MAHATMA GANDHI MISSION's

JAWAHARLAL NEHRU COLLEGE OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

REFRIGERATION AND AIR CONDITIONING

LAB MANUAL

Following are the Experiments include in the syllabus of Refrigeration and Air Conditioning.

1) Study of Domestic or Household Refrigerator

2) Study of Refrigeration Compressor

3) Study of Leak Detection, Evaluation and Charging of Refrigerants procedure

4) Study of Refrigerating Controls

5) Trial on Refrigeration Test Rig

6) Trial on Air Conditioning Test Rig

7) Trial on Mechanical Heat Pump

8) Trial on Ice Plant Test Rig

9) Technical report on visit to Refrigeration and Air Conditioning establishments.

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1) STUDY OF HOUSEHOLD/DOMESTIC REFRIGERATOR

EXPERIMENT TITLE:

Study of Household/Domestic Refrigerator

AIM:

To study the working of household refrigerator along with different auxiliary systems associated with household refrigerator and its wiring diagram.

PRIOR KNOWLEDGE:

Heat Pump, Refrigerator, Vapour compression refrigeration cycle.

DESCRIPTION:

The household refrigerator works on vapour compression refrigeration cycle. The refrigerant vapour is compressed by means of compressor to a pressure at which temperature obtained at the end of compression will be more then atmosphere so that at this high temperature it will reject heat to atmosphere and will get condensed. The condensate is then allowed to pass through a capillary so that the pressure and temperatures and lowered. Capillary device acts as a throttling unit. At low pressure and temperature refrigerant is supplied to the evaporator where load is kept, it absorbs the heat and refrigerant get converted into gaseous phase and it is again supplied to compressor and cycle is repeated.

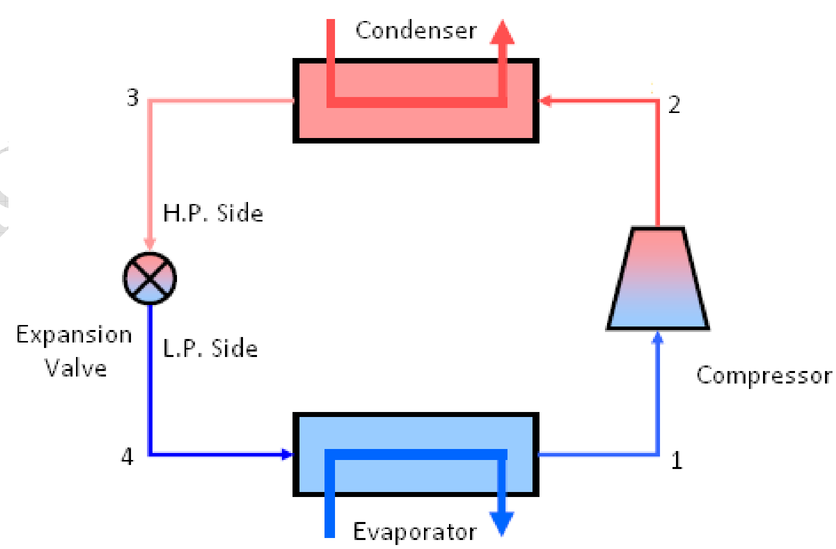


Fig.1 Simple Vapour Compression Cycle

The evaporator in the household refrigerant is always fitted in the cabinet of the refrigerator at the top potion and the concealed type of evaporator used. The condenser is mounted at the back of the cabinet. The expansion device used in household refrigerator is capillary tube. Capacity of household refrigerator is expressed in terms of litre. The refrigerators manufactured by various manufactures are available in capacities ranging from 90 litres to 380 litres. (The capacity of household refrigerator is expressed in terms of litre, it is defined as the amount of water occupied in the cabinet. It specifies the space available for keeping various commodities in refrigerator.)

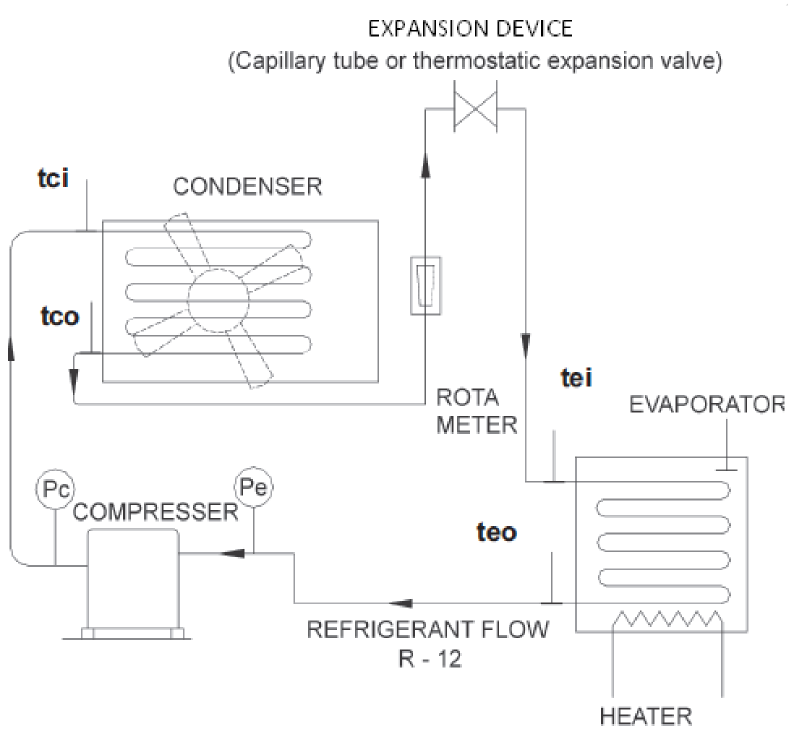


Fig.2 Schematic diag. of Refrigerating Parts

In the household refrigerator the air circulation inside the cabinet is maintained by natural convection. The temperature in freezer is around - 5 to -10 c, the temperature is increased at the bottom most portion where vegetable crisper is kept. Also there is provision for keeping stuff like eggs, water, etc. fitted in the door of refrigerator.

The refrigerator body is insulated with insulating materials like PUF (Polyainthene foam). Magnetic strips are provided to avoid thermal leakage through doors.

ATTAINMENTS OF FREEZING AND DEFROSTING IN REFRIGERATOR:

Freezing and Defrosting done by two ways:

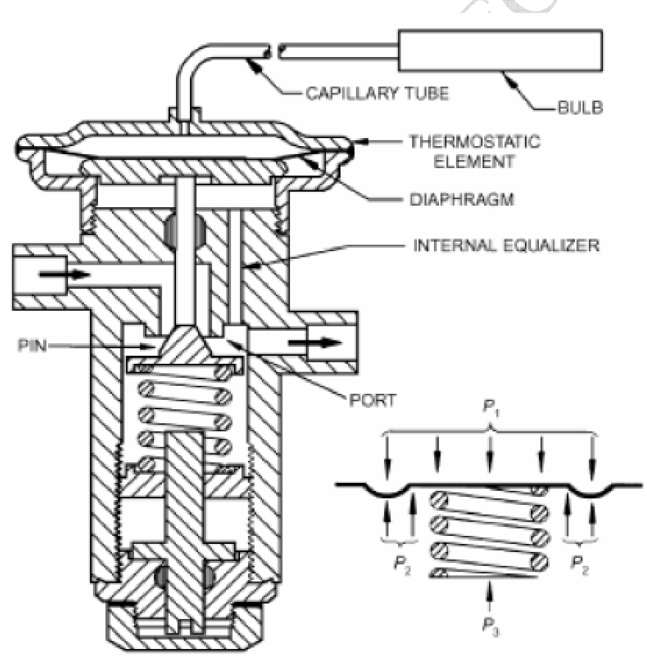
1. Thermostat

2. Defrosting Unit

1. Thermostat:

Thermostat is used to control the temperature in the refrigerator by varying time to idle time ratio. The bulb of the thermostat is clamped to the evaporator or freezer. The thermostat bulb is charged with few drops of refrigerant.

The temperature at which compressor motor starts, by closing the thermostat contacts is called cut-in temperature. Cut-out temperature is higher then cut-in temperature and the difference between the two is called differential. Higher is the differential, longer is the running time and less is the idle time of refrigerator. By changing range adjustment and differential, any cut-in and cut-out temperature can be adjusted for maintaining desired temperature in the refrigerator.



P_1 = Thermostatic Elements Pressure

P_2 = Evaporator Pressure

P_3 = Pressure Equivalent Of the Superheat Spring Force

Fig.3 Thermostatic Expansion Valve

As the temperature of the bulb increases, gas pressure in the bellow assembly increases, and this closes the compressor motor circuit and refrigerator starts. As the compressor runs, the thermostat bulb is cooled; gradually reducing the pressure in the bulb and this opens the circuit when desired temperature is attained.

