

Parts of refrigeration systems (Condenser)

Condenser

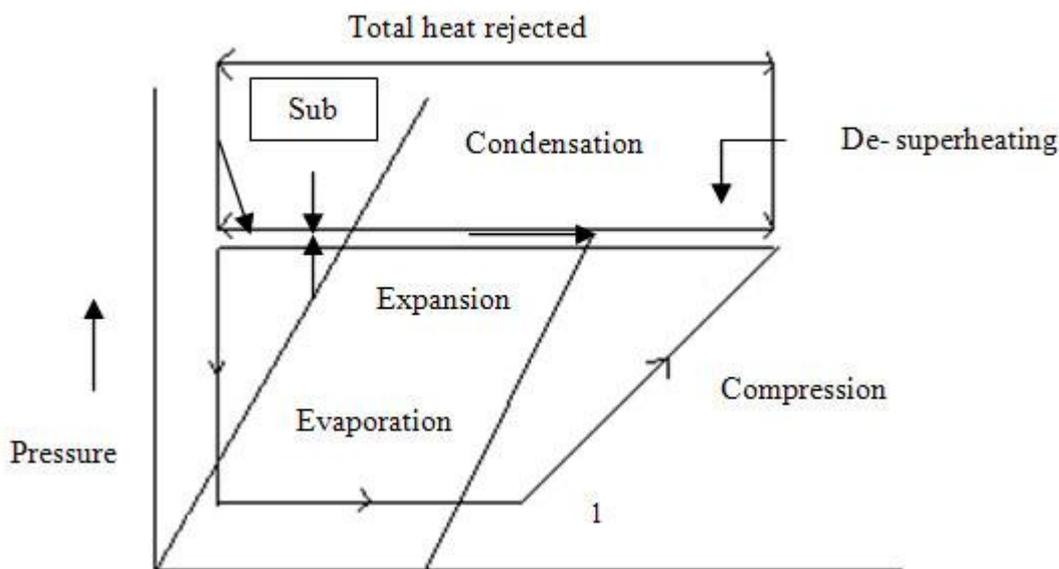
The condenser is an important device used in the high pressure side of a refrigeration system. Its main function is to transfer heat from the refrigeration system to condensing medium. The hot vapour refrigerant consists of the heat absorbed in the evaporator and the heat of compression added by the mechanical energy of the compressor. The heat from the hot vapour refrigerant in a condenser is removed first by transferring it to the walls of the condenser tubes and then from the tubes to the condensing or cooling medium. The cooling medium may be air or water or a combination of the two. The selection of a condenser depends upon the capacity of the refrigerating system, the type of refrigerant used and the types of cooling medium available.

3.3.1. Working of condenser

The compressor draws in the superheated vapour refrigerant that contains the heat it absorbed in the evaporator and the compressor which adds more heat (i.e. the heat of compression) to the superheat vapour. This highly superheated vapour from the compressor is pumped to the condenser through the discharge line.

The condenser cools the refrigerant in the following three stages.

- First of all superheated vapour is cooled to saturation temperature to the pressure of the refrigerant



- Now the saturated vapour refrigerant gives up its latent heat and is condensed to a saturated liquid refrigerant. This process is called condensation.
- The temperature of the liquid refrigerant is reduced below its saturation temperature (i.e. sub cooled) in order to increase the refrigeration effect.

3.3.2. Factors Affecting the Condenser Capacity

The condenser capacity is the ability of the condenser to transfer heat from the hot vapour refrigerant to the condensing medium. The heat transfer capacity of a condenser depends upon the following factor.

Material

Different materials have different abilities of heat transfer, therefore the size of a condenser of a given capacity can be varied by selecting the right material. It may be noted that higher the ability of a material to transfer heat, the smaller will be the size of condenser.

Amount of contact

The condenser capacity may be varied by controlling the amount of contact between the condenser surface and the condensing medium. This can be done by varying the surface area of the condenser and the rate of flow of the condensing medium over the condenser surface. The amount of liquid refrigerant level in the condenser also affects the amount of contact between the vapour refrigerant and the condensing medium.

