ABES ENGINEERING COLLEGE, GHAZIABAD

Subject: Fundamentals of Mechanical Engineering (BME101)

Unit 3
Topic: Introduction to Refrigeration and Air-Conditioning
Lecture Notes

INDEX

1. Refrigeration

Introduction to Refrigeration

"Science of providing and maintaining temperatures below that of surroundings"

Refrigeration is defined as the process of extracting heat from a lower temperature heat source, substance, or cooling medium and transferring it to a higher temperature heat sink. A refrigeration system is a combination of components and equipment connected in a sequential order to produce the refrigeration effect.

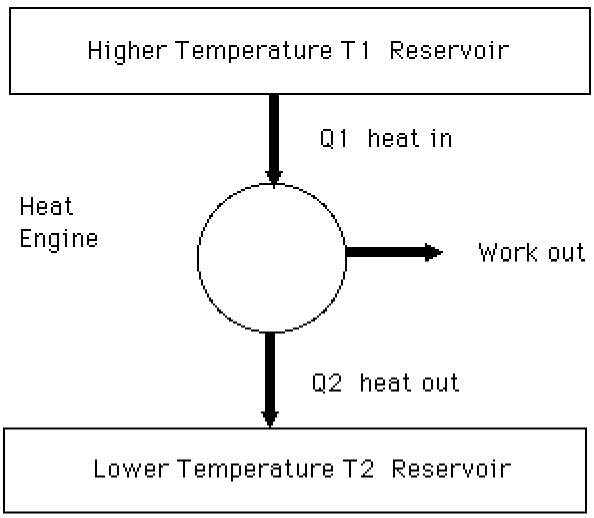
Refrigeration may also be defined as the process of achieving and maintaining a temperature below that of the surroundings, the aim being to cool some product or space to the required temperature

Refrigeration Effect:

Refrigeration defines the amount of cooling produced by a system. This cooling is obtained at the expense of some form of energy. Refrigeration effect means that cooling action should be done at the rate of heat absorption from any place in a cycle. Refrigeration means cooling a space, substance or system to lower and maintain its temperature below the ambient temperature (Atmospheric temperature), while the removed heat is rejected at a higher temperature. A refrigeration machine can be called efficient only of it can create maximum refrigerating effect for the work allotted to it

2. Heat Engine, Heat Pump and Refrigerator

a. **Heat Engine:** A heat engine is a thermodynamic device used for continuous production of work from heat when operating in a cycle.



Thermal efficiency (η_{th}) = net work output/total heat supplied = W/Q1 = (Q1-Q2) / Q1 = 1-(Q2/Q1)

b. Heat Pump & Refrigerator:

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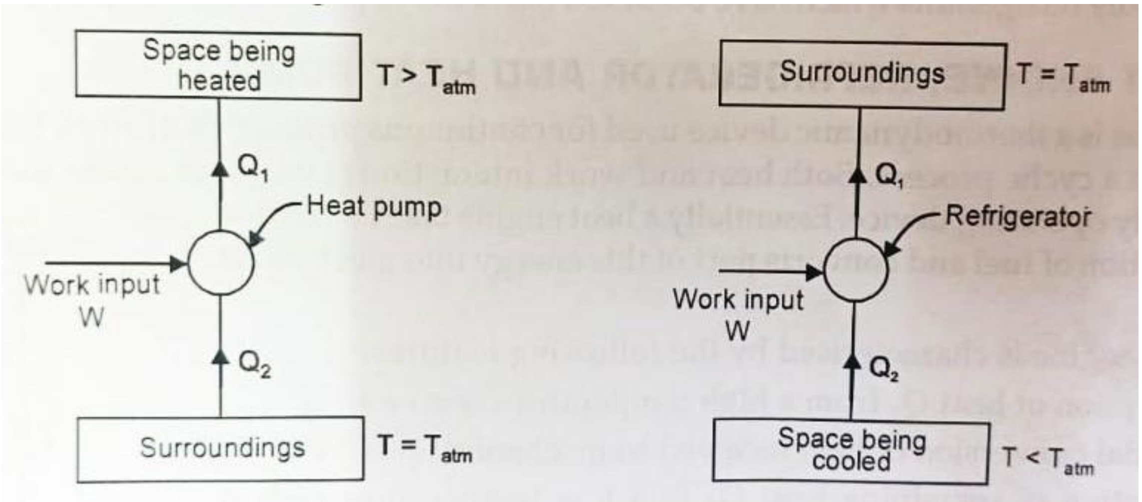


Fig. 4.2. Functional difference between a heat pump and a refrigerator

$(COP)_{HP}$ = Q1/W or Q1/Q1-Q2

$(COP)_{ref}$ = Q2/W or Q2/Q1-Q2

$(COP)_{HP} = (COP)_{ref} + 1$

3. Rating or Capacity of Refrigeration

Ton of Refrigeration - The standard unit of refrigeration is ton of refrigeration or simply ton denoted by **TR**.

Definition I: 1 tonne of refrigeration (1 TR) is defined as the amount of heat, which is to be extracted from one tonne of water at 0°C in order to convert into ice at 0°C in 24 hours (1 day).

Since amount of water is 1 tonne (1000 kg) and latent heat of ice (also the heat of fusion) is taken 335 kJ/kg, therefore one tone of refrigeration,

1 TR = (1000x335)/ 24 = 13958.33 kJ/min

1 TR = (1000x335)/ 24x60 = 232.63 kJ/min

1 TR = (1000x335)/ 24x60x60 = 3.87 kJ/sec

Definition II: 1 tonne of refrigeration is the refrigeration effect produce to freeze the 1 short ton (2000 pounds) of water at 0°C in 24 hours.