The refrigerator is provided with a control knob. By operating knob desired temperature can be maintained.

2. Defrosting:

The freezing of moisture on evaporator coil is called as frosting. The frost thickness increases due to frequent door openings, as the frost thickness increases the heat transfer through the coil decreases. This increases the running time of refrigerator and hence the power consumption. Therefore regular defrosting must be done when frost thickness increases above certain limit.

Generally following methods are used for defrosting.

i) Defrosting by stopping unit:

Stop the unit, keep door open and chill tray must be kept in defrost position till defrosting takes place.

ii) Timer Defrosting:

The most popular defrost system used in household refrigerator is clock timer defrost cycle. The number of defrost periods varies from one to four in 24 hours depending upon timer used. The timer contacts initiate either the defrost cycle or cooling cycle. When the timer is in the cooling cycle, the thermostat control the on-off periods of the compressor. When the timer is in the defrost cycle. The thermostat cannot turn the compressor ON. In other words, thermostat has no control on the compressor when the defrost timer is in the defrost position.

The defrost cycle terminates approximately 20 minutes after being turned on. The defrost heater is wired in series with a bimetal thermostat whose contacts will open at some predetermined temperature, there by disconnecting the heater. The length and time it takes for the contacts of the bimetal thermostat to open is determined by the amount of frost on the evaporator.

DO AND DON'T – WHILE USING REFRIGERATOR:

1. The refrigerator should be placed away from the heat source such as sunrays, heating appliance, cooking gas, etc.
2. Install the refrigerator away from wall at least by one foot which provides good air circulation over condenser.
3. Hot fluids should not be kept in refrigerator.
4. Keep door openings at minimum.
5. Strongly flavored food must be kept wrapped.
6. Vegetables, fruits should be kept in polythene bags before placing into the refrigerator.
7. Clean with soft cloth. No soap, detergent should be used.

IN HOLIDAYS:

1. Remove every stored item including ice trays.
2. Defrost refrigerator.
3. Make refrigerator dry.
4. Disconnect three-pin plug.
5. Leave the door slightly open for movement of fresh air.

RESTARTING:

1. Clean the Refrigerator.
2. Connect 3-pin plug.
3. Load the refrigerator after temperature has stabilized.

CONCLUSION:

The domestic refrigerators now a day are becoming essential part of life. These refrigerators are available in different capacities as well as different working models. These are having single door double door options, frost free refrigerators; quick chill refrigerators are also available. To make the refrigerators smart now a day the condensers are sealed and refrigerators are mode flat back.

The compressors used in household refrigerator are hermetically sealed reciprocating units. Now a days noise free rotary hermetically seals compressors are also used.

The refrigerant R-12 which was popularly used in household refrigerators is discarded due to its ODP (ozone depletion potential). It is replaced by R-134(a).

2) STUDY OF REFRIGERATION COMPRESSORS

EXPERIMENT TITLE:

Study of Refrigeration Compressors

AIM:

To study the working of compressor used in refrigeration system.

PRIOR KNOWLEDGE:

Different types of compression processes and working of vapour compression refrigeration system.

DESCRIPTION:

The compressor is the heart of vapour compression system. The compressor is used to reclaim the refrigerant vapour leaving the evaporator. The refrigerant must be compressed to the pressure corresponding to a saturation temperature higher then the temperature of the naturally available air or water. The compressor is also used to circulate the refrigerant through the system. The capacity of compressor determines the capacity of refrigeration system as a whole.

The refrigeration compressor and gas or air compressor differs very much because the refrigerating compressor is integral part of the cycle and it is coupled to other components.

CLASSIFICATION:

Classification of refrigeration compressors:

1. Reciprocating compressor.
2. Rotary compressor.
3. Screw Compressor.

4. Centrifugal and scroll compressor.

1. Reciprocating Compressor:

The reciprocating compressors are available in sizes as small as 1/12 hp up to about 150 hp for large capacity installation.

The reciprocating compressors are of three types.

i) Open type compressor.
ii) Hermetically sealed compressor.

1. Open type of compressor:

A compressor whose crankshaft extends through the compressor housing so that a motor can be externally coupled to the shaft is called open type compressor.

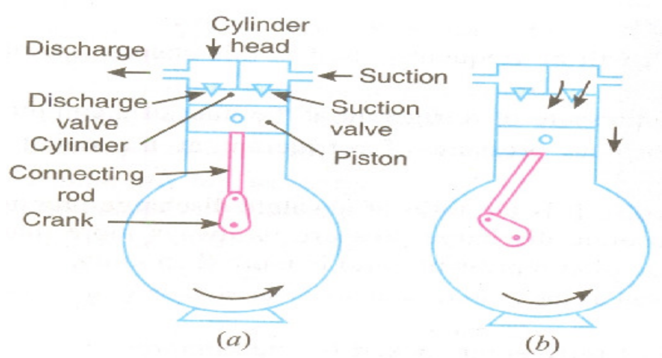


Fig.1 Open type Reciprocating Compressor

The open type of compressor is flexible in the sense that the speed of compressor can be varied for obtaining different refrigeration capacities. It can be operated by any type of prime mover like electric motor, IC engine etc. In the field the motor can be easily charged in case of a motor burnout. The refrigeration system is not affected by burnouts. A disadvantage of the open type of compressor is that the shaft seal is most vulnerable point for leakage of refrigerant.

2. Hermetically sealed compressor:

In hermetic compressor there is no need for shaft seal. The compressor and motor are mounted on single shaft and whole assembly is fixed in a steel shell, the joint of which are welded. The losses due to drive package and shaft seal friction are also eliminated i.e. the power required per tone of refrigeration is less then that of the open type.

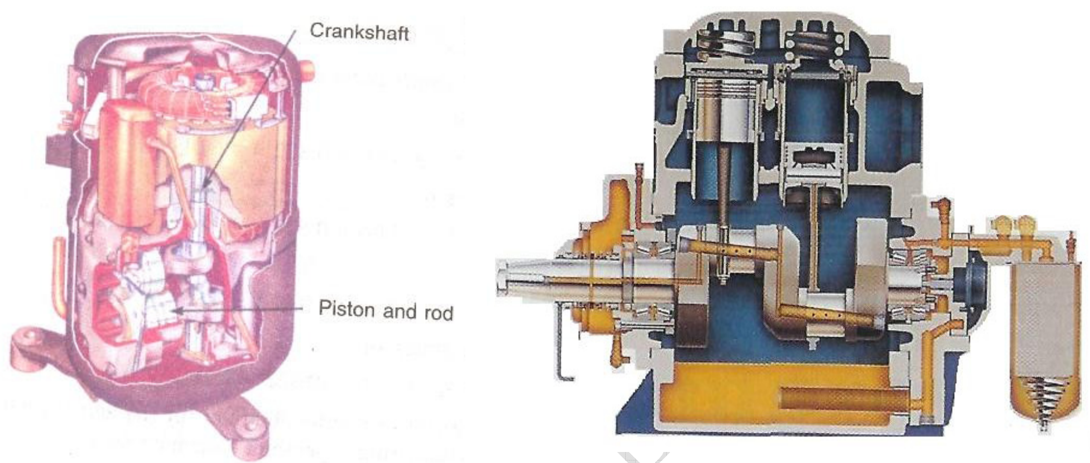


Fig.2 Hermetically Sealed Reciprocating Compressor

For sealed unit a. c. electric supply with particular voltage and frequency for which compressor is designed is needed to run the compressor. In the event of motor burnout, highly corrosive hydrochloric and hydrofluoric acids are formed. The system therefore gets contaminated. Before repairing or installing a new compressor assembly, the system has to be thoroughly flushed and cleaned.

In hermetic compressor the compressor assembly is suspended inside a steel shell, the winding and rotor cannot get natural cooling. The cold refrigerant vapour coming from the evaporator accomplishes the cooling of the winding and rotor. If there is minute leak in the system motor cooling will be affected.

Causes of Burn Outs:

1. Voltage fluctuation.
2. Low refrigerant charge.
3. Quality of oil and refrigerant.
4. High discharge pressure.

2. Rotary Compressor:

As the name implies, the displacement and compression of the refrigerant vapour is achieved due to circular or rotary motion instead of reciprocating motion.

