CHAPTER: 2 REFRIGERATION AND AIRCONDITIONING

Refrigeration:
It is defined as the process of providing and maintaining a temperature well below that of surrounding atmosphere. In other words refrigeration is the process of cooling substance.

Refrigerators and heat pumps:
If the main purpose of the machine is to cool some object, the machine is named as refrigerator. If the main purpose of machine is to heat a medium warmer than the surroundings, the machine is termed as heat pump.

Terminologies of Refrigeration:

Refrigerating Effect (N): It is defined as the quantity of heat extracted from a cold body or space to be cooled in a given time. N= Heat extracted from the cold space
Time taken

Specific Heat of water and ice : It is the quantity of heat required to raise or lower the temperature of one kg of water (or ice), through one kelvin or (10 c) in one second.

Specific heat of water, C_{pw} = 4.19 kJ/kg K
Specific heat of ice, C_{pice} = 2.1 kJ/kg K.

Capacity of a Refrigeration Unit :
Capacity of a refrigerating machines are expressed by their cooling capacity.
The standard unit used for expressing the capacity of refrigerating machine is One ton of refrigeration is defined as, "the quantity of heat abstracted (refrigerating effect) to freeze one ton of water into one ton of ice in a duration of 24 hours at 0o c".

Heat extracted from at 0^o c = latent heat of ice
Latent heat of ice = 336 kJ/kg
i.e., 336 kJ of heat should be extracted one kg of water at 0o C to convert it into ice.

One ton of refrigeration = 336x1000 kJ/24 hrs.
= 336x1000 kJ/min
24x60

One ton of refrigeration = 233.333 kJ/min
= 3.8889 kJ/sec

Co efficient of Performance: It is defined as the ratio of heat extracted in a given time (refrigerating effect) to the work input.
The COP is always greater than 1 and known as theoretical coefficient of performance.

Applications of Refrigeration:

- In chemical industries, for separating and liquefying the gases.
- In manufacturing and storing ice.
- For the preservation of perishable food items in cold storages.
- For cooling water.
- For controlling humidity of air manufacture and heat treatment of steels.
- For chilling the oil to remove wax in oil refineries.
- For the preservation of tablets and medicines in pharmaceutical industries.
- For the preservation of blood tissues etc.,

- For comfort air conditioning the hospitals, theatres, etc.,

Properties of Refrigeration:

- A good refrigerant should have high latent heat of vapourisation.
- It should have low boiling and low freezing point.
- It should be non toxic and should non corrosiveness
- It should be non flammable and non explosive.
- It should have high thermal conductivity
- It should be easy to handle
- It should have low specific volume of vapour.
- It should have high co efficient of performance

Vapour Compression Refrigeration System:

Construction:

This system consists of a compressor, condenser, a receiver tank, an expansion valve and an evaporator.

Compressor : Reciprocating compressors generally used. For very big plants centrifugal compressors directly coupled with high speed rotating engines (gas turbine) are used.

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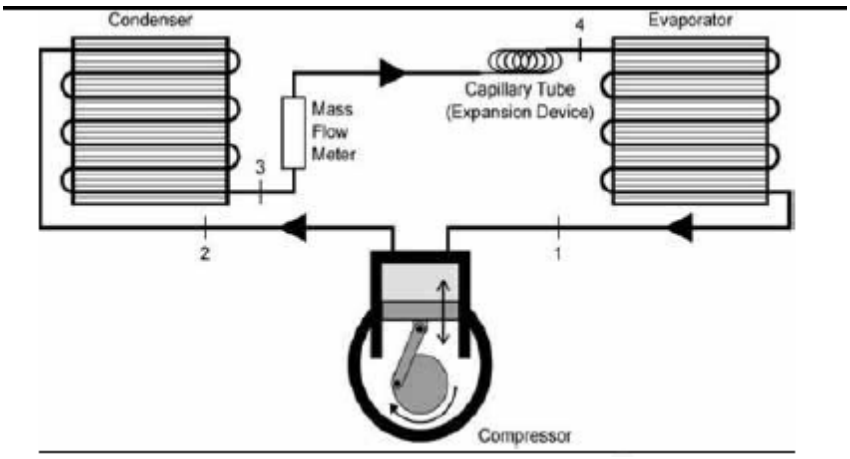
Condenser : It is a coil of tubes made of copper.

