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REFRIGERATION AND AIR CONDITIONING

Basic terminologies:-

Kilo-calories
It is defined as the amount of heat to be added/removed to raise/lower the temperature of one kg of water by one degree Celsius.
BTU
It is defined as the amount of heat to be added/removed to raise/lower the temperature of one pound of water by one degree Fahrenheit.

1 Kilo-calorie = 3.97 BTU.

Sensible heat
It is that heat which when applied to a body, results in a rise of its temperature. It is the heat which is sensed by a thermometer.
Latent heat
It is that heat which when applied, merely changes the state of substance, whether solid, liquid or, gas without causing any change in its temperature.

Latent heat of fusion of ice—80 K. cal./kg. and 144 BTUs/lb.
Latent heat of evaporation of water- 538.75 K. cal./ kg. and 970 BTUs/lb.

Enthalpy
It is a calculated property of vapour which is defined as "Total heat content".It is the sum of the sensible heat and latent heat.
Critical temperature
There is a certain temperature for every liquid or gas, which is called its critical temperature; when a gas is above its critical temperature, any amount of increase in pressure cannot liquefy it. When the temperature is below its critical point, the gas can be liquefied without lowering its temperature, by merely increasing the pressure.

Definition: Refrigeration may be defined as the process by which temperature of a given space or a substance is lowered below that of the atmosphere or surroundings.
In order to maintain a temperature below the surroundings atmosphere, it is essential that whatever amount of heat gets into the refrigerated space, must be extracted out to maintain the desired temperature differential.
The cooling effect may be obtained by any of the following principles.
I) By chemical means.
II) By bringing the substance to be cooled directly or indirectly in contact with some cooling medium such as Ice or chilled water.
III) By using mechanical or heat energy to operate a 'heat pump' by which it may be abstracted from a low temperature region and rejected, together with the energy required to sustain the process, to the reason of high temperature.

Application of refrigeration
I) Comfort - Cinemas, restaurants, hospitals, departmental stores, residential buildings.

II) Industries - cotton mills, textile mills, liquidizing of gases, treatment of metals and miscellaneous Tools.
III) Medicines - Preservation of blood, human tissues
IV) Reservation and distribution of food products.
V) Production of rocket fuels made the astronaut's visit to moon a reality.
VI) Computer functioning.

Performance of a refrigerating machine

A refrigerator is a cyclically operating device which absorbs energy (Q_1) as heat from a low temperature thermal reservoir and rejects energy (Q_h) as heat to a high temperature thermal reservoir, when work (w) is done on it. In a refrigerator the ambient atmosphere is usually used as the high temperature thermal reservoir.

The performance of any system depends upon what get and what we pay.

$w = Q_h - Q_1$

And, $C_{op} = Q_1/w = Q_1 / Q_h - Q_1$.

This is known as theoretical C.O.P.

Relative C.O.P = Actual C.O.P/ Theoretical C.O.P

Refrigeration equipment

1) Compressor
2) Condenser and cooling tower
3) Evaporator
4) Expansion devices
5) Piping and pumps
6) Electric Motors.

Types of mechanical refrigerators:

There are two types of mechanical refrigerators: 1) Cold air refrigerator. 2) Vapour compression refrigerator.

Unit of refrigeration

The power or capacity of mechanical equipment is generally given in horsepower similarly the capacity of electrical equipment are generally given in kilowatt for small units in megawatt for power plants. A unit used in the field of refrigeration is known as ton of refrigeration.

A ton of refrigeration is defined as the quantity of heat required to be removed from one ton of water within 24 hours when the initial condition of water is 0 degrees Celsius, because some cooling effect will be given by melting the same ice.

In S.I. units, $1 \text{ Ton of refrigeration} = 12660 \text{ KJ/Hr}$

$= 211\ KJ/Min$

$= 3.517\ KJ/Sec$

$= 3.517\ Watt$

Thus ton of refrigeration is not a unit of mass but a measurement of the rate of heat transfer.

Technical data of house hold Refrigerator:

1. Compressor H.P. 1/8 to 1/6.
2. Capillary

Refrigerants:

Refrigerant is a carrier of heat which absorbs heat from low temperature space that is usually known as refrigerated space and heat liberates at high temperature and high pressure place/space.