There are two types of rotary compressor.

i) Rotating Blade Type Rotary Compressor
ii) Stationary Single Blade Type Rotary Compressor

i) Rotating Blade Type Rotary Compressor

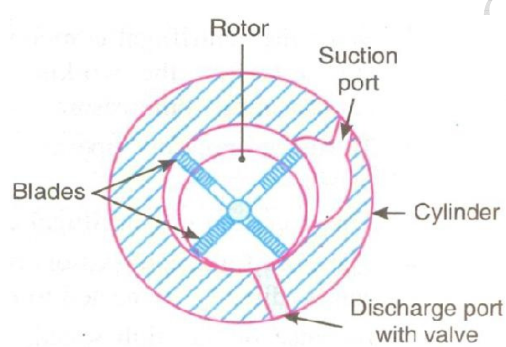
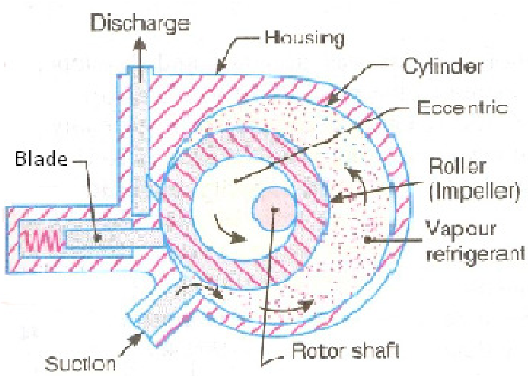


Fig.3 Rotating Blade Type Rotary Compressor

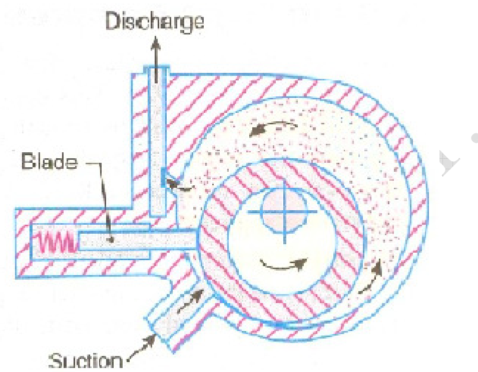
The rotor is concealing with the shaft and rotates in a cylinder which is off capture with respect to the shaft and rotor. Multiple vanes are positioned in slots in the rotor, ride on the cylinder wall faction vapour entering the cylinder is trapped between successive vanes and gets compressed due to reduction in volume as the rotor rotates.

Ii) Stationary Single Blade Type Rotary Compressor:

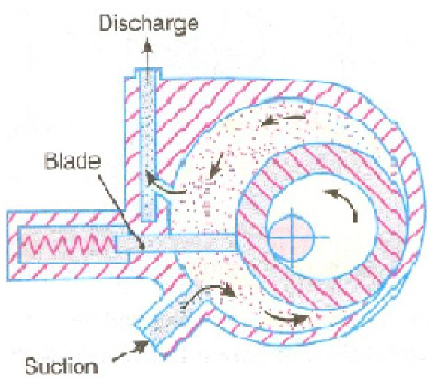
The main components of rotary compressor are cylinder, roller mounted eccentrically on motor shaft and a spring loaded shaft. The roller moves eccentrically on the driver shaft inside a stationary cylinder.



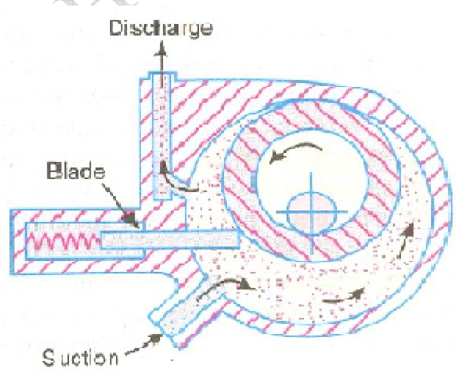
a) Completion of Intake Stroke & Begining of Compression Stroke



b) Compression Stroke Continued & New Intake Stroke Started



c) Compression Continued & New Intake Stroke Continued



d) Compressed Vapour Discharged to Condenser & New Intake Stroked Continued

Fig.4 Stationary Single Blade Type Rotary Compressor

The vane moves up and down in the slot. This vane is dividing line between the suction and discharge of compressor. The suction and discharge ports of the compressor are located on either side of the vane. The suction vapour entering the cylinder gets compressed due to eccentric rotation of the rotor. It progressively reduces the volume of the annular space between cylinder and the rotor. The compressed vapor passes out of the discharge port.

iii) Screw Compressor:

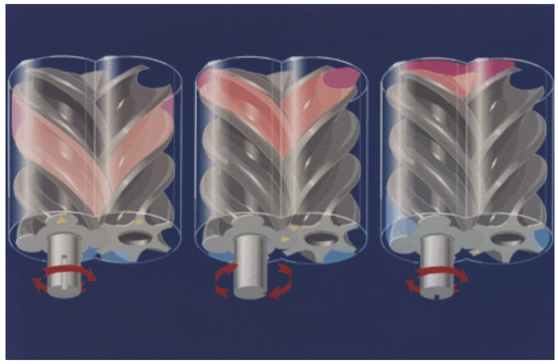
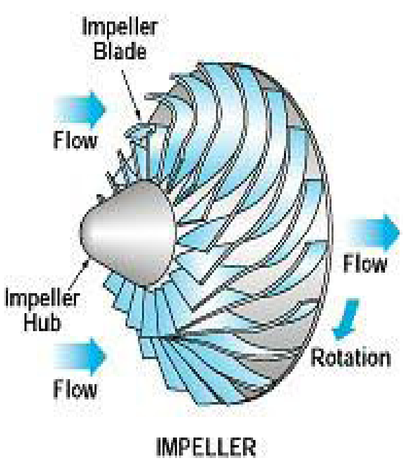


Fig.5 Screw Compressor

Screw compressor is also known as helical rotary compressor. It consists of two meshing multistory helical grooved rotors with vary close tolerance clearance within a housing. Suction and discharge ports are provided at the either ends of the housing. The rotor whose shaft is connected to motor is called as male rotor and other as female. When the male rotor rotates, the female rotor in turn rotates, obviously in opposite direction.

iv) Centrifugal Compressor:



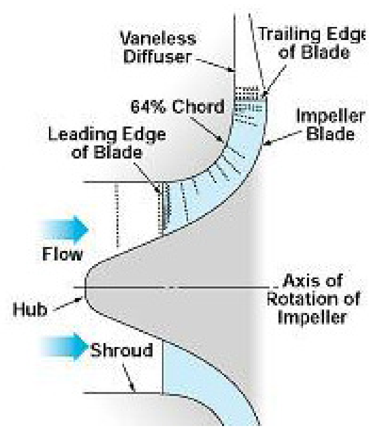


Fig.6 Centrifugal Compressor

Centrifugal compressors are similar in construction to centrifugal pumps , the incoming fluid enters the eye of the spinning impeller and is thrown by centrifugal force to the periphery of the impeller. Thus the blades of the impeller imparts a high velocity to the gas and also build up the pressure. From the impeller the gas goes either into diffuser blades or into a volute casing, where some of the kinetic energy is converted into pressure. The centrifugal compressors may be manufactured with only one wheel if the pressure ratio is low, although the machines are generally multistage. Centrifugal compressors operate with adiabatic compression efficiency of 70 to 80%.

DIFFERENT PROTECTIVE DEVICES USED ON COMPRESSORS:

Protective devices are designed to protect the compressor against abnormal working conditions.

1. High pressure cutout switch.
2. Internal pressure relief value.
3. Low pressure switch
4. Motor winding thermal protector (Thermostat).
5. Time delay relays.

CONCLUSION:

The four types of compressor are studied in this experiment i.e. reciprocating, screw, and rotary, centrifugal. All these have different qualities, so each type of compressor has its own share of application where it has advantage over the other.

1. The reciprocating and screw compressors are best suited for use with refrigerants, which require relatively small displacement and condense relatively at high pressure such as R-12, R-22, Ammonia, etc.
2. Centrifugal compressor is generally suitable for handling refrigerants that require large displacement and operate at low condensing pressure. Such as R-11, R-113 etc. however R-12 is also employed for large capacity application and low temperature jobs.
3. The rotary compressor is most suitable for pumping refrigerants having moderate or low condensing pressure such as R-21 and R-114.

3) STUDY OF LEAK DETECTION, EVALUTION AND CHARGING PROCEDURE FOR REFRIGERANT

EXPERIMENT TITLE:

Study of Leak Detection, Evaluation and Charging Procedure for Refrigerant.

AIM:

To study different methods used for detection of leakage of different types of refrigerants, to study effects of non condensable on the system and to study the procedure for charging the refrigerant into the system,

PRIOR KNOWLEDGE:

Different types of commonly used refrigerants along with their properties (i.e. physical, chemical and thermodynamic), the effect of undercharge or overcharge of refrigerant, the effect of non-condensable on the performance of the system.