Receiver tank: It is the reservoir of liquid refrigerant.

Expansion Valve: This is a throttle valve. High pressure refrigerant is made to flow at a controlled rate through this valve.

Evaporator : It is the actual cooler and kept in the space to be cooled. The evaporator is a coil of tubes made of coppe



Vapour Absorption Refrigeration system:

Construction:

The vapour absorption system consists of a condenser, an expansion valve and an evaporator.

They perform the same as they do in vapour compression method.

In addition to these, this system has an absorber, a heat exchanger, an analyser and a rectifier.

Working:

Dry ammonia vapour at low pressure passes in to the absorber from the evaporator. In the absorber the dry ammonia vapour is dissolved in cold water and strong solution of ammonia is formed. Heat evolved during the absorption of ammonia is removed by circulating cold water through the coils kept in the absorber. The highly concentrated ammonia (known as Aqua Ammonia) is then pumped by a pump to generator through a heat exchanger. In the heat exchanger the strong ammonia solution is heated by the hot weak solution returning from the generator to the absorber. In the generator the warm solution is further heated by steam coils, gas or electricity and the ammonia vapour is driven out of solution. The boiling point of ammonia is less than that of water. Hence the vapours leaving the generator are mainly of ammonia. The weak ammonia solution is left in the generator is called weak aqua. This weak solution is returned to the absorber through the heat exchanger.

Ammonia vapours leaving the generator may contain some water vapour. If this water vapour is allowed to the condenser and expansion valve, it may freeze resulting in chocked flow. Analyser and rectifiers are incorporated in the system before condenser. The ammonia vapour from the generator passes through a series of trays in the analyser and ammonia is separated from water vapour. The separated water vapour returned to generator. Then the ammonia vapour passes through a rectifier. The rectifier resembles a condenser and water vapour still present in ammonia vapour condenses and the condensate is returned to analyser. The virtually pure ammonia vapour then passes through the condenser. The latent heat of ammonia vapour is rejected to the cooling water circulated through the condenser and the ammonia vapour is condensed to liquid ammonia.

The high pressure liquid ammonia is throttled by an expansion valve or throttle valve. This reduces the high temperature of the liquid ammonia to a low value and liquid ammonia partly evaporates. Then this is led to the evaporator. In the evaporator the liquid fully vaporizes. The latent heat of evaporation is obtained from the brine or other body which is being cooled. The low pressure ammonia vapour leaving the evaporator again enters the absorber and the cycle is completed. This cycle is repeated again to provide the refrigerating effect.

Applications of refrigeration system:

- Preservation of food items like vegetables, milk and eggs.
- Preservation of medicines.
- Preservation of blood, tissues, etc.,
- Preservation and cooling of cool drinks.
- Preservation of chemicals (Chemical industries)
- Cooling of water.
- Industrial and comfort airconditioning.
- Processing of dairy products.

SL.NO	PRINCIPLE	VAPOR COMPRESSION SYSTEM	VARS
1	WORKING	Refrigerant vapor is compressed	Refrigerant vapor is absorbed & heated
2	TYPE OF ENERGY SUPLIED	Works on mechanical energy	Works on heat energy
3	COP	Higher	Lower
4	CAPACITY	can produce upto 1000 TOR	Can produce more than 1000 TOR
5	NOISE	More due to presence of compressor	Quiet in operation as there is no compressor
6	LEAKAGE	Due to high pressures, the chance of leakage of refrigerant is more	There is no leakage of the refrigerant
7	MAINTENANCE	High	Less
8	OPERATING COST	High, since electrical energy is used	Less because the thermal energy can be supplied from various sources

AIR CONDITIONING:
Air Conditioning is the process of conditioning the air according to the human comfort, irrespective of external conditions.

Applications of Air Conditioning

- Used in offices, hotels, buses, cars.,etc
- Used in industries having tool room machines.
- Used in textile industries to control moisture.
- Used in printing press.
- Used in Food industries, Chemical plants.

CLASSIFICATION OF AIR CONDITIONING:
Air conditioning systems are classified as

1) **According to the purpose**
    a) Comfort Air conditioning.
    b) Industrial Air conditioning.
2**) According to Season of the year**
    a) Summer Air conditioning.
    b) Winter Air conditioning.
    c) Year round Air conditioning.