Since amount of water is 1 short tonne i.e., 2000 pounds (2000 pounds = 2000/2.204 = 907.44 Kg) and latent heat of ice (also the heat of fusion) is taken as 333.43 kJ/kg, therefore one tone of refrigeration,

1 TR = (907x333.43)/ 24 = 12600.87 kJ/min

1 TR = (907x333.43)/ 24x60 = 210.01 kJ/min

1 TR = (907x333.43)/ 24x60x60 =3.5 kJ/sec

(Note: Above values are taken in standard practice)

4. Coefficient of performance

Refrigerator: Refrigerator is a thermodynamic system operates between the temperature of surrounding and a temperature below that of the surrounding. It is used to maintain the temperature of body below the atmospheric temperature. A refrigerator is reversed heat engines. The direction of heat and work interactions is opposite to that of heat engine. A refrigerator is used to remove heat from a body at low temperature and then transfer this heat to another body athigh temperature. A refrigerator is shown in Fig. 2.1.

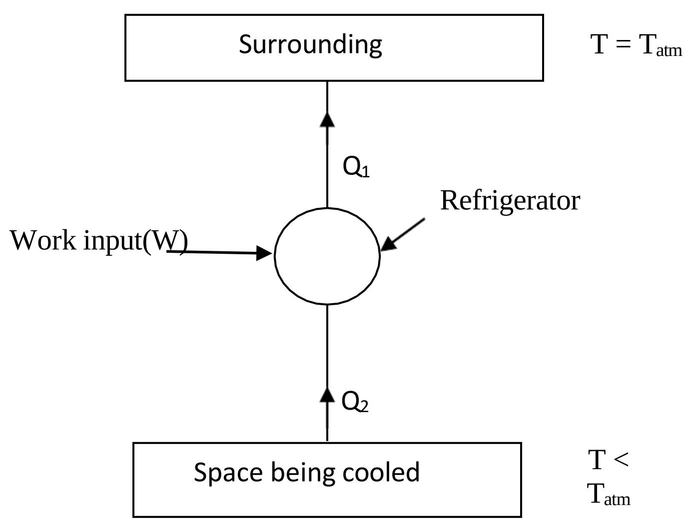


Fig 2.1 Engine Interactions in Refrigerator

Performance of refrigerator is expressed in the terms of Coefficient of performance (COP). Coefficient of performance of refrigerator is defined as the ratio of desired effect (heat extracted at low temperature) to work input. Expression of coefficient of performance of refrigerator can be written as

$$(COP)_{ref} = Q2/Q1\text{-}Q2$$

5. Methods of refrigeration

There are number of methods by which the refrigeration can be achieved.

1. **Evaporation (Adiabatic Cooling)** – when liquid evaporates, it absorbs heat from the surroundings equivalent to its latent heat of vaporization and that results in lowering the temperature of the

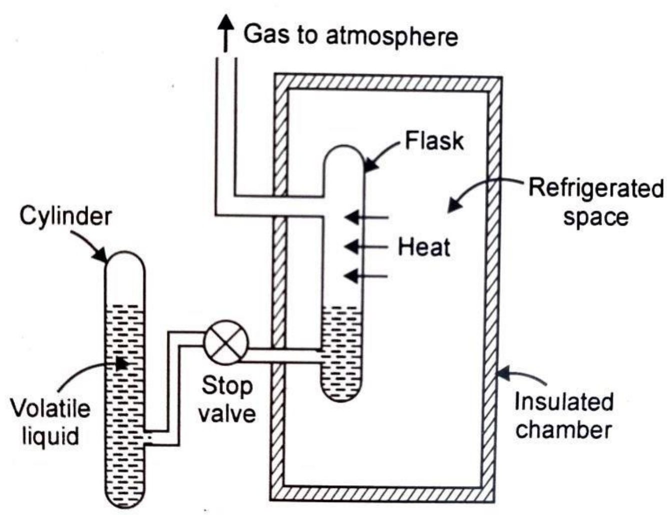


Fig. 4.3. Liquid gas refrigeration

surroundings. For example, when a volatile liquid (liquid N2 or CO2) contained in the flask evaporates and gets converted into gas. For evaporation, it absorbs heat from the chamber and cooling effect is produced (as shown in fig below)

2. **Dissolution of salt in water –** When certain salts are dissolved in water, they absorb the heat and lower the temperature of water and create a sort of refrigeration bath for cooling substance.

Salts Used –

i. NaCl (Lowers water Temp up to -20°C)

ii. CaCl2 (Lowers water Temp up to -50°C)

Limitations –

i. Small refrigeration effect
ii. Salt recovery is cumbersome

3. **Ice Refrigeration (Change of phase) –** The natural or artificially produced ice is brought into contact with the substance to be cooled. The ice melts by extracting the heat from the substance. It was generally used for food preservation. The cooling effect produced by the ice is-

$$\mathbf{Q = m \times h_{sf}}$$

m = rate of fusion

h_{sf} = enthalpy of fusion (335 kJ/kg at 1 atm or 1.01325 bar)