DESCRIPTION:

It is well known that the moisture, air and other non-condensable are very harmful for the refrigeration system. The moisture present may choke capillary tube and also if moisture is combined with hydrochloric and hydrofluoric acids they are having ill effects on the system. The presence of air and non-condensable increases the head pressure of the system. As the head pressure goes higher, the compressor motor draws more current. Also higher head pressure reduces the refrigeration capacity of the unit appreciably. The temperature rise of the compressor accelerates the chemical action inside the system.

From above points it is clear that moisture, air and non-condensable should be removed from the refrigeration system to the maximum possible extent. Hence before system can be charged with a refrigerant it should be thoroughly evacuated and dehydrated by drawing a high vacuum. If this is not done at the initial stage itself, a clean system can near be attained.

After the completion of erection the plant should be checked and the refrigerant should be charged into the system.

During working also there is chance of leakage in a refrigeration system. Finding a leakage is the job of patience. The approach should be to find leak rather then concluding that there are no leaks on a cursory check. Apart from the cost of charging refrigerant into a leaky system, a shortage of refrigerant can cause real danger to the plant.

Therefore leak testing should be done periodically without fail in all seriousness and with full concentration.

LEAK TEST METHODS:

Different leak testing methods one employed for different types of refrigerants.

1. AMMONIA, R12, R22:

i) SULPHUR TEST METHOD:

Burning sulphur stick shows a dense white smoke if ammonia is present. The burning sulphur stick is passed around all the joints and suspected leaky points for the appearance of smoke. This test is applicable for tracing minute leaks only.

ii) SOAP BUBBLE TEST:

This test may not be very effective to trace very minute ammonia leak as it is soluble in water. Fortunately, ammonia is having plungent odor, a heavy leak can be easily detectable.

iii) LITMUS TEST:

Wet litmus paper (Phenolpthalene paper) which turns red in contact with ammonia can also be used to detect leaks.

2. HALOGENATED REFRIGERANTS:

Soap solution, Halogen leak detector, Halide torch and Electronic leak detectors are the methods used to trace leaks in halogenated refrigerants

i) HALOGEN TORCH:

A halogen torch can detect minute leaks, which are not possible to trace with soap solution. The presence of trace of refrigerant can change the light blue colour of the detector flame to green or deep blue. The end of the explorer tube of the detector is carefully passed over the joints and suspected leakage points.

If there is a leak, the refrigerant can be drained in with the suction effect at the end of the explorer tube to the hot copper or brass portion of the burning torch. The refrigerant reacts with the metal to form copper chloride, which produces the color change in the flame.

A well maintained halogen torch is claimed to detect leaks of the order of about 15 gram per year.

ii) Electronic Leak Detector:

This is an electrical instrument. In this also an explorer tube is used to suck the refrigerant from the leaky points to an instrument. A vibrator is provided to suck the refrigerant through the explorer tube. A filter is also provided at the tip of the tube to prevent atmospheric dert entering the instrument. A heating element in the tube heats the refrigerant drawn in and the refrigerant creates a variation in the current flow of the instrument. The extent of variation of the current is an indication of the amount of leak. The current variation is read on the dial of the instrument. The change of current actuates a relay which operates an indicating light.

These detectors are capable of detecting refrigerant leaks of the order of about 0.3 gm per year. The electronic leak detector is a very sensitive instrument and should be handled and stored carefully.

CHARGING PROCEDURE FOR REFRIGERANT:

The vacuum pump mounted on the charging kit is of rotary type. Also metering system is provided so that we can charge sufficient quantity of refrigerant.

PURGING:

Many times during the operation of the system, the air leaks inside the system. It is necessary to remove the air for maintaining the efficiency of the system. Owing to the presence of air in a system, the high-side pressure and load on condenser increase. The method of removing air from the system is known as purging. During purging, the compressor discharge valve is intermittently opened for few seconds at a time. Air and few grams of refrigerant vapour escape under high-pressure. A noticeable pressure and temperature drop in the system occurs and normal operating pressure is established. The refrigerant is added from outside if excessive purging is occurred.

CONCLUSION:

The refrigeration system must be free from non-condensable and correct quantity of refrigerant must be there in the system for good performance.

At the time of charging of refrigerant the lubricating oil of required grade must be added to the compressor.

4) STUDY OF REFRIGERATING CONTROLS

EXPERIMENT TITLE:

Study of Refrigerating Controls

AIM:

To study different controls used in refrigeration and air conditioning equipments for better performance.

PRIOR KNOWLEDGE:

Basic principles of RAC and mechanical measurements.

DESCRIPTION:

For efficient and safe working of refrigeration and air conditioning systems different control devices are used these are listed as below.

1. Flow control devices.
2. Safety devices.
3. Air conditioning controls.

1. Flow Control devices:

The major devices under this category air the expansion devices. The purpose of the expansion devices is two fold : it must reduce the pressure of the liquid refrigerant, and it must regulate the flow of refrigerant to the Evaporator.

An expansion device offers a resistance to flow so that the pressure drops resulting in a throttling process. Basically there are two types of expansion devices these are:

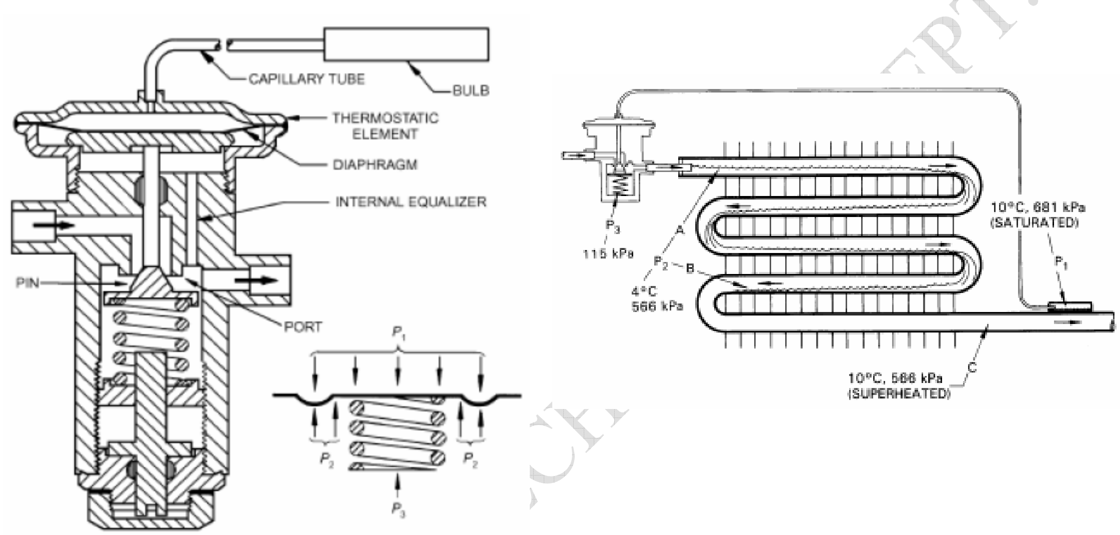
1. Variable restriction type
2. Constant restriction type

In the variable restriction type the extent of opening or area of flow keeps on changing depending on the type of control. There are two common types of such control devices viz,

a) Thermostatic expansion valve.
b) Automatic expansion valve.

a. Thermostatic Expansion value (TEV):

The name may give an impression that it is a temperature control device. It is not a temperature control device and it cannot be adjusted and used to vary evaporator temperature. Actually TEV is a throttling device which works automatically maintaining proper and correct liquid flow as per the dictates of the load on the evaporator. Because of automatic operation, high efficiency and ability to prevent liquid flood backs this value is extensively used.



P_1 = Thermostatic Elements Pressure

P_2 = Evaporator Pressure

P_3 = Pressure Equivalent of the Superheat Spring Force

Fig.1 Thermostatic Expansion Valve

The functions of thermostatic expansion value are:

1. To reduce the pressure of the liquid from the condenser pressure to evaporator pressure.

2. To keep the evaporator fully active.

3. To modulate the flow of liquid to the evaporator according to the load requirement of the evaporator so as to prevent flood back of liquid refrigerant to the compressor.

4. Pressure P1 in the power element acts to open the valve i.e. to move the value needle

away from its seat.

5. The evaporator pressure P2 acts an the bottom side of the diaphragm of the power element tending to close the value.

6. Pressure P3 of the superheat spring also assist in the closing action. Therefore if the power element pressure P1 is greater then the constrained pressure of P2 and P3, the value will open.