Temperature Difference

The heat transfer capacity of a condenser greatly depends upon the temperature difference between the condensing medium and the vapour refrigerant. As the temperature difference increases, the heat transfer rate increases and therefore the condenser capacity increases.

3.3.3.Types of the condenser

- Air cooled condenser
- Water cooled condense
- Evaporative condenser

3.3.3.1. Air-cooled condensers

An air cooled condenser is one in which the removal of heat is done by air. It consists of steel or copper tubing through which the refrigerant flows. The size of tube usually ranges from 6 mm to 18 mm outside diameter depending upon the size of the condenser. Generally copper tubes are used because of its excellent heat transfer ability. The condenser with steel tubes is used in ammonia refrigerating systems. The main disadvantage of an air cooled condenser is that it operates at a higher condensing temperature than a water cooled condenser. The higher condensing temperature causes the compressor to work more

Types of air cooled condenser

- Natural convection air-cooled condenser

In natural convection air-cooled condenser the heat transfer from the condenser coils to the air is by natural convection. As the air comes in contact with the warm condenser tubes, it absorbs heat from the refrigerant and thus the temperature of air increases. The warm air being lighter, rises up and the cold air from below rises to take away the heat from the condenser since the rate of heat transfer in natural convection condenser is slower therefore they require a large surface area as compared to forced convection condensers. The natural convection air cooled condenser are used in small capacity applications such as domestic refrigerators, freezers, water cooler and air-conditioners.

- Forced convection air cooled condenser:

In forced convection air cooled condenser, the fan is used to force the air over the condenser coils to increase the heat transfer capacity.

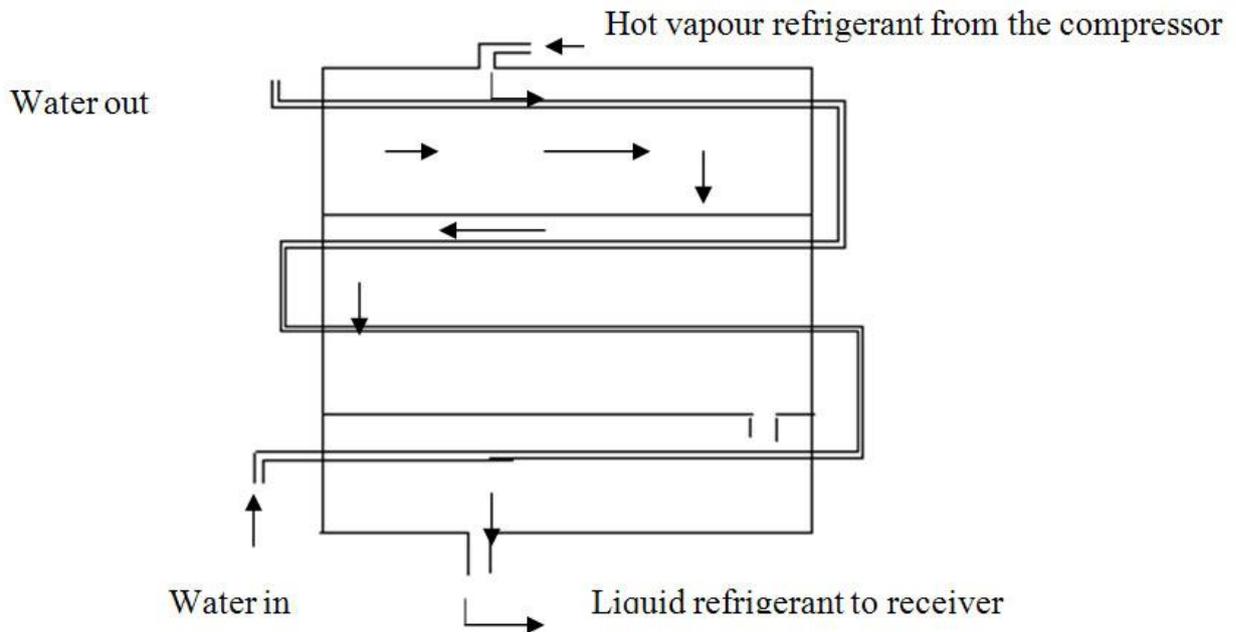
3.3.3.2. Water cooled condenser

A water cooled condenser is one in which water is used as the condensing medium. They are always preferred where as adequate supply of clear expensive water and means of water

