REFRIGERATION

Definitions:

Refrigeration: it is the process of continuous cooling or extraction of heat to below that of the atmosphere from a substance with a help of the external work.

Principle of refrigeration: It is based on the second law of thermodynamics that the heat can made to flow from cold body to a hot body with the help of external source.

Refrigerator: it is a machine which produces cold. It is used to remove heat from the refrigerated space and reject it to atmosphere. Hence it maintains the temperature below the surrounding atmosphere.

Refrigerant: it is the working fluid used in the refrigerator. E.g. Ammonia, Methyl chloride, Freon etc.

Ton of refrigeration:

It is the standard unit of the refrigerator. It is the freezing capacity of the one American short ton of water from 0 c in 24 hrs.

One ton of the refrigeration=3.5kW=3.5kJ/s=210kJ/min.

Coefficient of performance: it is the measure of the performance of the refrigeration system. it is the ratio of the refrigerating effect to the input work required to produce the effect.

COP=Output/input=Q/W.

The value of the COP may be less than the unity or greater than unity.

Relative COP: it is the ratio of the actual COP to the theoretical COP.

Relative COP=Actual COP/theoretical COP.

Types of refrigerants:

The two main types of refrigerants are

1. primary refrigerants
2. secondary refrigerants

Types of refrigeration systems

Mainly they are classified under two groups:

1. based on the type of the external work-
   Using mechanical energy:
   a. Cold air refrigeration
   b. Vapors compression refrigeration
   Using heat energy:
   a. simple vapour absorption refrigeration
   b. Actual vapour absorption refrigeration.

2. Based on the usage-
   a. primary refrigeration
   b. Secondary refrigeration.

Parts of a refrigerator and their functions:

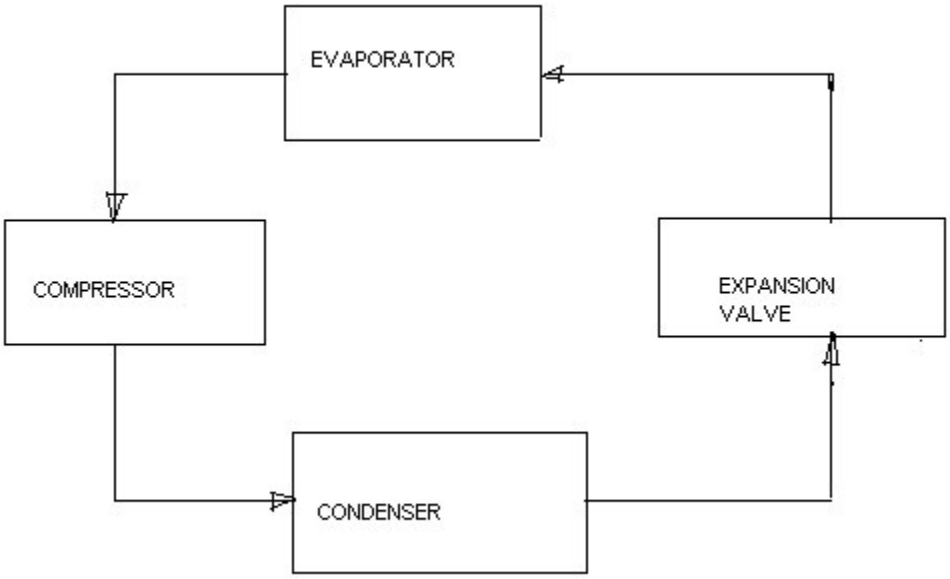
Evaporator: It is used to receive the liquid refrigerants from the condenser through throttle valve and to evaporate it. It is also called as cooling unit or freezing unit.
Compressor: It is used to draw the refrigerant from the evaporator through suction valve at low pressure and to force it to the condenser through exhaust valve at high pressure and temperature.

Condenser: It is used to condense the refrigerants at saturation temperature from vapour to liquid by transferring its latent heat to the water.

Throttle valve: It is used to control the rate of admission of refrigerants to the evaporator. As the refrigerant expands in the valve, it looses its pressure and temperature at its exit end and gets cooled.

Absorber: It is a unit contains water. It is used to receive the refrigerant from the evaporator and to absorb it with water to become a strong solution of ammonia with an increase in temperature.

