REFRIGERATION AND CONDITIONING

Refrigeration: Refrigeration is defined as a method of reducing the temperature of a system below that of the surroundings and maintains it at the lower temperature by continuously abstracting the heat from it.

Refrigerant: in a refrigerator, a medium called refrigerant continuously extracts the heat from the space within the refrigerator which is to be kept cool at temperatures less than the atmosphere and finally rejects to it. Some of the fluids like, ammonia, Freon, Methyl chloride, carbon dioxide are the commonly used refrigerants.

Refrigerants:

Refrigerants	**Uses**	**Boiling Temperature in ^{O}C**	**Properties**
Ammonia (NH3)	Vapour absorption refrigeration system	-33.3	Toxic, inflammable, irritating & corrosive
CO2	Marine/ships refrigeration system	-77.6	Non Toxic, Nonflammable, Low specific volume
SO2	Old (domestic refrigeration system)Vapour compression refrigeration system	-10	Colorless, suffocating, irritating odour
Freon-12 (Fe-12)	Domestic refrigeration system, water coolers, air conditioning systems(Vapour compression refrigeration system)	-29.8	Nonflammable, Non explosive, odourless
Freon-22 (Fe-22)	Domestic refrigeration system, water coolers, air conditioning systems(Vapour compression refrigeration system)	-29.8	Nonflammable, Non explosive, odourless

Properties of good Refrigerants:

1. Thermodynamic Properties

a. A good refrigerant must have a low boiling temperature at atmospheric pressure.

b. A good refrigerant must have a very low freezing point because the refrigerant should not freeze at low temperatures.

c. In order to avoid the leakage of the atmospheric air and also to enable the detection of the leakage of the refrigerant, both the evaporator and condenser pressures should be slightly above the atmospheric pressure.

d. The latent heat of evaporation must be very high so that a minimum amount of refrigerant will accomplish the desired result in other words, it other words, it increases the refrigeration effect.

e. The specific volume of the refrigerant must be very low. The lower specific volume of the refrigerant at the suction of the compressor reduces the size of the compressor. Physical properties

A good refrigerant must have low specific heat when it is in liquid state and high specific heat when it is vaporized.

a. The viscosity of a refrigerant at both the liquid and vapour states must be very low as it improves the heat transfer and reduces the pumping pressure.

b. A good refrigerant should be non-toxic,

c. A good refrigerant should be non-corrosive to prevent the corrosion of the metallic parts of the refrigerators.

d. Chemical stability an ideal refrigerant must not decompose under operating conditions.

e. The coefficient of performance of a refrigerant must be high so that the energy spent in refrigeration will be less.

f. A good refrigerant must be odourless, otherwise some foodstuff such as meat, butter, etc. lose their taste.

g. A good refrigerant should have any leakage can be detected by simple test.

h. A good refrigerant must not react with the lubricating oil used in lubricating the parts of the compressor.

Principle of refrigeration:

In refrigeration, the heat is to be removed continuously from a system at a lower temperature and transfer it to the surroundings at a higher temperature. This operation according to the second law of thermodynamics can only be performed by the aid of the external work. Therefore in a refrigerator, power is to be supplied to remove the heat continuously from the refrigerator cabinet to keep it cool at a temperature less than the atmosphere.

Refrigeration effect: in a refrigeration system, the rate at which the heat is absorbed in a cycle from the interior space to be cooled is called refrigerating effect.

Ton of refrigeration or Ice making capacity: a ton of refrigeration is defined as the quantity of heat absorbed in order to form one ton of ice in 24 hours when the initial temperature of the water is $0^{o}C$.

1 TON of refrigeration = 210 KJ/min = 3.5 KW

Coefficient of performance (COP): The COP of a refrigeration system is defined as the ratio of heat absorbed in a system to the work supplied.

If Q= Heat absorbed or removed, KW

W= work supplied, KW

$$COP = Q/W$$

Refrigeration concepts:

1. Heat flows from a system at higher temperature to another at lower temperature.
2. Fluids by absorbing the heat change from liquid phase to vapour phase and subsequently condense by giving off the heat.
3. Heat can flow from a system at low temperature to a system at higher temperature by the aid of external work as per the second law of thermodynamics.