The refrigerant may be divided into two main group which are

1) Primary refrigerant.
2) Secondary refrigerant.

The primary refrigerant directly take part in the refrigerating system and actually produce the low temperature. Such refrigerants are ammonia, carbon dioxide, Sulphur dioxide etc.

The secondary refrigerants are first cooled by the primary refrigerants and then they are further circulated for economical applications, in the places to be cooled. The important secondary refrigerants are water, ice and Brine's.

Brine is a solution of sodium chloride or calcium chloride in water. Brine solution are used when the required temperature is to be maintained below the freezing point of water as in ice plants.

Desirable Properties of refrigerants:-

- The refrigerant shall be non-poisonous.
- It shall be non-inflammable.
- It shall be non-corrosive.
- It shall be non-irritating.
- It shall have no harmful effect on the taste, colour or aroma of food or drinking water.
- It shall be cheap and readily available in market.
- It shall have high latent heat of vaporisation.
- It should have low boiling point.
- It should have low volume per kg when in a gaseous state.
- It shall have high coefficient of performance.
- Easy detection of refrigerant leakage.

What is comfort:-

Comfort is a subjective quantityrelated to the ease with which an individual maintains a thermal balance between himself and the environment. As such, feeling of great satisfaction with surrounding conditions may provide physical comfort. But human beings are complex in nature and feeling of comfort in them may depend upon state of mind, physical condition and state of activity. Moreover feeling of individual comfort may differ for the same individual at different times.

RMPU

The full form of RMPU, is roof mounted package unit. 1 complete RMPU system covers two set of vapour compression refrigeration system.

Advantages of RMPU:-

I) High saving: light in weight saves fuel in hauling. The total weight of both the unit is 900 kilogram, saves more than rupees 20000/Year per coach.

II) Easy to installation: this unit is factory made, assembled gas charged and tested for performance prior to the delivery. The installation requires simply to lower the unit in the false ceiling above the toilet area in both end of the coach and connect it. It takes less than 4 hours.

III) Low maintenance: it is almost maintenance free, since it uses 3-phase AC motor, sealed type.

IV) Environment friendly: it uses more environment friendly refrigerant and very small quantity, using less than 3 kilogram.

V) Rapid heat dissipation: mounted on roof, thus no dust collection in condenser and so requires practically no maintenance or water spraying on condenser oil.

VI) Safe operation: no chance of damage due to flash flood, cattle run over and flying blasts.

VII) Energy efficient: compact and modular with short pipeline causing less loss.
VIII) Capacity control: Use of 4 compressor offer 25 % to control hundred percent capacity and standby facility saving energy.
IX) Low downtime: failed unit can be replaced by complete unit in less than 2 hours simply by lifting by crane and lowering the new one in place.
X) Hygienic fresh air: fresh air is taken through roof from fresh air which supplied clean fresh air free of toilet odour.
XI) Refrigerant leak: hermetically sealed system with no fitting or opening (R22CHClF2) thus it present little potential of gas leakage and avoids major breakdown.

Hermetically sealed compressor- in ordinary compressor the crankshaft extended through the compressor housing and it is connected to the driving motor. A seal must be provided at the place where the shaft comes out through the compressor housing. This is necessary to prevent the leakage of refrigerant outside or leakage of air inside. With best type of seals, the leak develops with the working of the compressor. To avoid the complete leakage of the refrigerant the compressor and motor are enclosed in one housing which are known as hermetically sealed compressor.
Advantage of this type compressor are
1) Leakage of refrigerant is completely avoided.
2) It is less noisy then the ordinary systems.
3) Being more compact requires small space.

Brine:
Brine is a solution containing the salt in dissolved condition in water the freezing temperature of the brine is lower than the freezing temperature of water and it decreases with the increase in salt concentration, but if the concentration is increased beyond a certain point the freezing temperature of the brine increases instead of decreasing. The solution at this concentration is known as eutectic solution. The eutectic temperature of the calcium chloride brine is -55℃ at corresponding salt concentration of 30% by weight, the eutectic temperature of sodium chloride brine is -21℃ at corresponding salt concentration of 23% by weight.