Pump: it is used to pump the strong ammonia solution from the absorber to the separator.
Separator: It is used to separate the ammonia vapour from the strong solution using heat energy and then send it to the condenser.



Properties of good (ideal) refrigerants:

An ideal refrigerant should have the following properties:

1. low viscosity
2. low freezing point
3. low boiling point
4. low heat capacity
5. low specific volume
6. low saturation pressure
7. odorless
8. High latent heat of vaporization.
9. good thermal conductivity.

10. high COP
11. Non inflammable and non explosive.
12. high critical pressure and temperature.

Uses of Refrigerants:

Ammonia: Ice plants, large cold storages, etc.
Carbon dioxide: Marine refrigerators, dry ice making and air conditioning.
Methyl chloride: domestic and industrial refrigerators
Fluorocarbon refrigerants: Freon-11, 12, 13, 22,113,114, etc.
These are used in domestic refrigerators, water coolers, air conditioning plants cold storages etc.
Sulphur dioxide: Domestic refrigerators.

Uses of refrigeration:

1. Ice making
2. Preservation of food products and medicines.
3. Air conditioning.
4. Computer functioning.
5. Products of rocket fuels.
6. Transportation of foodstuffs, dairy products.
7. Special industrial processes.

VAPOUR COMPRESSION REFRIGERATION:

Principle: here the mechanical energy is utilized to achieve refrigeration. A compressor is used to increase the temperature and pressure of the refrigerant vapour. The refrigerant alternatively evaporates and condenses.

Construction: Here an evaporator is kept in a storage room. A compressor is connected in between an evaporator and a condenser. Both the condenser and the evaporator consist of pipes in coil form to provide more contact surface area for the refrigerant.

Arrangement is made to circulate cold water or air around the condenser. A tray as a collector for exit water is placed nearby the condenser. A throttle valve is connected in between the condenser and the evaporator.

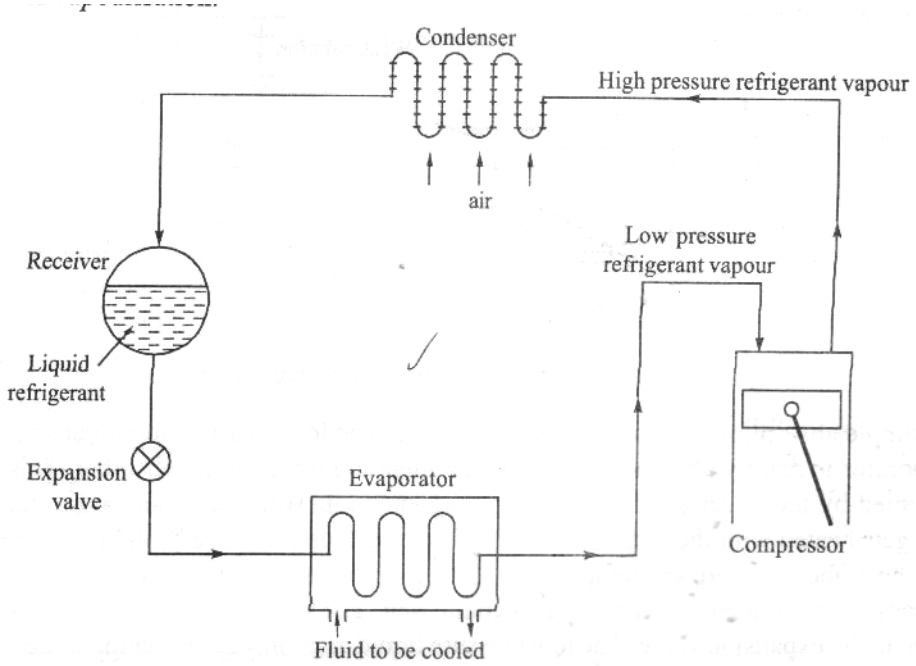


Fig. 8.1 Vapour compression refrigerator

Working: The unit completes one cycle with the following operations. Suction, compression condensation expansion, Vaporization.
Suction: the low pressure vapour in dry state is drawn from the evaporator during suction stroke of the compressor through its inlet valve.
Compression: During this stroke the pressure and temperature of the refrigerants increases and it is discharged through the exhaust valve and enters the condenser.
Condensation: The condenser absorbs its heat. The heat now flows from condenser to the cooling water which is circulated around it. As a result vapour is cooled and a return to liquid state.It is then made to exit through the throttle valve.
Expansion: The exit or expansion of the liquid result in decrease of its temperature and pressure to about -10 C and enters the evaporator kept in the storage room.
Vaporization: As the temperature of the liquid is less than that of the storage room, the heat will be absorbed by it from the room. As the result the liquid evaporates to almost dry vapour. Now this is dry vapour and is ready to start its next cycle.