It does last two functions by maintaining a constant superheat of the refrigerant at the outlet of the evaporator it would be more appropriate to call it a "constant superheat valve". The important parts of the valve are power element with feeler bulb, value seat, needle and a superheat adjustment spring. The power element is charged with a refrigerant.

The operation of the valve i.e. the closing and opening of the value is controlled by there basic forces. The force balance is shown in fig.

b. Automatic Expansion Valve:

AEV is also called as constant pressure expansion value. As name implies it maintains a constant pressure in the evaporator. It works on the same principle as the pressure reducing valves used in compressed air lines, oxyacetylene cylinders etc. A schematic diagram of the constant pressure Expansion. Valve is shown in fig.

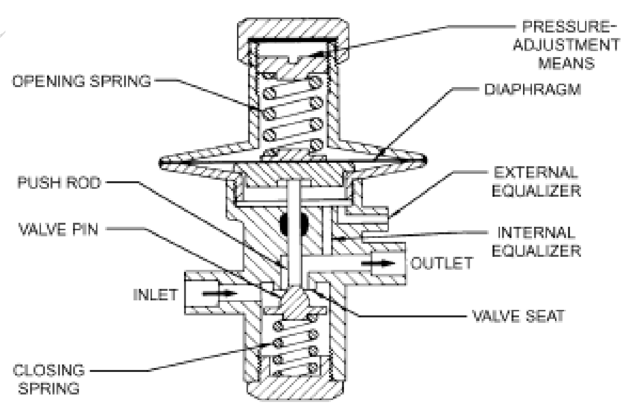


Fig.2 Automatic Expansion Valve

The valve consists of seat and needle- which forms the orifice, a metallic diaphragm or bellow, spring and an adjusting screw. The spring pressure and the atmospheric pressure acts on top of the diaphragm, thereby moving the needle a way from it seat that is moving the needle valve in the opening direction. The evaporator pressure acts below the diaphragm moving the needle valve towards the closing position. Thus the evaporator pressure and spring pressure oppose each other and whichever is greater will determine the position of the needle with respect to the seat.

When the plant is running the value maintain an evaporator pressure in equilibrium with the spring pressure plus atmospheric pressure. The tension of the spring can be varied by the spring adjusting screw. The value operates automatically to maintain a constant evaporator pressure as per the setting of the spring pressure.

By adjusting the tension of the spring, the evaporator pressure can be varied. Once a setting is made, the valve functions to maintain a constant evaporator pressure. Hence it is called the constant pressure expansion valve".

Once the plant stops, the evaporator pressure increases due to the vaporization of the liquid left in the evaporator. This increase in pressure acts on the diaphragm against the spring pressure and closes the valve tightly. It remains closed until the compressor start again and reduces the pressure in the evaporator. This is a big advantage.

2. Constant Restriction Type:

The capillary tube, a long tube with very small bore comes under constant restriction type expansion devices. The capillary tube is a fixed restriction type device. It is a long narrow tube connecting the condenser directly to the evaporator. The pressure drop through the capillary tube is due to the following reasons:

1. Friction due to fluid viscosity, resulting in frictional pressure drop.

2. Acceleration, due to the flashing of the liquid refrigerant into vapour resulting in momentum pressure drop.

The mass flow through the capillary tube will, therefore be adjusted so that the pressure drop through the tube just equals the difference in pressure between the condenser and evaporator. For a given state of the refrigerant, the pressure drop is directly proportioned to the length and inversely proportional to the bore diameter of the tube. A number of combinations of length and bore are possible for a capillary tube to obtain the desired flow and pressure drop. However, once a capillary tube has been selected, it will be suitable only for the designed pressure drop and flow. It cannot satisfy the flow requirements with changing condenser and evaporator pressures. Even then it is most commonly used expansion device in small refrigeration units such as domestic refrigerators, window A/C, water coolers, etc. The advantages of a capillary tube are its quite working, simplicity, low cost and absence of any moving part. Also it is found most suitable with on-off control because of its unloading characteristics. Thus when compressor stops it allow high and low pressure to equalize, thereby enabling the compressor motor to restart on no load. Accordingly lower starting torque motors can be used.

2.SAFETY DEVICES:

1. High pressure and low pressure cut-out:

Refrigerant compressors are provided with high pressure (HP) and low pressure (LP) cut outs. High pressure cut-out is merely a safety control. When the head pressure increases beyond a set point, the HP cutout cycles off the compressor in order to avoid the possible damage to the compressor. When the head pressure subsequently drops, the circuit is one again closed and the compressor starts. Because of the possibility of scale formation in condenser tubes and the failure of water supply high pressure cutout are essential in the system with water cooled condensers. These cutouts require manual setting.

The low-pressure cutout is used both as safety control as well as temperature control. The evaporator governs the suction pressure. A low-pressure cutout is actuated by change in suction pressure and can be indirectly used to control the evaporator temperature.

3. Starting relays:

The relays are generally used in hermetic type units. It allows the flow of electricity through the starting winding of the motor and disconnects the starting winding or starting capacitor from the circuit when the motor reaches 75% of its rated speed.

There are two types starting relays.

- Current relay
- Voltage relay.

01. Current relay:

The current relay is used primarily with capacitor start induction motors for disconnecting the starting winding and starting capacitor from the circuit. It is a Magnetic type relay and actuated by the change of current flow in running winding during starting and running periods of motor.

It consists of few turns of copper wire in which soft iron plunger is free to more up and down. This soft iron plunger is free to more up and down. This soft iron plunger may be called electronic net. It is connected in series with the running winding and the contact points, which are fitted near the electromagnet, are connected in series with the current relays with the starting winding.

When the motor is energized, the current flow through the relay in the running winding. In the starting, the magnetic field produces around the relay and attracts the plunger to close the contact thus energizing the stating winding. The speed of the motor increases gradually and when it reaches 75% of its rated speed, the motor current and magnetic field of the relay decreases. Permitting the contact points to open. Then motor runs on running winding alone.

2. Voltage Relay:

The voltage relay is growing in popularity, especially in the larger units. Its operation depends on the increase in voltage as a unit approaches and reaches its rated speed. In construction, the voltage coil made of many turns of wire as compared with current coil which is made of few turns of heavy wire and is connected parallel with starting winding. A set of content points are connected in series with the starting capacitor and closed when the motor is at rest.

When the supply is connected to the motor, the motor starts up and increases its speed then the voltage in the starting winding increases along the line voltage because of capacitor in service with this winding. The higher voltage creates more in magnetism in the relay coil, which attracts the plunger, the contact point opens and disconnect the starting capacitor from the circuit.

5) TRIAL ON REFRIGERATION TEST RIG

EXPERIMENT TITLE:

Trial on Refrigeration Test Rig

AIM:

To demonstrate vapour compression cycle and to calculate theoretical and actual COP.

PRIOR KNOWLEDGE:

Different types of refrigerants, thermodynamic processes and working of VCC.

DESCRIPTION:

The refrigeration test rig works on vapour compression cycle. The basic components of VCC are

1. Compressor
2. Condenser
3. Expansion device
4. Evaporator.

SPECIFICATIONS:

1. Compressor: Hermetically sealed type Kirloskar makes CAL-34.

2. Condenser: Air-cooled condenser with fins and cooling fan.

3. Expansion Device: 1.Thermostatic expansion valve

2. Capillary tube.

4. Evaporator: The evaporator coil is installed in the water tank. The tank is insulated.

5. Rotameter: Eureka make, range 0.32 to 3.2 kg. Calibrated for R12.

6. Energy meter: One each for power supply to the compressor and evaporator heater with

energy meter constant of -------R/kwh ---------R/kwh respectively.

7. Dimmerstat: To control power supply to the heater.

8. Solenoid valve: Solenoid valve 3/8” size Gaurav make.

9. Pressure Gauges: circuit.

10. Electric Heater: 1kw kept in evaporator tank.

11. Thermowells: For the measurement of temperature at various points in the circuit.

12. Dial Thermometer: To measure temperature in the evaporator.

13. HP & LP cutouts: Danfoss make, safety device suitable for the low and high pressure of compressor.

14. Agitator motor: 1/35 HP AVE makes for water.

15. Ammeter: For measure of current ( )

16. Volt meter: For measurement voltage ( )

17. Filter Drier: 1 No. 1/4” size Danfoss.

18. Hand shut off valve: To maintain desired path for circulation of refrigerant through the circuit hand shut off valves are used.

19. Switches: For various controls.

The refrigeration circuit is mounted on a board. The unit is supported on a frame.