Components of Refrigerator:

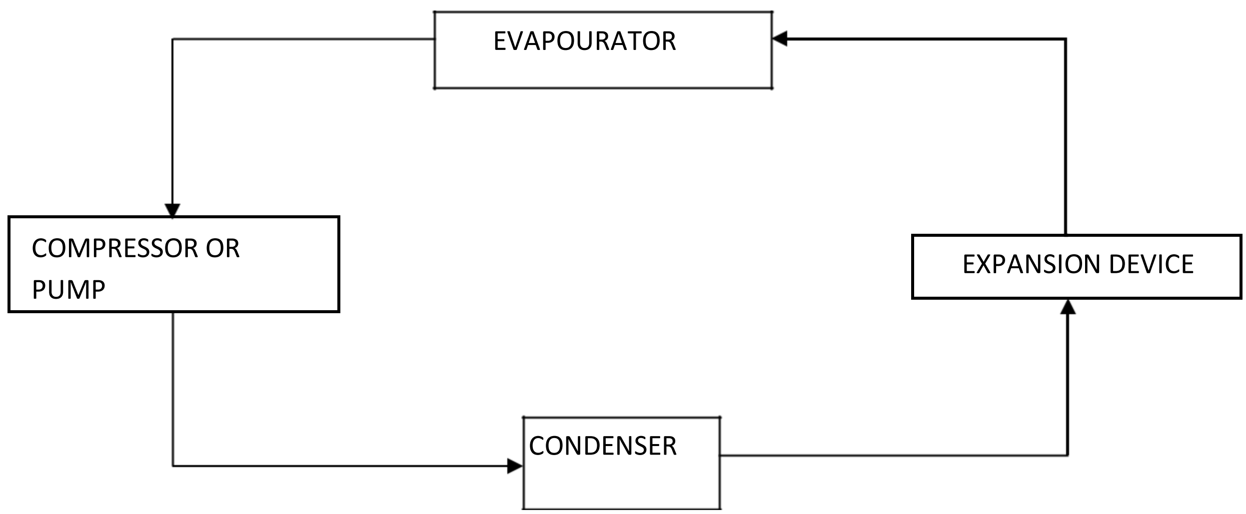


Figure 4.1 Components of Refrigerator

1) **Evaporator:** The evaporator is the heart of the refrigerator where the liquid refrigerant is evaporated by the absorption of heat from the refrigerator cabinet in which the substances which have to be cooled are kept.
2) **Circulating system:** Circulating devices such as compressor or pumps necessary to circulate the refrigerant to undergo the refrigeration cycle.

3) **Condenser:** In a condenser the refrigerant vapour gives off its latent heat to the air and Consequently condenses into liquid so that it can be recirculated in the refrigeration cycle.

4) **Expansion device** device to reduce the pressure of liquid refrigerant before passes to the evaporator

Vapour Compression Refrigerator:

The refrigerant at low pressure and low temperature, passing in the evaporator coils, absorbs the heat from the contents in the freezing compartment and evaporates.

The evaporated refrigerant at low pressure from the evaporator is drawn by a compressor. Which compresses it to, high pressure so that the saturation temperature of the refrigerant, corresponding to the increased pressure is higher than the temperature of the cooling medium in the condenser.

The high pressure-high-temperature refrigerant vapour from the compressor flows to the condenser where it gives off its latent heat to the atmospheric air.

As a result of the loss of latent heat in the condenser, the refrigerant condenses.

The high pressure condensed liquid refrigerant approximately at room temperature now flows to the throttle valve in which it expands to low pressure and then passes to the evaporator coils for recirculation once again.