VAPOUR ABSORPTION REFRIGERATION:

PRINCIPLE: Here the heat energy is utilized to achieve the refrigeration. An electric heater or steam is used to add the heat to the refrigerant for its evaporation. Also an absorber, a pump and a generator are used to complete the cycle.

Construction: Here a throttle valve is connected between an evaporator and a condenser. One pump is connected between an absorber and a separator. Water is filled in the absorber and it is connected to the evaporator. The evaporator is kept in the storage room. The separator is connected to the condenser.

Both the condenser and evaporator consists of pipes in coil form to provide more contact surface area for the refrigerant. Arguments are made to circulate the cold water around the condenser and in the absorber. An electric heater is housed in the separator. Trays may be positioned to collect the exit water near by the absorber and condenser. A receiver is connected in between the condenser and the throttle valve.

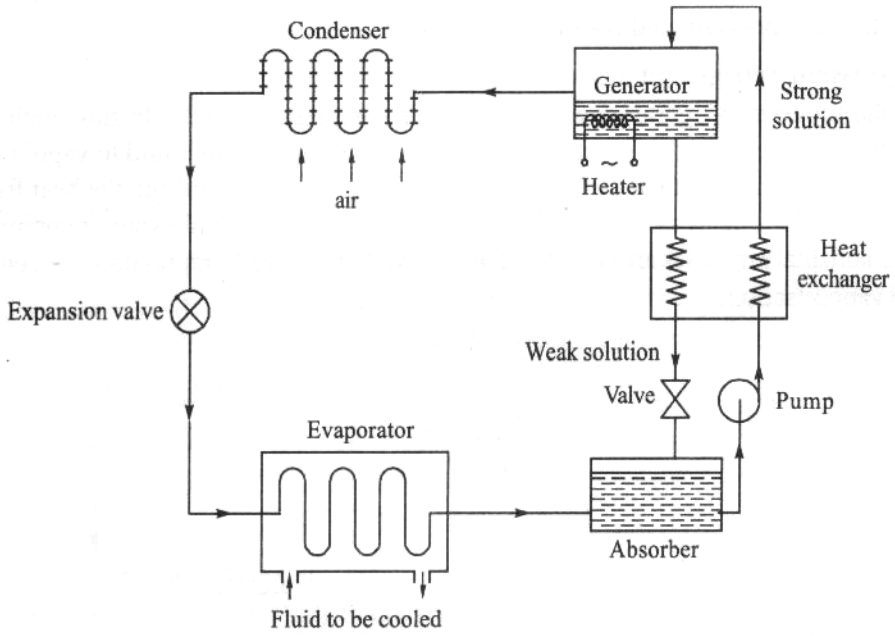


Fig. 8.2 Vapour absorption refrigerator

Working: Dry ammonia vapour from the evaporator enters the absorber containing water where it is absorbed by the water becomes a strong ammonia solution with an increase in temperature. The heat generated during this process is removed to some extent by circulating cold water through a pipe. Otherwise absorbing capacity reduces with hot water. The strong ammonia solution is now pumped by a pump to the generator where it is heated by an electric coil. As result ammonia vaporizes and separates out from the water. It is then driven out from the solution to the condenser where it is condensed and return to the liquid state. The liquid ammonia is then collected in the receiver. The high pressure liquid ammonia is then passed through the throttle valve where it is expanded with decrease in temperature and pressure. Later it enters the evaporator kept in the storage room.

Comparison between vapour compression and vapour absorption refrigeration.

Vapor compression refrigeration	Vapor absorption refrigeration
Works using mechanical energy Refrigeration capacity is less than 1000 tons. COP is much higher Noisy due to compressor. Chances of leakage of refrigerant are more. Maintenance and operating cost are high. Smaller in size. Ware and tear are more.	Works using heat energy Refrigeration capacity is greater than 1000tons. COP is less. Pump noise is less. No leakage. Less. Larger Wear and tear are less