Types of Air conditioners

a) Room Air conditioners
b) Winter Air conditioners
c) Central Air conditioners

Functions of Air conditioners

a) Cleaning air.
b) Controlling the temp of air.
c) Controlling the moisture content.
d) Circulating the air.

Terminology:
1) Dry air: The atmospheric air which no water vapour is called dry air.
2) Psychometry: Psychometry is the study of the properties of atmospheric air.
3) Temperature: The degree of hotness (or) Coldness is called the temperature.
4) Moisture: Moisture is the water vapour present in the air.
5) Relative humidity: Relative humidity is the ratio of actual mass of water vapour in a given volume to the mass of water vapour.
6) Dry bulb temperature: The temperature of air measured by the ordinary thermometer is called dry bulb temperature:
7) Wet bulb Temperature: The temperature of air measured by the thermometer when it is covered by the wet cloth is known as wet bulb Temperature.
8) Dew point Temperature: The temperature at which the water vapour starts condensing is called dew point Temperature

1) **Window Type Air Conditioner:**

Construction:

This is also called room air conditioner. A cooling system to cool and dehumidify the air involves a condenser, a compressor and a refrigerant coil. A filter to any impurities in the air. The filter is made of mesh,

glass wool or fibre. A fan and adjustable grills to circulate the air. Controls to regulate the equipment operation. The low pressure refrigerant vapour is drawn from the evaporator to the hermetic compressor through suction pipe. It is compressed from low pressure to the high pressure and supplied to the condenser. It is condensed in the condenser by passing the outdoor air over the condenser coil by a fan. The liquid refrigerant is passed through the capillary into the evaporator. In the evaporator the liquid refrigerant picks up the heat from the refrigerator surface and gets vaporized. A motor driven fan draws air from the room through the air filter and this air is cooled by losing its heat to the low temperature refrigerant and cold air is circulated back into the room. The vapour refrigerant from the evaporator goes to the compressor from evaporator and the cycle is repeated. Thus the room is air conditioned.

The quantity of air circulated can be controlled by the dampers. The moisture in the air passing over the evaporator coil is dehumidified and drips into the trays. This water evaporator to certain extent and thus helps in cooling the compressor and condenser. The unit automatically stops when the required temperature is reached in the room. This is accomplished by the thermostat and control panel.