TEST PROCEDURE:

i) PROCEDURE FOR STARTING THE TEST RIG:

- Ensure that sufficient amount of water is there in the evaporator tank.
    - i) Put 'ON' the main switch.
    - ii) Put 'ON' the air condenser fan and run it for 2-3 minutes.
    - iii) Then put 'ON' compressor switch.

ii) PROCEDURE FOR CONDUCT OF TRIAL:

Connect the two plugs to mains. Before putting 'ON' the supply, confirm that all the switches on panel are in 'OFF' position. See that the dimmerstat is at zero position. Then put on the heater switch and give power to heater. This will heat the water in evaporator and this can be seen on dial thermometer. Adjust the heater voltage such that the temperature on dial thermometer reading reaches to 25 to 30^{0}C.

Now put 'ON' the main switch, put 'ON' the condenser fan switch and wait for 2-3 minutes. Now put 'ON' the solenoid valve and compressor switch. The refrigerant flow will start. This can be confirmed on the rotameter. Now the ammeter, voltmeter will show the current and voltage, for 10 revolutions of energy meter for compressor.

After some time we will see that the temperature of water in the evaporator slowly goes down and reaches steady state **(adjust this temperature at 28 to 30^{0}C).**

iii) CONDUCTING TRIALS AND MEASURED READING:

After steady state note down the readings as follows:

1. Condenser pressure (HP) : ________________kg/cm^2

2. Evaporator pressure (LP) : ________________Kg/cm2

3. Rotameter reading : ________________LPH.

4. Condenser inlet tempt. (T_{ci}) : ________________0C

5. Condenser outlet tempt.(T_{co}) : ________________0C

6. Evaporator inlet tempt.(T_{ei}) : ________________0C

7. Evaporator outlet tempt.(T_{eo}): ________________0C

8. Time for 10 revolutions of

Compressor Energy meter : ________________sec.

9. Time for 10 revolutions of

Heater energy meter : ________________sec.

10. Ammeter reading : ________________amp

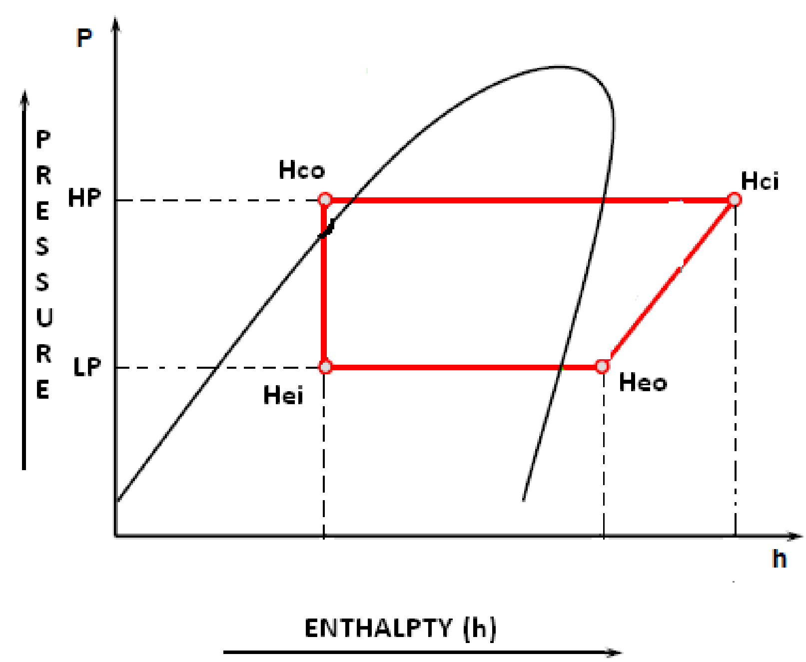
11. Voltmeter reading : ________________volt

12. Evaporator bath tempt : ________________0C

(25 to 28^0)

Fig. (ph) diagram: -

Plot the operating cycle on p-h chart



CALCULATIONS:

With the help of temperature and pressure readings draw the refrigeration cycle on p-h chart.

1. Compressor power (Wact) $= \frac{\text{rev} \times 3600}{t \times (EMC)}$

2. Heater power (Whact) $= \frac{\text{rev} \times 3600}{t \times (EMC)}$

3. COP (Actual) $= \frac{\text{Power consumed by heater}}{\text{Power consumed by compressor}}$

$= \frac{\text{Whact}}{\text{Wcact.}}$

4. Theoretical Cop $= \frac{H_{eo} - H_{ei}}{H_{ci} - H_{eo}}$

Where,

h_{eo} = Enthalpy of refrigerant at outlet of evaporator

h_{co} = h_{ei} Enthalpy of refrigerant at outlet of compressor.

h_{ci} = Enthalpy refrigerant at inlet to evaporator.

NOTE: These values can be calculated with the help of ph diagram.

5. Carnot Cop $= \frac{TL}{TH - TL}$

Where,

TH : Saturation tempt. corresponding to condenser pressure.

TL : Saturation tempt. Corresponding to evaporator pressure.

6. Relative COP : $\frac{\text{Actual Cop}}{\text{Theoretical Cop}}$

CONCLUSION:

The actual cop is less then the theoretical due to the losses at different points and also the errors made while measurement of pressures and temperature.

6) TRIAL ON AIR CONDITIONING TEST RIG.

EXPERIMENT TITLE:

Trial on Air Conditioning Test Rig

AIM:

To study basic need of air conditioning, representation of different air conditioning processes on psychrometric chart and performance of refrigeration system.

PRIOR KNOWLEDGE:

Basic concepts of refrigeration and various equipments used in refrigeration cycle. Use of refrigeration in context air conditioning.

DESCRIPTION:

Previously the air conditioning for human comfort was considered luxury in most of the countries but now a days it is a necessity. Therefore air conditioning industry is growing fastly throughout the world.

Due to increase in population and industrialization the uncomfort may be due to the inadequate supply of oxygen or unbearable temperature.

Full air conditioning does the automatic control of an atmospheric environment either for comfort of human being or animals or for the proper performance of some industrial or scientific processes. The purpose of air conditioning is to supply sufficient volume of clean air containing a specific amount of water vapour and at a temperature capable of maintaining predetermined atmospheric conditions.

In brief the air conditioning the space signifies.

1. **Temperature Control:** You can enjoy a perfect constant temperature because of the control of not only cooling but also heating.

2. **Humidity Control:** The room can be humidified or dehumidified.

3. **Air Filtering, Cleaning and Purification**: The room is cleaned by removing dust and dirt from the air.
4. **Air movement and Circulation:** Air which is cleaned and controlled in temperature and humidity is distributed throughout the room. As a result, room air can be maintained evenly.

EXPERIMENTAL SET-UP:

The equipment consists of a hermetically sealed compressor, air cooled condenser, blower for air circulation through a duct mounted on a frame, an evaporator is placed in the duct, also there are heaters of suitable capacity in the duct.

The refrigerant used in the system is R22. The mass flow rate of air through duct can be varied by arrangement provided on the blower unit. The humidity of air is increased by introducing steam generated in small boiler. The relative humidity of air at inlet and outlet can be measured by noting dry / wet bulb temperatures. The duct is insulated from outside to avoid heat loss.

The control panel consists of switches, voltmeter, ammeter etc. as well as energy meter for measuring the power consumption of compressor. The refrigeration circuit and duct are mounted on a fabricated frame.

SPECIFICATIONS:

a) Compressor: Hermetically sealed type, Kirloskar make CAT – 2425

b) Condenser: Air cooled type, cooling fan driven by motor (1/10 HP) which is

13” x 12” x 3 row.

c) Rotameter: Eureka make, range 6.1-61 LPH, calibrated for R22

d) Thermostatic Expansion valve: Danfos make no

e) Evaporator: Evaporator fitted in the duct size 10” x 10” x 3 row.

f) Blower unit: To force air through the duct 1HP 3 phase motor.

g**) Heater fitted in the duct after the evaporator:** 2kw

h) Steam generator to generate steam with suitable piping for introducing steam in the duct- 8 litre capacity, with 2 kw heater.

i) Pressure gauges for measurement of pressures.

j) HP & LP cutouts:

k) Energymeter for compressor with EMC ______ R/kwh.

TEST PROCEDURE:

The demonstration of the following processes can be done on the test rig.

1. Cooling process.
2. Heating process.
3. Cooling with dehumidification process.
4. Heating with humidification. Process.

1. COOLING PROCESS: (Sensible cooling)

it is cooling with out subtraction of moisture is termed as sensible cooling. The cooling can be achieved by parsing the air over cooling coil like evaporating coil of refrigeration cycle.

2. HEATING PROCESS:

Heating of air without addition of moisture is termed sensible heating. The heating can be achieved by passing air over heater in the duct.