Hence the refrigerant coming out of the expansion valve will be a very wet vapour and at a very low temperature which will be around -10degree. He required low temperature is maintained in the refrigerator by a thermostat switch which switches on and off the compressor motor by a relay as and when the temperature either falls below or rises above the required temperature. The refrigerant is Freon-12

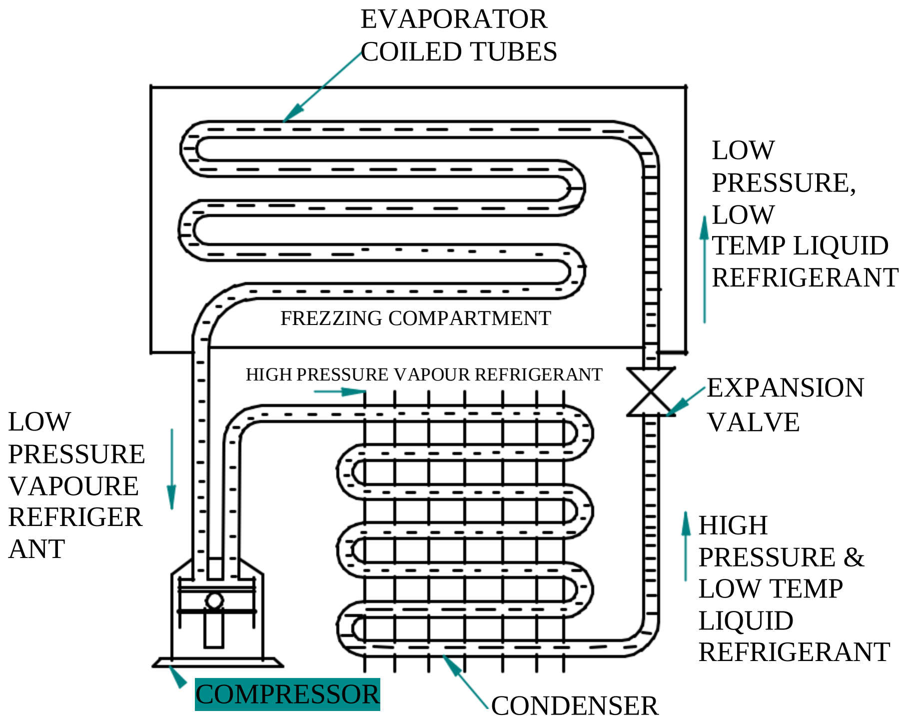


Figure 4.2 Vapour compression Refrigeration

Vapour Absorption Refrigerator:

- The liquid ammonia vapouries in the evaporator coils,
- Absorbing the latent heat from the freezing compartment thus keeping it cool and subsequently gives off heat when it condenses in a condenser.
- Dry ammonia vapour is dissolved in the cold water contained in the absorber, which will produce a strong ammonia solution which is flowing back from the heater-separator from the heat exchanger.
- The worm high pressure strong ammonia solution is passed to the heater-cum-separator provided with the heating coils.

Heating of the high pressure strong ammonia solution will drive out the ammonia vapour from it and consequently the solution in the heater-separator becomes weak which in turn flows back to the heat exchanger. Where it worms up the strong ammonia solution passing through it.

The high pressure ammonia vapour from the heater-separator now passes to a condensed.

The high pressure ammonia liquid is now expanded to a low pressure and low temperature in the throttle valve.

The low pressure condensed ammonia liquid at low temperature is passed onto the evaporator coils provided in the freezing compartment, where it absorbs the heat and evaporates.