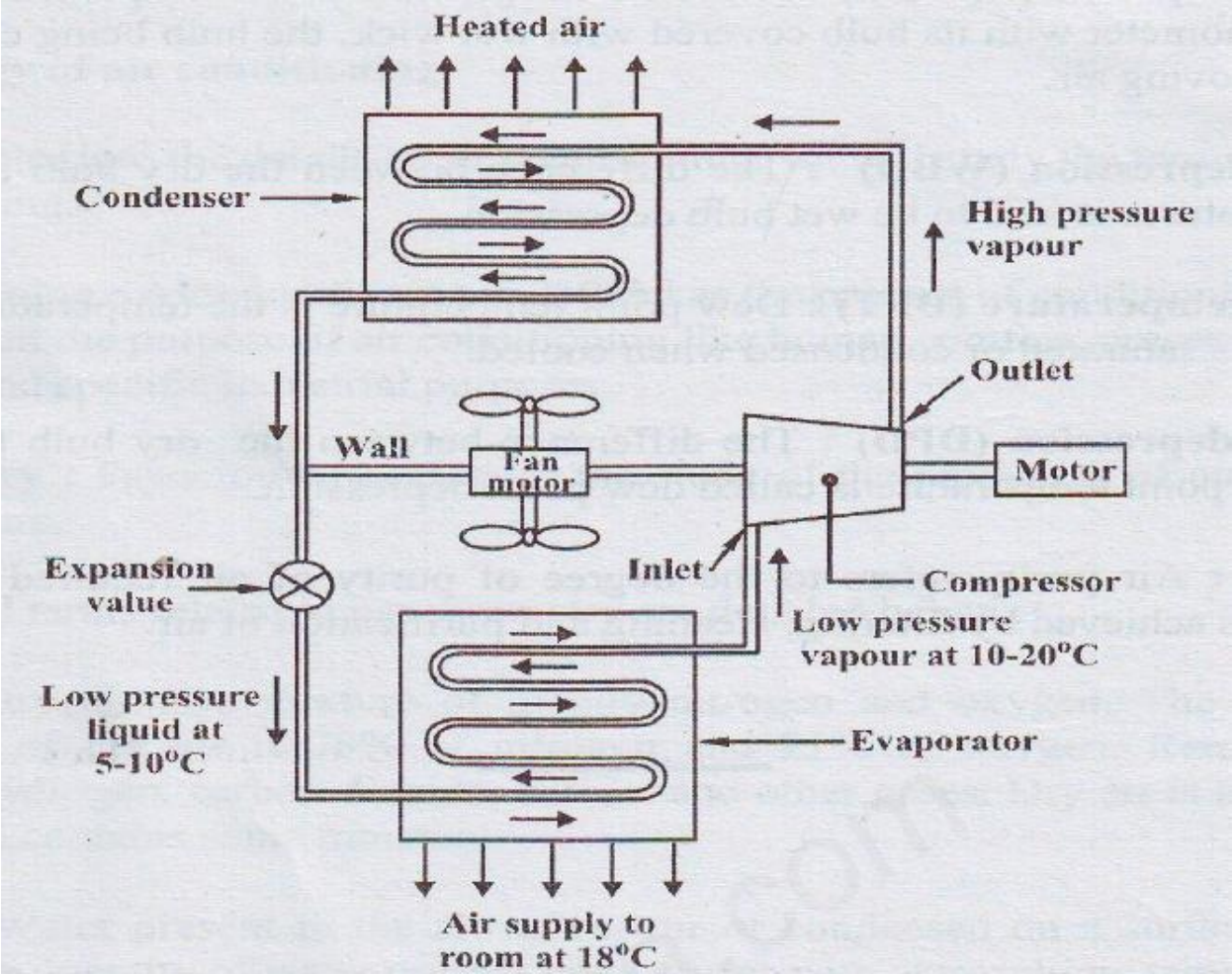
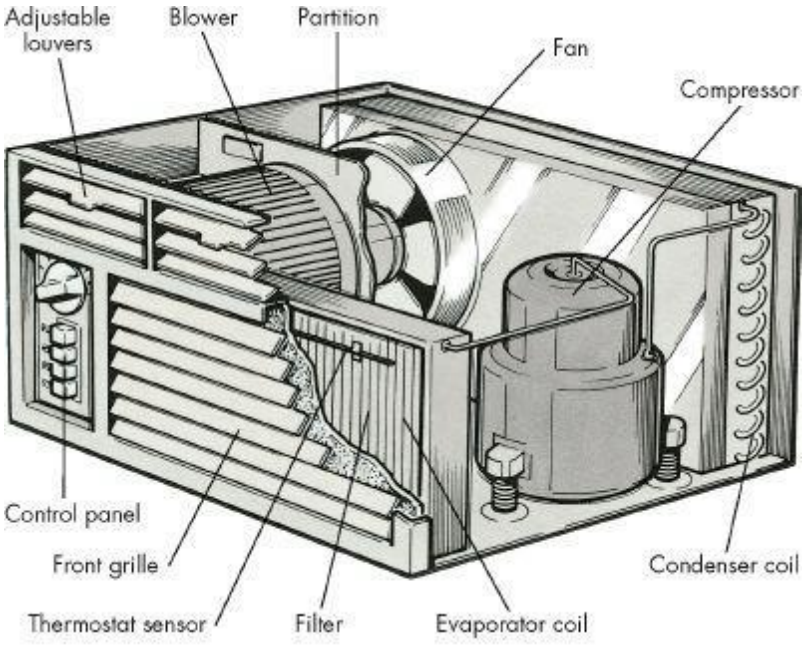


Fig.1 Window room air conditioner



Merits and Demerits of Window type air conditioner:

Merits :

- A separate temperature control is provided in each room.
- Ducts are not required for distribution.
- Cost is less.
- Skilled technician is required for installation.

Demerits:

- It makes noise.
- Large hole is made in the external wall or a large opening to be created in the window panel. This leads to insecurity to inmates**.**

Split Type Air Conditioner –

Layout:

In split air type air conditioner noise making components like compressor and condenser are mounted outside or away from room. Split type air conditioning system has two main components.
(i) Outdoor Unit (ii) Indoor unit.
The outdoor unit consists of compressor and condenser. The indoor unit consists of power cables, refrigerant tube and an evaporator mounted inside the room.