The process is represented as below:

3. COOLING WITH DEHUMIDIFICATION:

In this process cooling along with humidification is carried out it is represented as below.

4. HEATING WITH HUMIDIFICATION:

It is represented as given below.

PROCEDURE: for starting the test rig.

Put 'ON" the air condenser fan and run it for 2-3 minutes.

1. Then start blower with suction full open.
2. Now put 'ON' the compressor switch, so that refrigeration cycle may produce refrigeration effect.
3. Run the plant for achieving steady temperature at condenser and Evaporator.
4. Measure the air velocity in the duct by using anemometer.
5. Note down the following observations.

CONDUCTING TRIALS AND MEASURED READING:

1. Condenser pressure = _____________kg/cm2

2. Evaporator pressure = _____________kg/cm2

3. a) Temperature of gas at inlet

to condenser Tc1 = _____________0C

b) Temperature of gas at outlet

to condenser Tco = _____________0C

c) Temperature of gas at inlet

to evaporator Tei = _____________0C

d) Temperature of gas at outlet =

to evaporator Teo = _____________0C

4) a) Refrigerant flow rate = ______________LPH.

b) Dry bulb temperature of inlet air DBT1 = __________0C

c) Wet bulb temperature of inlet air WBT1= __________0C

d) Dry bulb temp. after evaporator DBT2 = ___________0C

e) Wet bulb temp. after evaporator WBT2 = ___________0C

5) **Time for 10 revolutions of energy meter** = __________sec.

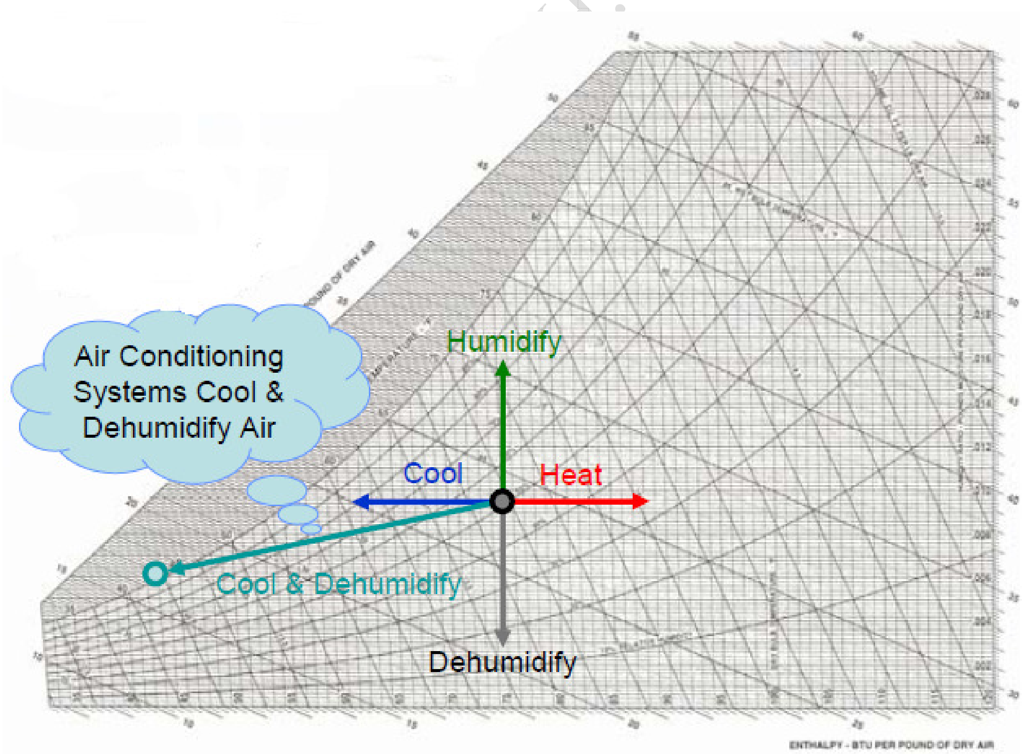
6) **Air velocity in duct** = _________m/sec

7) **Voltmeter reading** = ________volts

8) **Ammeter reading** = ____________Amp.

NOTE: Another set of reading can be done by changing the air velocity in the duct. This can be done by adjusting the flapper position of air inlet to blower. And take all the readings.

Represent all the processes on psychometric chart.



CALCULATIONS:

1. **Theoretical COP** = $\frac{Heo - Hei}{Hcl - Heo}$ (Hco = Hei)

2. **Actual COP** = $\frac{\text{Refrigeration effect produced}}{\text{Work done}}$

3. **Refrigeration effect produced** = Ma x (h1 – h2).

4. **Mass of air (ma)** = density x volume of air

5. **h1 and h2 can be calculated from psychrometric chart**

6. **Work done by compressor =** $\frac{rev \times 3600}{T \times EMC}$ watt

5. **Relative COP** = $\frac{\text{Actual COP}}{\text{Theoretical COP}}$

6. **Carnot COP** = $\frac{TL}{TH - TL}$

TH = Saturation temperature of condenser pressure in ^{o}K

TL = Saturation temperature of evaporator pressure in ^{o}K

CONCLUSION:

With the help of lab work we can verify different psychrometric processes and we can study performance of refrigeration system.

7) TRIAL ON MECHANICAL HEAT PUMP

EXPERIMENT TITLE:

Trial on Mechanical Heat Pump

AIM:

To study the Mechanical Heat Pump Testing Rig and calculate its Coefficient of Performance (COP).

PRIOR KNOWLEDGE:

Basic concepts of Heat Pump and various equipments used in testing rig. Use of Mechanical heat pump in Refrigeration.

DESCRIPTION:

Now-a-days, energy conservation is becoming very important. Hence engineers have started using heat pump systems for commercial and industrial buildings to save energy.

The heat pump is a machine that absorbs heat at one location and transfers it to another location at a different temperature. Heat pump is the modern expression for a refrigeration system In which heat discharged at the condenser is of prime importance. Thus heat pump is device which collects heat from one source and delivers it to another source using refrigeration cycle. The medium being, cooled serves as heat source. Heat is picked up by the refrigerant, which is pumped to another higher level by the compressor and given to the medium cooling condenser so that it can be used practically.

The heat pumps can be operated on low temperature heat energy using winter air, a body of water or the ground as a reservoir and rejecting heat at a higher temperature, not enough to energize heating systems. Thus the basic heat sources that are normally used are air, water and earth. When heat pumps are installed frequently provision is made for both heating and cooling services to be supplied simultaneously to the separate zones of buildings.

EXPERIMENTAL SET-UP:

Mechanical Heat Pump is a table mounted model which uses water as well as air as a heat source and sink for both cooling and heating purposes. The experiments can be done as water to water heat pump i.e. using water condenser and water evaporator and water to air heat pump i.e. using water condenser and air evaporator.

On the unit, compressor is mounted centrally and both the water and air condensers are mounted on either sides of the compressor. All the components are mounted on the main unit and the schematic layout of the Mechanical Heat Pump Is sell-explanatory.

SPECIFICATIONS:

a) Compressor: Kirloskar Make, hermetically sealed. Model CAJ 2612 using R-12 refrigerant.

b) Condenser: Water cooled copper tube, Shell & Coil type.

c) Rotameter: Eureka make, range 6.1-61 LPH, calibrated for R22

d) Thermostatic Expansion valve: Thermostatic expansion valve having 1/2 ton of Refrigerating Capacity.

e) Evaporator: (a) Water circulated copper tube, Shell and Coil type.

(b) Air circulated copper tube type.

g) Multichannel Digital temperature indicator with thermocouples: 0-300^0 C. with 1^0 C least count

h) Pressure gauges: Two Nos. for delivery and suction for measurement of pressures.

i) HP & LP cutouts: of suitable range**.**

j) Energymeter for compressor with EMC ______ R/kwh.

TEST PROCEDURE / OPERATING PROCEDURE:

WATER TO WATER HEAT PUMP

This experiment is performed by using water condenser and water evaporator. -

i) Start the water supply to both condenser and evaporator and adjust the flow rate to predetermine value.

ii) See that pressures in both the gauges are equal.

iii) Put 'ON' the main switch.

iv) Check the valve positions as per given diagram.

v) Now, start the compressor cooling fan first and then start the compressor. Within a short period, clear liquid refrigerant flow will be seen in the rotameter.

vi) After sometime the pressure of refrigeration cycle will become stable. Allow the plant to run for at least half an hour.

vii) During testing see that water flow rates are constant and not varying.

viii) Allow the plant to attain steady state. Check tor steady state by taking the readings periodically.

ix) Take all readings as mentioned in the observation table. Complete one set of observations.

x) By varying the water flow rate of condenser, effect of sub- cooling can be studied. Similarly by varying water flow rate of evaporator, load on the plant can be varied.