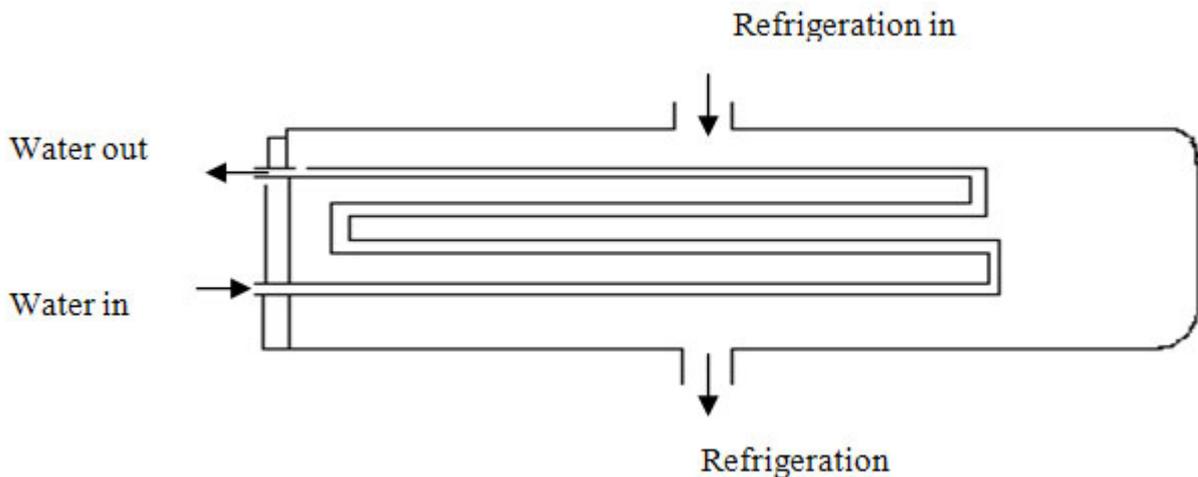
disposal are available. These condenser are commonly used in commercial and industrial refrigerating units.

3.3.3.2.1. Tubes in tube or double tube condenser

This type of condenser consists of a water tube inside a large refrigerant tube. In this type of condenser the hot vapour refrigerant enters at the top of the condense



The water absorbs the heat from the refrigerant and the condensed liquid refrigerant flows at the bottom since the refrigerant tubes are exposed to ambient air, Therefore some of the heat is also absorbed by ambient air by natural convection. The cold water in the inner tubes may flow in either direction. Opposite to the refrigerant, it is said to be a counter flow system on the other hand, when the water enters at the top and flows in the same direction as the refrigerant, it is said to be parallel flow system.