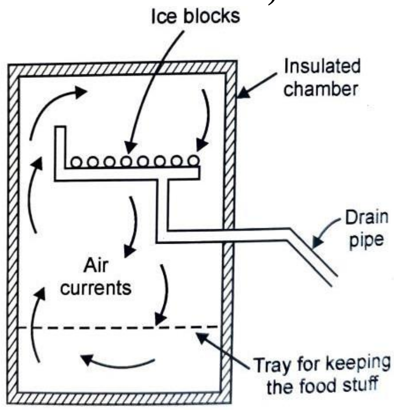


Fig. 4.4. Ice refrigeration

4. **Dry ice refrigeration –** Solid CO2 (Dry Ice) has a peculiar characteristic, that it changes from solid state to vapor state without passing through liquid state. During change of phase, it absorbs heat equivalent to its latent heat of vaporization and produces cooling effect. The process occurs when the solid is maintained below triple point. It was generally used for food preservation during transportation.

$$\mathbf{Q = m \times h_{sv}}$$

m = rate of fusion

h_{sf} = enthalpy of evaporation (573 kJ/kg at 1 atm or 1.01325 bar),

Equivalent refrigeration effect (573 Kj/kg) can maintain the of temperature = -78.5°C

5. **Chemical Method –** In this method the heat required for the chemical reaction is extracted from the substance to be cooled. It cannot be used for commercial purposes as the refrigeration effect is small.

6. **Air of Gas Refrigeration –** In this method the gas after expansion is used to produce the refrigeration effect. Expansion process lowers the pressure and temperature of gas. Expanded gas

extracted the heat from the substance and produce cooling effect.

7. **Throttling Process (Irreversible Adiabatic Expansion of Gases or Joule-Thomson Effect) -** Throttling is an irreversible process in which a fluid, flowing across a restriction, undergoes a drop in total pres-sure. Such a process occurs in the flow through a porous plug, a partially closed valve, or a small orifice. Joule and Thomson performed the basic throttling experiments in the period 1852-62, and their experiments clarified the process and led to use of throttling as a method for determining certain properties of gaseous substances.
A steady stream of gas flows through a porous plug contained in a horizontal tube. This system is open, is thermally insulated (Q = 0) and does not exchange work with its environment (W=0). At sections i and e both the temperature and the pressure are measured.

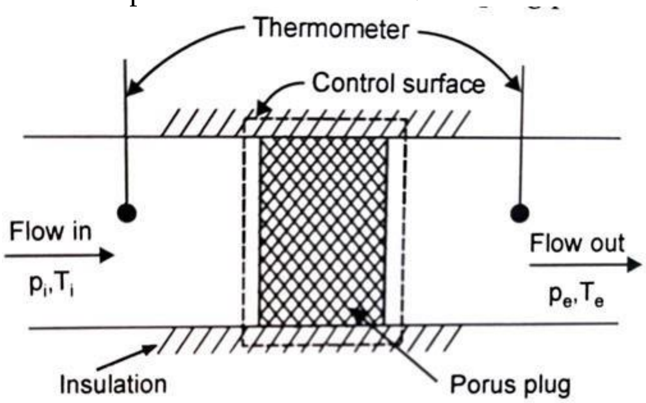


Fig. 4.5. Schematic of porous plug apparatus

The steady flow energy equation is for fluid

$$h_1+V_1^2/2+gz_1+q = h_2+V_2^2/2+gz_2+w_s$$

If the kinetic energy does not change significantly as the fluid passes through the porous plug, the steady, flow energy equation reduces to-

$$h1 = h2$$

Thus, the throttling expansion process is isenthalpic process. Hence, in an adiabatic throttling process the enthalpy remains constant. When a series of Joule-Thomson experiments is performed at the same initial temperature ti and pressure pi but with different downstream pressure, it is found that the temperature te changes.

8. **Mechanical Refrigeration -**In this method the mechanical device (refrigerator) extracted the heat from the substance or space (which is to be cooled) and pumped it to a surrounding (which is at higher temperature) with the help of an external source (work input) as input to the refrigerator machine.

The mechanical refrigeration method has 4 main types –

a. Air or gas refrigeration system
b. Vapour compression refrigeration system
c. Vapor absorption refrigeration system

d. Steam jet refrigeration system

9. **Magnetic Refrigeration -** The working principle of magnetic refrigerators is based on magnetocaloric effect, perceived as a adiabatic temperature change or isothermal entropy change. Let us examine the schematic diagram of the theoretical magnetic refrigeration system in Figure 3 and its vapour compression counterpart. The conventional vapour compression system makes use of a compressor, two heat exchangers – an evaporator and a condenser, a throttling device. The refrigerant picks up heat from the space to be refrigerated in the evaporator where it is converted into vapour state. This vapour then passes through the compressor where its pressure and temperature is increased. Refrigerant then emits its heat in a condenser and is converted into a liquid in the magnetic system.

   Magneto-Caloric Effect the Magneto caloric effect (MCE, from magnet and calorie) is a magneto-thermodynamic phenomenon in which a reversible change in temperature of a suitable material is caused by exposing the material to a changing magnetic field. This is also known as adiabatic demagnetization by low temperature physicists.

10. **Thermoacoustic Refrigeration –** Thermoacoustic refrigeration systems operate by using sound waves and a non-flammable mixture of inert gas (helium, argon, air) or a mixture of gases in a resonator to produce cooling. Thermoacoustic devices are typically characterized as either 'standing-wave' or 'travelling-wave'.

11. **Vortex Tube -** A vortex tube is a mechanical-thermal device that separates a compressed flow of air (or any inert gas) into hot and cold streams and has no mechanical moving parts. A vortex tube creates cold air and hot air by forcing compressed air through a generation chamber, which spins the air at a high rate of speed (1,000,000 rpm) into a vortex. The high-speed air heats up as it spins along the inner walls of the tube toward the control valve.