Cryogenic refrigerant: The temperature range of -157℃ to -273℃ is known as cryogenic range and refrigerant used for producing these temperatures are known as cryogenic refrigerant. These temperatures may be produced by evaporating cryogenic liquids which have very low boiling point at atmospheric pressure. The common cryogenic refrigerant are oxygen, nitrogen, hydrogen and helium.

Equipment of ac system on ac coaches:
1) Compressor motor.
2) Section line.
3) Compressor discharge.
4) Air cooled condenser.
5) Contention motor.
6) Charging valve.
7) Liquid receiver.
8) Delivery pipe.
9) Evaporator
    9a) evaporator motor.
    9b) evaporator coil.
    9c) evaporator refrigerant valve.
    9d) evaporator air return duct.
10) Roof insulation.
11) Floor insulation.

12) Air duct.
13) Thermostat.

The primary refrigerant can further be classified as:
Halocarbon compounds->
Azeotropes->
Hydro carbons->
Inorganic compounds->
Unsaturated organic compounds ->

Vapour compression refrigeration system:

A vapour compression refrigeration system uses a refrigerant sealed in an airtight and leak proof mechanism. The refrigerant is circulated through the system and it under goes a number of changes in its state while passing through various components of the system. Each such change in the state of vapour is called a process. The system repeats over and over these processes. The processes of repetition of a similar order of operations is called a cycle.

The compression cycle is given this name because it is the compression of the refrigerant by the compressor which permits transfer of heat energy. The refrigerant absorbs heat from one place and releases it to another place. In other words the compressor is used to put the heat loaded refrigerant vapour in such a condition that it may dissipate the heat it absorbed at low pressure from the refrigerated space to an easily available cooling medium.

Vapour compression refrigeration cycle
Most of them ordered refrigerators work on this cycle. In its simplest form there are 4 fundamental operations required to complete one cycle:
a) Compression b) condensation c) expansion d) vaporisation.
These are explained in relation to flow diagram shown in figure:

Compression. The low pressure vapour in dry state is drawn from the evaporator during the suction stroke of the compressor. During compression stroke the pressure and temperature increase until the vapour temperature is greater than the temperature of condenser cooling medium (air or water).

Condensation. When the high temperature refrigerant vapour enters the condenser heat flows from condenser to cooling medium, thus allowing the vaporized refrigerant to return to liquid state.

Expansion. After condenser the liquid refrigerant is stored in the liquid receiver until needed. From the receiver it passes through an expansion valve where the pressure is reduced sufficiently to allow the vaporisation of liquid at a low temperature of about -10 degrees Celsius.

Vaporisation. The low pressure refrigerant vapour after expansion in the expansion valve enters evaporator or refrigerated space where a considerable amount of heat is absorbed by it and refrigeration is furnished.

1) Evaporator
2) Suction line
3) Compressor
4) Discharge line
5) Condenser
6) Receiver tank
7) Liquid line
8) Expansion valve

Principal parts of a simple vapour compression system

The principal parts of a simple vapour compression refrigeration system shown in the flow diagram (magnified) is briefly described in the following lines.

1) **Evaporator.** Its function is to provide a heat transfer surface through which heat can pass from the refrigerated space into the vaporising refrigerant.

2) **Suction Line.** It carries the low pressure vapour from the evaporator to the suction inlet of the compressor.

3) **Compressor.** The function of the compressor is to draw refrigerant vapour from the evaporator and to raise its temperature and pressure to such a point so that it may be easily condensed with normally available condensing media. It also maintains a continuous flow of the refrigerant through the system.

4) **Discharge line** it conveys the high pressure and high temperature refrigerant from the compressor to the condenser.

5) **Condenser.** The function of the condenser is to provide a heat transfer surface through with heat passes from the refrigerant to the condensing medium which is either water or air.

6) **Receiver tank.** It acts as a receiver which stores the liquid refrigerant coming from the condenser and supplies it to the evaporator according to the requirement.

7) **Liquid line.** It carries the liquid refrigerant from the receiver and conveys it to the expansion valve.

8) **Expansion valve.** Its function is to supply a proper amount of refrigerant to the evaporator after reducing its pressure considerably, so that the refrigerant may take sufficient amount of heat from the refrigerating space during evaporation.