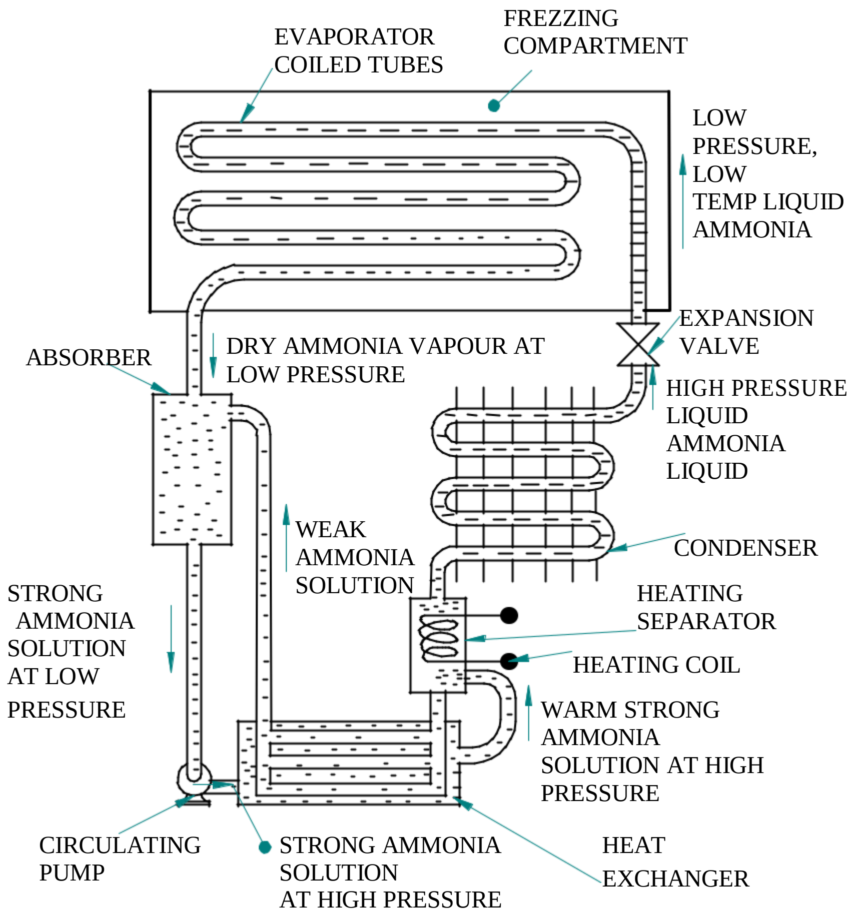
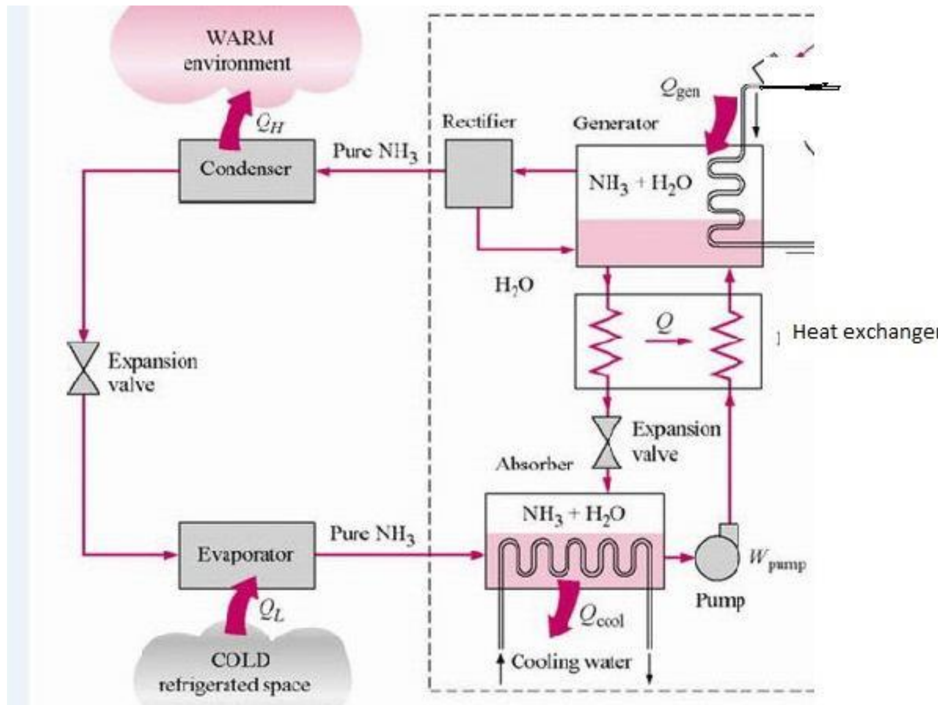


Figure 4.3 Vapour Absorption Refrigeration


WARM environment
Q_H
Condenser
Pure NH_3
Rectifier
Generator
Q_{gen}
$NH_3 + H_2O$
H_2O
Q
Heat exchanger
Expansion valve
Expansion valve
Absorber
$NH_3 + H_2O$
Evaporator
Pure NH_3
W_{pump}
Pump
Q_L
Q_{cool}
Cooling water
COLD refrigerated space

Comparison between Vapour Compression and Absorption system:

SL.NO	PRINCIPLE	VAPOR COMPRESSION SYSTEM	VAPOR ABSORPTION SYSTEM
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

Providing a cool constant indoor atmosphere at all times regardless of weather conditions

needed either for human comfort or industrial purposes by artificially cooling, humidifying or dehumidifying, cleaning and recirculating the surrounding air is called air conditioning.