6. Construction and working of domestic refrigerator

Vapour Compression Refrigeration System (Domestic Refrigerator)

A vapour compression refrigeration system is an improved type of air refrigeration system in which a suitable working substance, termed as refrigerant, is used.

- It condenses and evaporates at temperatures and pressures close to the atmospheric conditions.
- The refrigerants, usually, used for this purpose are ammonia (NH_3), carbon dioxide (CO_2) and sulphur dioxide (SO_2)
- The vapour compression refrigeration system is now-a-days used for all purpose refrigeration.
- It is generally used for all industrial purposes from a small domestic refrigerator to a big air conditioning plant.

Advantages and Disadvantages of vapour Compression Refrigeration System over Air Refrigeration System

Advantages

1. It has smaller size for the given capacity of refrigeration.
2. It has less running cost.
3. It can be employed over a large range of temperatures.
4. The coefficient of performance is quite high.

Disadvantages

1. The initial cost is high
2. The prevention of leakage of the refrigerant is the major problem in vapour compression system

Mechanism of a Simple Vapour Compression Refrigeration System

It consists of the following five essential parts:

1. **Compressor:** The low pressure and temperature vapour refrigerant from evaporator is drawn into the compressor through the inlet or suction valve A, where it is compresses to a high pressure and temperature. This high pressure and temperature vapour refrigerant is discharge the condenser through the delivery or discharge valve B.
2. **Condenser:** The condenser or cooler consists of coils of pipe in which the high pressure and temperature vapour refrigerant is cooled and condensed. The refrigerant, while passing through the condenser, gives up its latent heat to the surrounding condensing medium which is normally air or water.
3. **Receiver:** The condensed liquid refrigerant from the condenser is stored in a vessel known as receiver from where it is supplied to the evaporator through the expansion valve or refrigerant control valve.
4. **Expansion valve:** It is also called throttle valve or refrigerant control valve. The function of the expansion valve is to allow the liquid refrigerant under high pressure and temperature to pass at a controlled rate after reducing its pressure and temperature. Some of the liquid refrigerant evaporates as it passes through the expansion valve, but the greater portion is vaporised in the evaporator at the low pressure and temperature.
5. **Evaporator**: An evaporator consists of coils of pipe in which the liquid-vapour refrigerant at low pressure and temperature is evaporated and changed into vapour refrigerant at low pressure and temperature. In evaporating, the liquid vapour refrigerant absorbs its latent heat of vaporisation from the medium (air, water or brine) which is to be cooled.

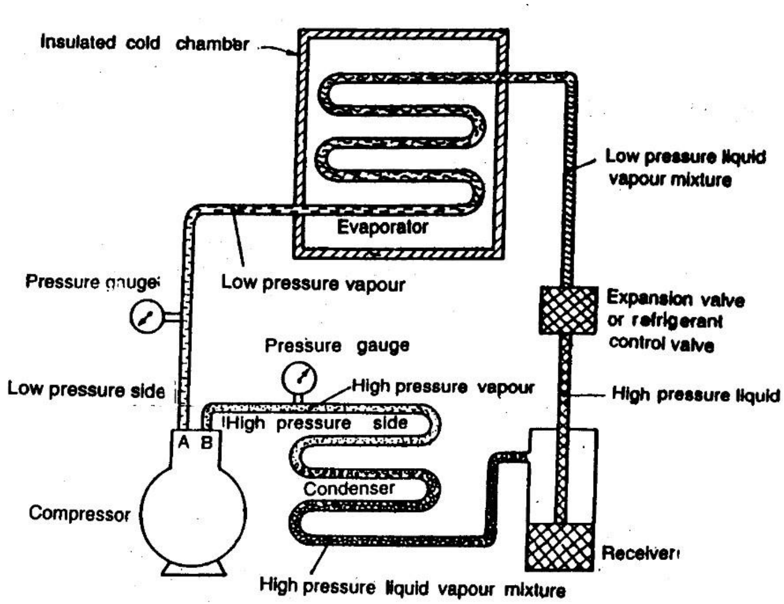
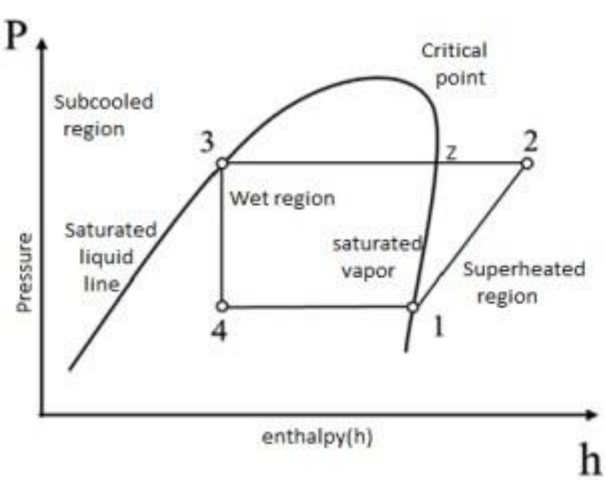