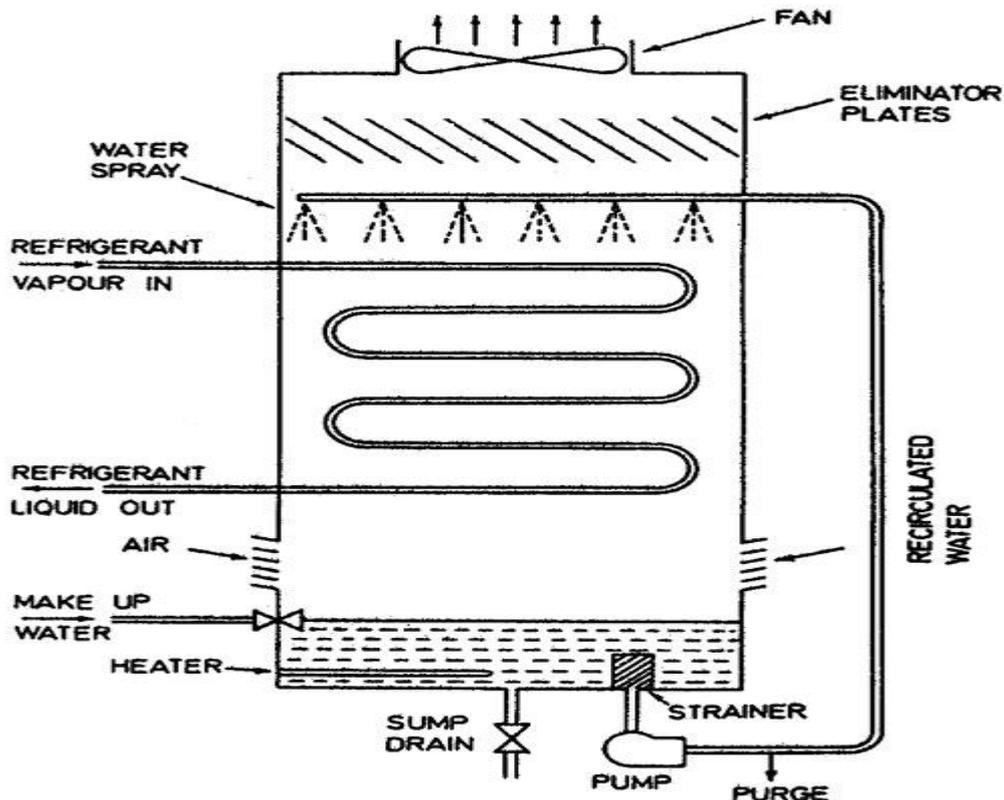
3.3.3.2.2. Shell and coil condenser

Shell and coil water cooled condensers are widely used in the smaller size up to 10 tones capacity. They have the advantage of being compact in size and serve the dual function of

condenser and receiver. As the name implies, a water coil is wound inside a shell. The refrigerant gas within the shell condenses on the outside of the water coils. The liquid refrigerant collects at the bottom of the shell where it is then removed through a bottom outlet.

3.3.3.3. Evaporative Condenser

The evaporative condenser use both air and water as condensing mediums to condense the hot vapour refrigerant to liquid refrigerant. These condenser combines the effectiveness of forced convection currents with the ability of a vaporizing liquid to absorb heat.



In its operation, the water is pumped from the sump to a spray header and sprayed through nozzles over the condenser coils through which the hot vapour refrigerant from the compressor is passing. The heat transfers from the refrigerant to the condensing tube walls and into the water that is wetting the outside surface of the tubes. At the same time, a fan draws air from the bottom side of the condenser and discharged out at the top of the condenser. The air causes the water from the surface the condenser coils to evaporate and absorb the latent heat of evaporation from the remaining water to cool it. Though most of the cooling takes place by evaporation, the air can also absorb some sensible heat from water. Since the heat for vaporizing the water is taken from the refrigerant therefore the vapour refrigerant condenses in to a liquid refrigerant. The cold water that drops down into a sump is recirculated. In order to make up the deficiency caused by the evaporated water additional water is supplied to the sump. A float valve in the sump controls the make up supply. The eliminator is provided above the spray header to stop particles of water escaping along with the discharge air.

3.3.3.4. Comparison between Air cooled and water cooled condensers

s.I Air cooled condenser	Water cooled condenser
--------------------------	------------------------

no		
1	Construction of air cooled condenser is very simple. Therefore the initial cost is low. The maintenance cost is also low	Construction of water cooled condenser is complicated therefore the initial cost is high. The maintenance cost is also high.
2	There is no handling problem with air cooled condenser	The water cooled condenser are difficult to handle
3	The air cooled condenser do not require piping arrangement for carrying the air	The pipes are required to take water to and from the condenser
4	There is no problem in disposing of used air	There is a problem of disposing the used water unless recirculation system is provided.
5	There is no corrosion therefore fouling effect is low	There is a corrosion occurs inside water tubes therefore the fouling effects is high
6	The air cooled condenser have low heat transfer capacity due to low thermal conductivity of air	The water cooled condenser have high heat transfer capacity due to high thermal conductivity of water
7	These condenser are used for low capacity plans (less than STR)	These condenser are used for large capacity plants
8	The distribution of air on condenser surface is not uniform	There is even distribution of water on the condensing surface.