Room Conditioner:

The high pressure, low-temperature liquid refrigerant from the condenser is passed to the evaporator coils through the capillary tube where it undergoes expansion.

The evaporator fan continuously draws the air from the interior space within the room through air filler by forcing it to pass over the evaporator coils.

The air from the interior passing over the evaporator coils is cooled by the refrigerant which consequently evaporates by absorbing the heat from the air.

The higher temperature evaporated refrigerant from the evaporator is drawn by the suction of the compressor which compresses it and delivers it to the condenser.

The high pressure, high temperature refrigerant vapour now flows through the condenser coils.

The condenser fan draws the atmospheric air from the exposed side portions of the air conditioner which is projecting outside the building into the space behind it and discharges to pass through the centre suction of the condenser unit over the condenser coils.

The high pressure, high temperature refrigerant passing inside the condenser coils condensers by giving off the heat to the atmospheric air.

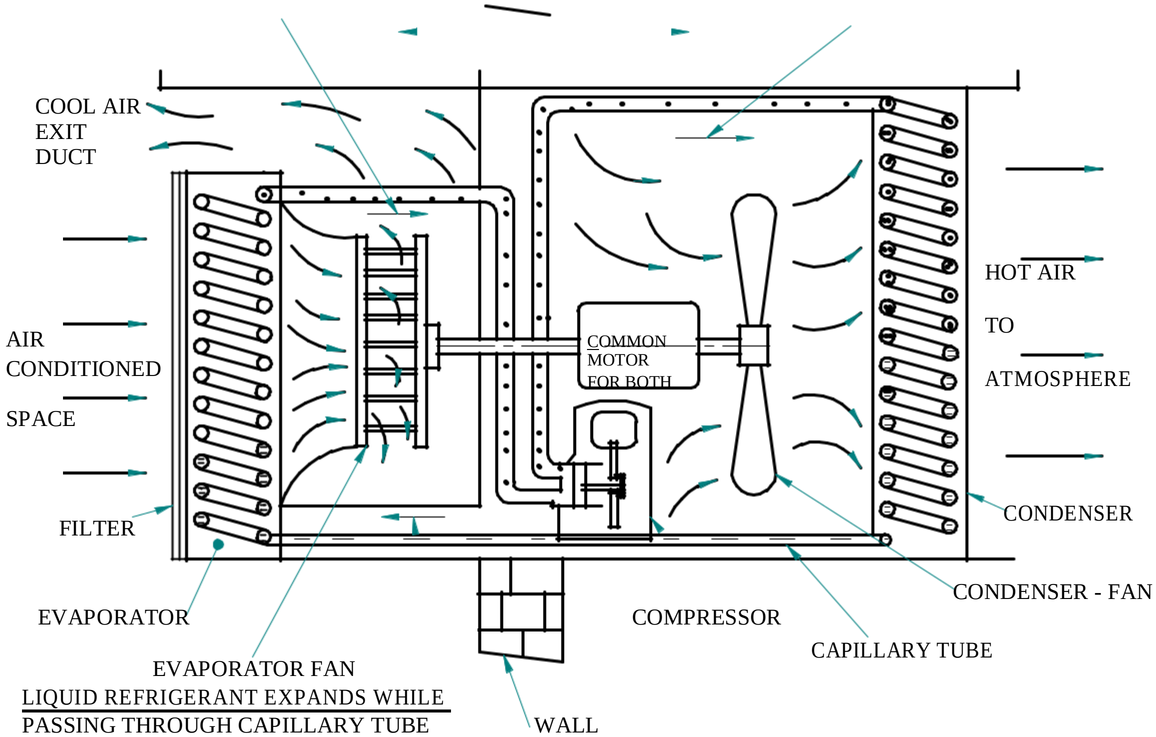


Figure 4.4 Room Air conditioner

Applications of Air-conditioning:

- Aviation industry
- Transportation
- Office applications
- Medical applications
- Agriculture industry