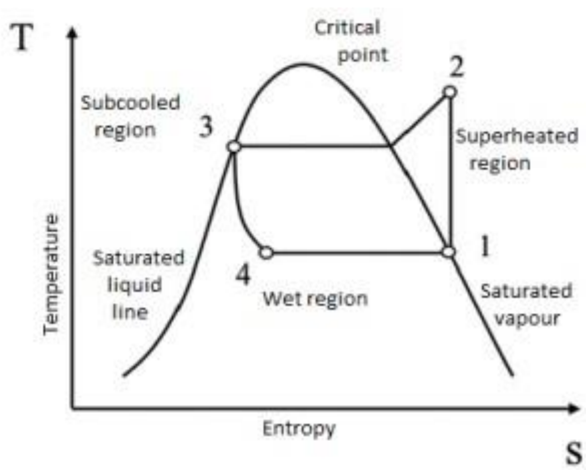
Fig: Simple Vapour Compression Refrigeration System

Types of Vapour Compression Cycles

1. Cycle with dry saturated vapour after compression
2. Cycle with wet vapour after compression
3. Cycle with superheated vapour after compression
4. Cycle with superheated vapour before compression
5. Cycle with undercooling or sub cooling of refrigerant.

<u>Theoretical Vapour Compression Cycle with Dry Saturated Vapour after Compression</u>





1. **<u>Reversible adiabatic compression (1-2)</u>**: The vapour at a low pressure P_1 temperature T_1 and

preferably dry (state 1) is drawn from the evaporator during suction stroke of the compressor. During compression, the vapour is compressed isentropic ally to a higher pressure P_2 and temperature T_2. At compressor exit, the vapour may be wet, dry or superheated. In addition to raising the pressure of vapour, the compressor creates the pressure difference between the evaporator and condenser and that maintains a continuous flow of refrigerant through the system.

The compressor is of rotary type for domestic refrigerators and of reciprocating type for large plants and machines, viz., ice plants and cold storages. For plants with capacity over 50 tons, centrifugal compressors are used and these are directly coupled with high speed gas turbines or electrical controls.

The work done during the isentropic compression per kg of refrigerant is given by

$$\mathbf{w = h2 - h1}$$

where h1 = Enthalpy of vapour refrigerant at temperature T1 , i.e. at suction of compression, and h2 = Enthalpy of the vapour refrigerant at temperature T2, i.e. at discharge of the compressor.

2. **Constant pressure condensation (2-3)**: The vapour refrigerant at high temperature and pressure (state 2) coming from the compressor is delivered to the condenser where its condensation takes place at constant pressure. The condenser first absorbs the heat of superheat and the temperature of the vapour falls to saturation temperature. Subsequently the refrigerant loses its latent heat and is changed into a high-pressure liquid (state 3). For small machines (i.e., domestic refrigerators), the cooling medium is atmosphere and for larger units it may be a stream of water.

3. **Throttling (3-4)**: The expansion of the high-pressure liquid refrigerant is done by the throttling process. During throttling pressure drops but the enthalpy remains constant. Due to drop in pressure, the liquid starts boiling and the required heat is provided by the refrigerant itself. Consequently, the temperature falls and at throttle exit, the refrigerant is a mixture of liquid and vapour (very wet vapour of 10 to 20% quality). Throttling is an irreversible process and has been shown by dotted line on T-S plot. The throttling device may be a capillary tube, a thermostatic expansion valve, an automatic expansion valve and float valve etc.

4. **Constant pressure evaporation (4-1)**: The wet vapour after throttling passes through evaporator coils placed in the medium (usually brine) which is to be cooled. Since the temperature of the vapour is below that of brine, it absorbs latent heat from the brine and gets evaporated at constant pressure. The vaporization continues upto state point 1 and this stage of the refrigerant depends upon the heat absorbed. The refrigerant may remain wet, become dry saturated or get slightly superheated.

$$R_E = h_1 - h_4 = h_1 - h_{f3}$$

h_{f3} = Sensible heat at temperature T_3, enthalpy of liquid refrigerant leaving the condenser

7. **Concept of heat pump Thermal Reservoir:**

A thermal Reservoir is referred to large thermodynamic system in stable equilibrium such that, any finite amount of heat can be transferred from it or to it, without any change in its temperature. It has infinite heat capacity and due to addition or emission of heat, temperature of thermal reservoir does not change. Source and sink are the types of thermal reservoir.

Source: The reservoir which is at high temperature and supplies heat to the system is known as source. Examples: Boiler furnace, Combustion chamber

Sink: The reservoir which is maintain at low temperature and rejected heat from system is absorbed. Examples: Atmospheric air, ocean.

Heat pump:

Heat pump is a thermodynamic system operates between the temperature of surrounding and a temperature above that of the surrounding. It is basically a heat engine run in the reverse direction. It is a device which maintains higher temperature as compared to surrounding by absorbing heat from a cold space and releasing it to a warmer one. It is used to maintain the temperature of body above the atmospheric temperature. Heat pump is reversed heat engines. The direction of heat and work interactions are opposite to that of heat engine. Heat pump is used to keep the rooms warm in winter. A heat pump is shown in Fig below.

