable and can be cleaned easily.

❑ Double pipe Heat Exchanger

- These are simplest of all type of heat exchangers.
- They are made up of two pieces of pipe –one inside the other.
- One fluid flows through the inner pipe while second fluid flows through annulus between the pipes.
- Flow inside double pipe heat exchanger can be co-current or counter current.
- **Advantage :**
 - They are inexpensive
 - Easy to design for high pressure service.





Disadvantage

- They are difficult to clean
- They are suitable only for small sizes.

Multipass Heater

- In multipass heater, the velocity of fluid can be increased, this causes increase in heat transfer coefficient.
- Liquid to be heated is passed through the tubes several times before leaving equipment.
- This facilitates the effective heat transfer. Therefore multipass tubular heaters are superior to single pass shell and tube heater.
- **Construction –**
 - It consist of number of parallel tubes.
 - The bundle of tube is wrapped in cylindrical casing.
 - Two distribution chambers are provided at each end of casing. Since the heater is multipass, the same liquid has to flow through several tubes back and forth.

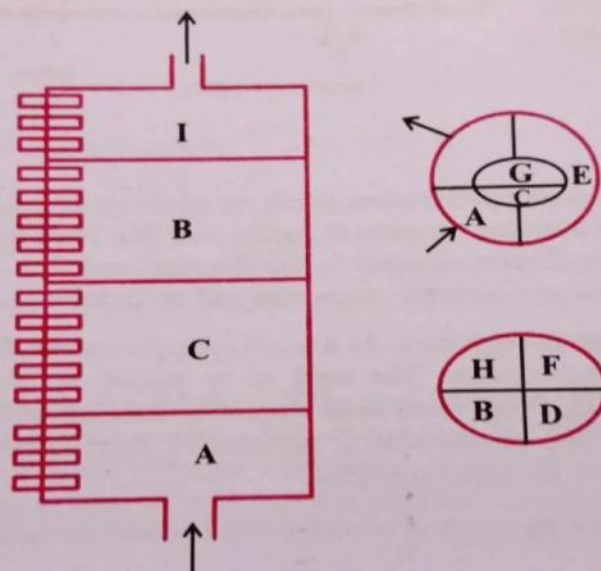


Figure 4.7: Multipass heater

Working -

- The feed is entered into compartment A of one of the head.
- Then it is passed through tubes into compartment B of other head.
- Then fluid back through other set of tubes to compartment C .
- And finally leaves through compartment I.
- The fluid is diverted by using baffles. Since heater is multipass, so same liquid has to flow through several tubes back and forth.

Advantage:

- Multipass tubular heaters are superior to the single pass shell and tube heater.

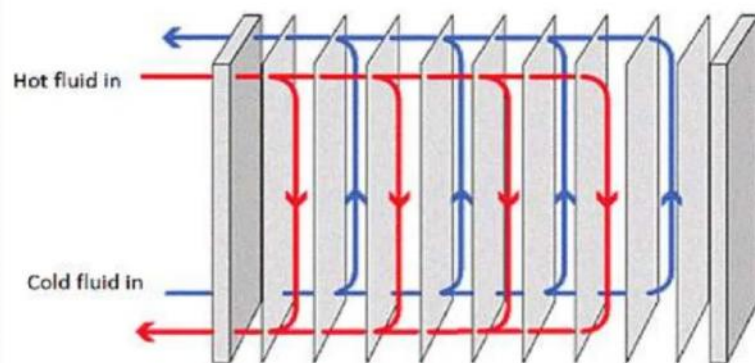
Disadvantages:

- The fabrication of multipass heater is more complicated .
- The pressure drop through apparatus is increased bcz of enhanced velocity of fluid flow.
- More number of exit and entrance points increase the friction losses.

B. Plate –type heat exchanger

- A plate exchanger consists of a series of parallel plates that are placed one above the other so as to allow the formation of a series of channels for fluids to flow between them.
- The space between two adjacent plates forms the channel in which the fluid flows.
- Inlet and outlet holes at the corners of the plates allow hot and cold fluids through alternating channels in the exchanger so that a plate is always in contact on one side with the hot fluid and the other with the cold.
- Fluids are divided into several parallel streams and can produce a perfect countercurrent.

Plate type heat exchanger



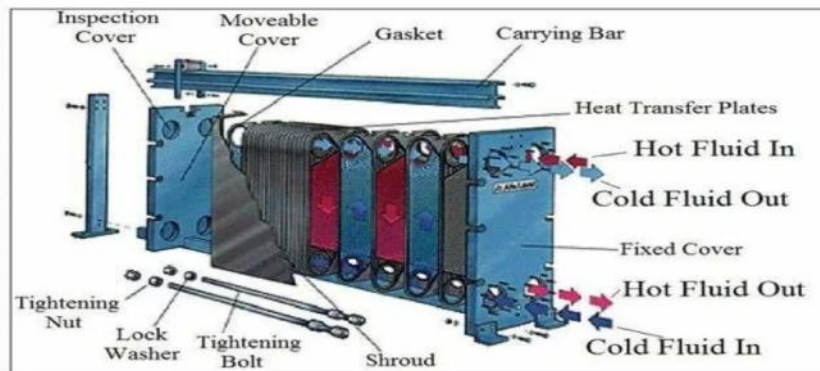


Plate and Frame Heat Exchanger Parts

Application :

- They are most common in dairy ,juice, beverage,general food processing and pharmaceutical industries.
- Used in synthetic rubber industry, paper mill.

Advantage :

- It has high value of overall heat transfer coefficient.
- Easy maintenance and cleaning.
- There are no significant hot or cold spots in exchanger.

Heat interchanger

- These are device used for transferring heat energy from one liquid to another liquid or from one gas to another gas through a metal wall.
- In heat interchangers, the heating medium is hot liquid. The liquid to be heated is a cold liquid.
- The film coefficient can be enhanced by increased by increasing velocity of flow.
- But this is difficult from point of construction of the device.
- The **Shell and tube exchanger** and **Double pipe heat exchanger** can be used as heat interchanger.