Working:

Compressor is used to compress the refrigerant. The refrigerant moves between the evaporator and condenser through the circuit of tubing and fins in the coils. The evaporator and condenser are usually made of coil of copper tubes and surrounded by aluminium fins. The liquid refrigerant coming from the condenser evaporates in the indoor evaporator coil. During this process the heat is removed from the indoor unit air and thus, the room is cooled. Air return grid takes in the indoor air. Water is dehumidified out of air is drained through the drain pipe. The hot refrigerant vapour is passed to the compressor and then to the condenser where it becomes liquid. Thus the cycle is repeated. A thermostat is used to keep the room at a constant, comfortable temperature avoiding the frequent turning on off.

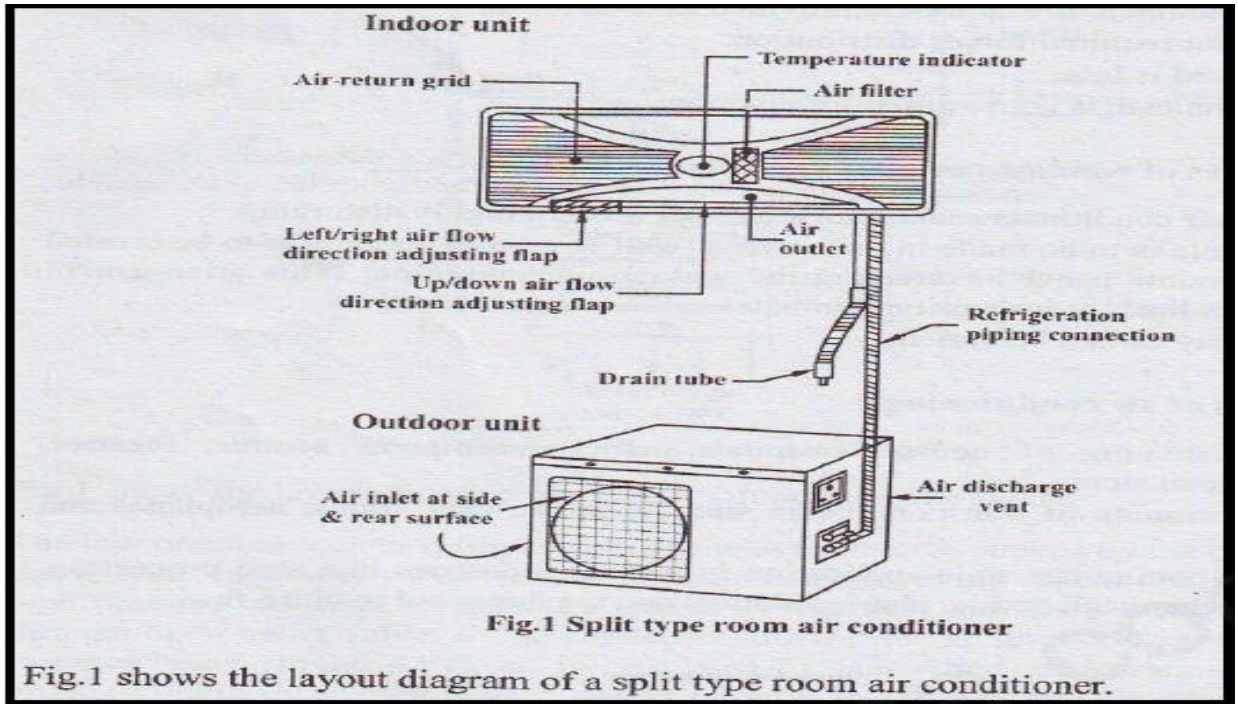


Fig.1 Split type room air conditioner

Fig.1 shows the layout diagram of a split type room air conditioner.

Merits and Demerits of Split type air conditioner:

Merits :

- It is compact
- Upto four indoor AHU's may be connected to one outdoor unit.
- It is energy and money saving.
- Duct is not used.
- Easier to install.
- It is noiseless, because rotary air compressor used is, kept outside.
- It is more efficient and powerful.
- It has the flexibility for zoning.

DeMerits :

- Initial cost is higher than window air conditioner
- Skilled technician is required for installation.
- Each zone or room requires thermostat to control the air cooling.

Applications of air conditioning:

- Used in houses, hospitals, offices, computer centres, theatres, departmental stores etc.,
- Air-conditioning of transport media such as buses, cars trains, aeroplanes and ships.
- Wide application in food processing, printing, chemical, pharmaceutical and machine tool, etc