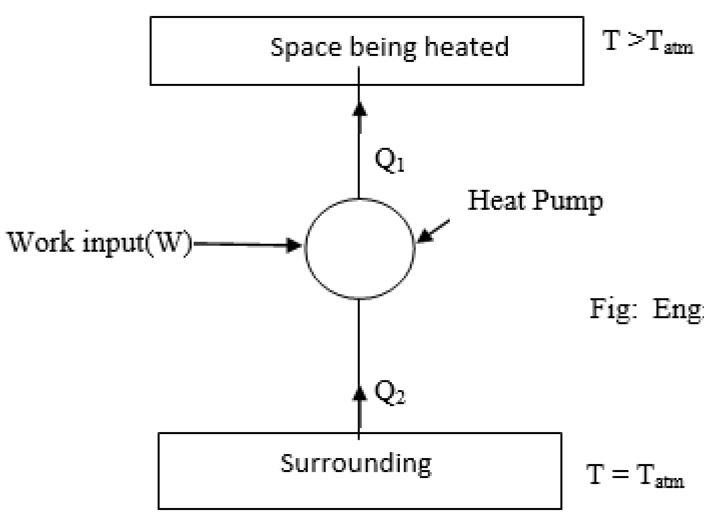


Fig: Engine Interactions in Heat Pump

Performance of heat pump is expressed in the terms of Coefficient of performance (COP). Coefficient of performance of heat pump is defined as the ratio of desired effect (heat supplied to the space being heated) to work input. Expression of coefficient of performance of heat pump can be written as

$$(COP)_{HP} = Q1/W \text{ or } Q1/Q1\text{-}Q2$$
$$(COP)_{ref} = Q2/W \text{ or } Q2/Q1\text{-}Q2$$

$$(COP)_{HP} = (COP)_{ref} + 1$$

8. Air-Conditioning: Its meaning and application

Introduction to Air Conditioning:

- **Air Conditioning:** It is the simultaneous control of temperature, humidity, airvelocity and purity of air.
- **Psychrometry:** It is the study of the properties of mixtures of air and water vapour(moist air).
- **Atmospheric air:** Atmospheric air is a mixture of many gases plus water vapour and a number of pollutants.
- The amount of water vapour and pollutants vary from place to place
- The concentration of water vapour and pollutants decrease with altitude, and above an altitude of about 10 km, atmospheric air consists of only dry air.
- The pollutants have to be filtered out before processing the air.
- Hence, what we process is essentially a mixture of various gases that constitute airand water vapour.
- This mixture is known as moist air.

Composition of standard air:

S. NO	Constituent	Molecular weight	Mole fraction
01	Oxygen	32	0.2095
02	Nitrogen	28.016	0.7809
03	Argon	39.944	0.0093
04	Carbon Dioxide	44.010	0.0003

Based on the above composition the molecular weight of dry air is found to be 28.966and the gas constant R is 287.035 J/kg.K.

- At a given temperature and pressure the dry air can only hold a certain maximum amount of moisture
- When the moisture content is maximum, then the air is known as saturated air
- For calculation purposes, the molecular weight of water vapour is taken as 18.015 and its gas constant is 461.52 J/kg.K

9. Humidity, dry bulb, wet bulb, and dew point temperatures

Specific Humidity or Humidity ratio (w):
It is defined as the ratio of mass of vapour to the mass of dry air.

$$W = \frac{m_v}{m_a} = \frac{Kg\ of\ water\ vapour}{Kg\ of\ dry\ air}$$

P_t = total atmospheric pressure

P_a = partial pressure of dry air

P_v = partial pressure of vapour

According to dalton's law, $P_t = P_a + P_v$

Also for dry air, Also for dry air, $P_a V = m_a R_a T$ (1)

For water vapour, $P_v V = m_v R_v T$ (2)

Divide eq. (2) / (1)

$m_v / m_a = R_a P_v / R_v$

P_a

$$w = 0.622 \left(\frac{P_v}{P_t - P_v}\right)$$

Relative humidity (ϕ):

It is defined as the ratio of the mole fraction of water vapour in moist air to mole fraction of water vapour in saturated air at the same temperature and pressure.

$\phi = \frac{m_v}{m_{vs}} = \frac{P_v}{P_{vs}}$ Where P_{vs} = partial pressure of saturated vapour

Relative humidity is normally expressed as a percentage. When is 100 percent, the air is saturated.

Dry bulb temperature (DBT):

Dry bulb temperature (DBT) is the temperature of the moist air as measured by a standard thermometer or other temperature measuring instruments.

Dew-point temperature (DPT):

If unsaturated moist air is cooled at constant pressure, then the temperature at which the moisture in the air begins to condense is known as dew-point temperature (DPT) of air. Thermodynamically it is defined as the saturation temperature corresponding to partial pressure of vapour.

Wet bulb temperature (WBT):

It is the lowest temperature to which air can be cooled by the evaporation of water into the air at constant pressure.
The wet-bulb temperature is the temperature read by a thermometer covered in water-soaked cloth over which air is passed. At 100% relative humidity, the wet-bulb temperature is equal to the air temperature.

Saturated vapour pressure (Psat):

It is the saturated partial pressure of water vapour at the dry bulb temperature. This is readily available in thermodynamic tables and charts.

Degree of saturation (μ):

The degree of saturation is the ratio of the humidity ratio W to the humidity ratio of a saturated mixture Ws at the same temperature and pressure

$$\mu = \frac{w}{w_s}$$

Enthalpy:

The enthalpy of moist air is the sum of the enthalpy of the dry air and the enthalpy of the water vapor. Enthalpy values are always based on some reference value.

For moist air, the enthalpy of dry air is given a zero value at 0^{o} C, and for water vapour the enthalpy of saturated water is taken as zero at 0^{o} C.

$$H = H_a + H_v = m_a h_a + m_v h_v$$

$$h = h_a + w\, h_v = Cp_a\, t + w\, \mathbf{[2500 + 1.88\, t]}$$

Enthalpy of moist air, $h_a = Cp_a\, t$

Enthalpy of water vapour, $h_v = LH + Cp_v\, t$

LH = 2500 kJ/kg, $Cp_v = 1.88$ kJ/kgK

$\mathbf{h_v = 2500 + 1.88\ t}$ where t = DBT in C

10. Comfort conditions

REQUIREMENTS OF HUMAN COMFORT AND CONCEPT OF EFFECTIVE TEMPERATURE

The Comfort Chart:

- The comfort chart (see Figure 8-8) is an empirically determined effective temperature index that has been published by the ASHRAE since 1950.
- The purpose of the comfort chart is to indicate the percentage of people feeling comfortable at various effective temperatures in the winter and summer.
- This serves only as an approximate standard of comfort, because individual reactions to warmth and cold are much too variable, but it is the most precise and scientific form of measurement available.
- From the chart, one can obtain an approximate idea of the various effective temperatures at which a majority of people will feel comfortable (that is, the summer and winter comfort zones).

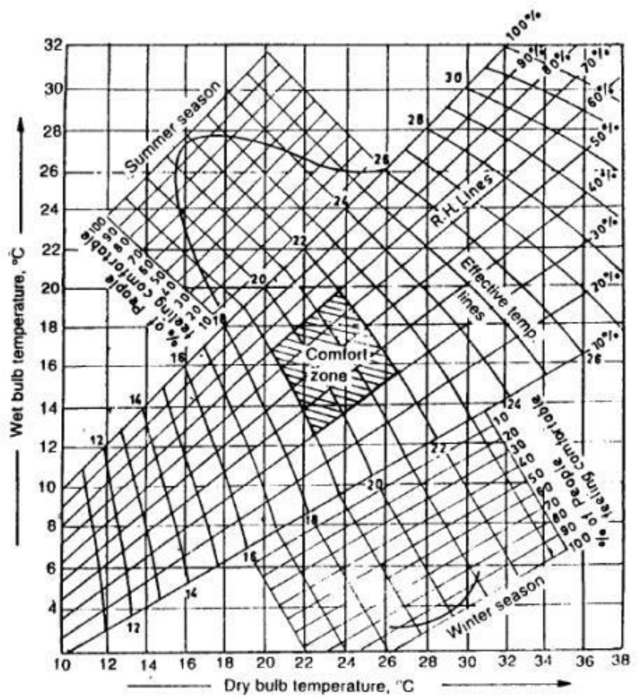


Fig. 1 Comfort chart for still air (air velocities from 5 to 8 *m /min*).

Psychrometric chart:

A Psychometric chart graphically represents the thermodynamic properties of moist air. Standard psychometric charts are bounded by the dry-bulb temperature line (abscissa) and the vapour pressure or humidity ratio (ordinate). The Left-Hand Side of the psychometric chart is bounded by the saturation line. Psychometric charts are readily available for standard barometric pressure of 101.325 kPa at sea level and for normal temperatures (0-$50\ ^oC$)

Question No 01: On a particular day the weather forecast states that the dry bulb temperature is 37 C, while the relative humidity is 50% and the barometric pressure is 101.325 kPa. Find the humidity ratio and enthalpy of moist air on this day.

Answer: At $37\ ^oC$ the saturation pressure (p_s) of water vapour is obtained from steam tables as 6.2795 kPa.

Since the relative humidity is 50%, the vapour pressure of water in air (p_v) is:

$p_v = 0.5 \times p_s = 0.5 \times 6.2795 = 3.13975$ kPa

The humidity ratio W is given by:

$W = 0.622 \times p_v/(p_t - p_v) = 0.622 \times 3.13975/(101.325 - 3.13975)$

$= 0.01989$ kgw/kg

The enthalpy of air (h) is given by the equation:

$h = 1.005t+W(2501+1.88t) = 1.005 \times 37+0.01989(2501+1.88 \times 37)$

$= 88.31$ kJ/kg Ans.

11. Construction and working of window air conditioner Window ai conditioner:

The working of window air conditioner can be explained by separately consideringthe two cycles of air:

1. **Room air cycle**
2. **Hot air cycle**.

The compartments of the room and hot air are separated by an insulated partition insidethe body of the air conditioner.

1. **Room Air Cycle:**

- The air moving inside the room and in the front part of the air conditioner where the cooling coil is located is considered to be the room air.
- When the window AC is started the blower starts immediately and after a few secondsthe compressor also starts. The evaporator coil or the cooling gets cooled as soon as the compressor is started.
- The blower behind the cooling coil starts sucking the room air, which is at high temperature and also carries the dirt and dust particles.
  - On its path towards the blower, the room air first passes through the filter where the dirt and dust particles from it get removed.
- The air then passes over the cooling coil where two processes occur.
- Firstly, since the temperature of the cooling coil is much lesser than the room air, the refrigerant inside the cooling coil absorbs the heat from the air. Due to this the temperature of the room air becomes very low, that is the air becomes chilled.
- Secondly, due to reduction in the temperature of the air, some dew is formed on the surface of the cooling coil. This is because the temperature of the cooling coil is lower than the dew point temperature of the air. Thus, the moisture from the air is removed so the relative humidity of the air reduces. Thus, when the room air passes over the cooling coil its temperature and relative humidity reduces.
- This air at low temperature and low humidity is sucked by the blower and it blows it at high pressure.
- The chilled air then passes through small duct inside the air conditioner and it is then thrown outside the air conditioner through the opening in the front panel or the grill.

- This chilled air then enters the room and chills the room maintaining low temperature and low humidity inside the room.

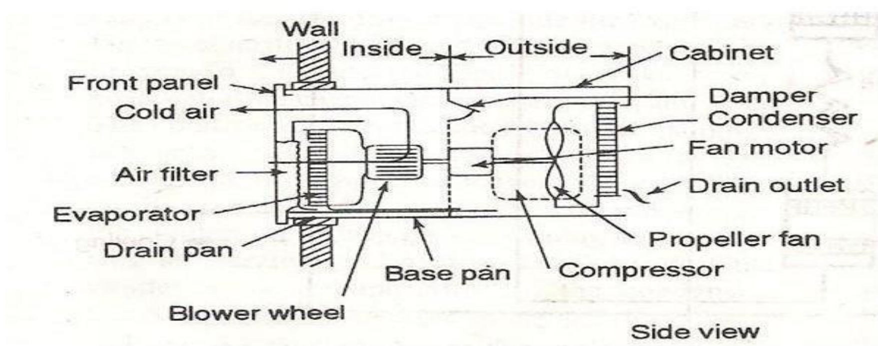


Fig: window air conditioner

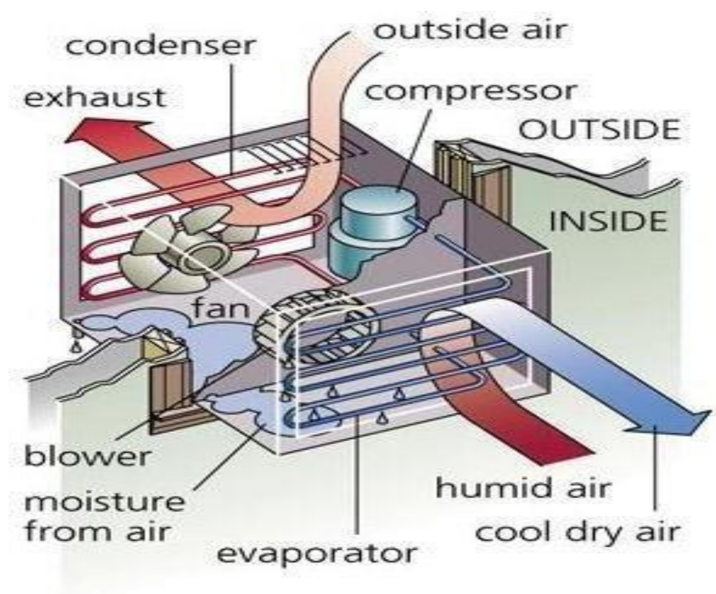


Fig: Component of window air conditioner

The cool air inside the room absorbs the heat and also the moisture and so its temperature and moisture content become high.
This air is again sucked by the blower and the cycle repeats.
Some outside air also gets mixed with this room air. Since this air is sent back to the blower, it is also called as the return room air. In this way the cycle of this return airor the room air keeps on repeating.

2. Hot Air Cycle:

- The hot air cycle includes the atmospheric air that is used for cooling the condenser.
- The condenser of the window air conditioner is exposed to the external atmosphere.
- The propeller fan located behind the condenser sucks the atmospheric air at high temperature and it blows the air over the condenser.
- The refrigerant inside the condenser is at very high temperature and it has to be cooled to produce the desired cooling effect.
- When the atmospheric air passes over the condenser, it absorbs the heat from the refrigerant and its temperature increases.
- The atmospheric air is already at high temperature and after absorbing the condenser heat, its temperature becomes even higher.
- The person standing behind the condenser of the window AC can clearly feel the heatof this hot air. Since the temperature of this air is very high, this is called as hot air cycle.
- The refrigerant after getting cooled enters the expansion valve and then the evaporator.
- On the other hand, the hot air mixes with the atmosphere and then the fresh atmospheric air is absorbed by the propeller fan and blown over the condenser. This cycle of the hot air continues.

Fig: A typical window unit

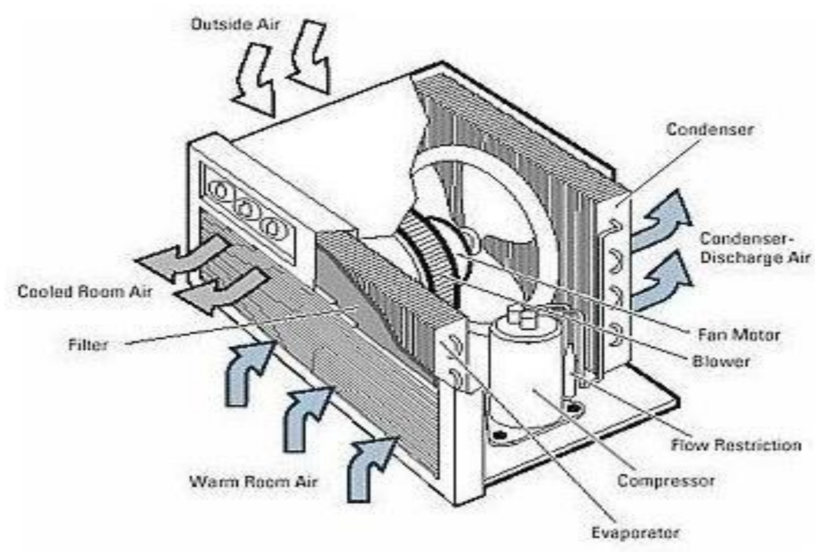


Fig: Different components of window air conditioner