CONDUCTING TRIALS AND MEASURED READING:

1. Condenser pressure = _____________kg/cm2

2. Evaporator pressure = _____________kg/cm2

3. Tempratures

a) Condenser Inlet T_{ci} = _____________0C

b) Condenser Outlet T_{co} = _____________0C

c) Evaporator Inlet T_{ei} = _____________0C

d) Evaporator Outlet T_{eo} = _____________0C

4) **a) Refrigerant flow rate** = _______________LPH.

5) **Time for 10 revolutions of**

Compressor energy meter = __________sec.

CONDENSER SIDE

1) **Water Temperature**

a) Inlet = ________ ^{o}C

a) Outlet = ________ ^{o}C

2) **Water flow rate** = _________LPH

EVAPORATOR SIDE

1) **Water Temperature**

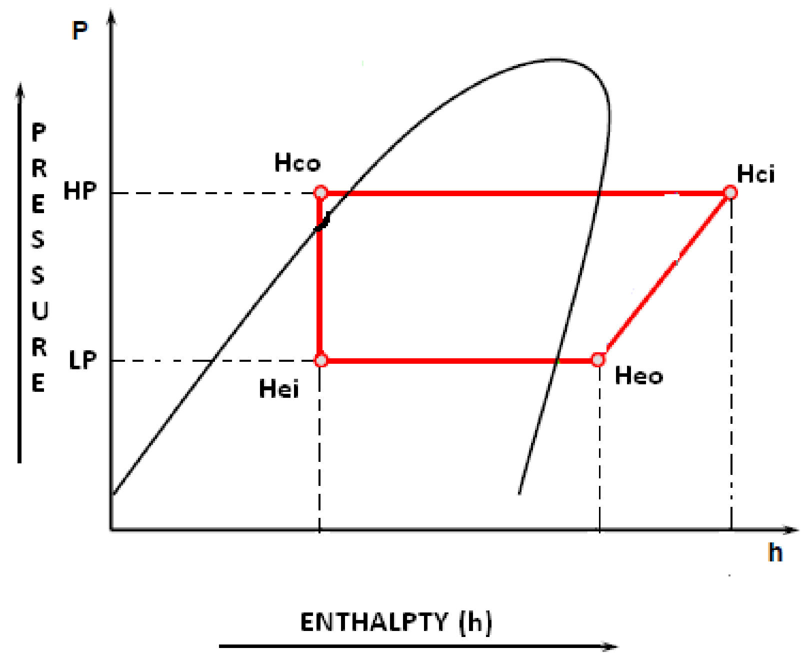
a) Inlet = ________ ^{o}C

a) Outlet = ________ ^{o}C

2) **Water flow rate** = _________LPH

Fig. (ph) diagram: -

Plot the operating cycle on p-h chart



CALCULATIONS:

1. **Theoretical COP** = $\frac{Heo - Hei}{Hcl - Heo}$ (Hco = Hei)

2. **Actual COP** = $\frac{\text{Heat absorbed in evaporator from water}}{\text{Compressor Work}}$

3. **Heat absorbed in evaporator from water** = $m_e \times C_p \times T_e$

Where,

m_e = Mass flow rate of water in evaporator Kg / hr

C_p = Specific heat of water 1 Kcal / Kg ^oC

T_e = Temp. difference of water in Evaporator

4. **Work done by compressor =** $\frac{860 \times 10 \times 3600}{T_c \times EMC}$ watt

Where,

T_c = Time for 10 revolutions of energymeter disc sec.

5. **Relative COP** = $\frac{\text{Actual COP}}{\text{Theoretical COP}}$

6. **Carnot COP** = $\frac{TL}{TH - TL}$

TH = Saturation temperature of condenser pressure in ^{o}K

TL = Saturation temperature of evaporator pressure in ^{o}K

CONCLUSION:

With the help of above data we can determine the COP of the Mechanical Heat Pump and study performance of various Heat Pumps.

8) TRIAL ON ICE PLANT TEST RIG

EXPERIMENT TITLE:

Trial on Ice Plant Test Rig

AIM:

To study the Ice Plant Testing Rig and calculate its Coefficient of Performance (COP).

PRIOR KNOWLEDGE:

Basic concepts of simple vapor compression cycle. Ice formation process in Ice factory.

DESCRIPTION:

Introduction:

Ice is needed in commercials units, Medicines and in food processes etc. This ice is manufactured in large plant requires a huge space. However present compact unit is useful to study the process of ice making and to know the behavior of basic parameters of the system. Ice cans be produced by two methods:

1) Plate Type
2) Can Type

The present equipment uses compression cycle system with Freon 12 as the cooling media. The unit differs in many aspect than the commercial plants.

The equipment consists of control panel, condensing unit, cooling system, brine solution tank and a main tank etc. The brine tank is insulated from all sides with a door at the top side to load / unload the cans. The brine is placed in main tank.

The brine tank has a structure at the top side where the cans be hold. An agitator (stirrer) is used to stir the brine solution. A drain is provided to at the brine tank. This tank is coated from inside to prevent any action by brine.

The compressor is mounted at one side of base with a condenser and fan. A liquid receiver is adopted in the circuit. The evaporator coil is held at one side in the brine tank.

The panel consist of switches, energymeter, pressure gauges, HP/LP cutout, dial thermometer.

EXPERIMENTAL SET-UP:

Mechanical Heat Pump is a table mounted model which uses water as well as air as a heat source and sink for both cooling and heating purposes. The experiments can be done as water to water heat pump i.e. using water condenser and water evaporator and water to air heat pump i.e. using water condenser and air evaporator.

On the unit, compressor is mounted centrally and both the water and air condensers are mounted on either sides of the compressor. All the components are mounted on the main unit and the schematic layout of the Mechanical Heat Pump Is sell-explanatory.

SPECIFICATIONS:

a) Compressor: Kirloskar Make, hermetically sealed.

b) Condenser: Air Cooled Condenser size 14” X 14” with cooling fan.

c) Brine Tank: Brine tank is insulated from all side with provision to hold cans, evaporator coil at one side and arrangement to drain the brine solution. The door is provided at the top of this tank.

d) Ice Tank: Suitable size made out of galvanized sheet.

e) Stirrer arrangement: A fan is used to stir the brine solution and is connected to the shaft of an electrical motor of suitable capacity.

f) The panel: Following items are mounted on panel

i) High and Low pressure gauge: These gauges indicate, High and Low pressure respectively in the circuit.

ii) Thermostat and HP/LP cut: These are the safety devices for the compressor.

iii) Energymeter : To measure the power consumption of the compressor.

iv) Switches for compressor, condenser fan and a starter for stirrer motor.

v) Dial thermometer for measurement of brine temperature.

PREPERATION OF UNIT FOR TEST :

Empty before starting the refrigeration cycle please check the following :

- The pressure gauges should indicate equal pressure, that indicates HP & LP side are balanced. Proper earthing is provided to unit.
- See that the motor shaft along with fan is free in its bearing.
- This can be conformed by rotating the shaft manually cans concentration of brine.
- Put water in the brine tank approximately up to mark.
- Add 100 Kgs of common salt in tho the tank without splashing the water.
- Then stir this water by using the stirrer for some time.
- If the strength is proper then closed door of the tank also confirm that there is no leakage at the drain of the tank.

TEST PROCEDURE:

This experiment is performed by using water condenser and water evaporator. -

i) Start the water supply to both condenser and evaporator and adjust the flow rate to predetermine value.

ii) See that pressures in both the gauges are equal.

iii) Put 'ON' the main switch.

iv) Check the valve positions as per given diagram.

v) Now, start the compressor cooling fan first and then start the compressor. Within a short period, clear liquid refrigerant flow will be seen in the rotameter.

vi) After sometime the pressure of refrigeration cycle will become stable. Allow the plant to run for at least half an hour.

vii) During testing see that water flow rates are constant and not varying.

viii) Allow the plant to attain steady state. Check tor steady state by taking the readings periodically.

ix) Take all readings as mentioned in the observation table. Complete one set of observations.

x) By varying the water flow rate of condenser, effect of sub- cooling can be studied. Similarly by varying water flow rate of evaporator, load on the plant can be varied.

CONDUCTING TRIALS AND MEASURED READING:

1. **Condenser pressure** = _____________kg/cm2

2. **Evaporator pressure** = _____________kg/cm2

3. **Tempratures**

a) Condenser Inlet T_{ci} = _____________0C

b) Condenser Outlet T_{co} = _____________0C

c) Evaporator Inlet T_{ei} = _____________0C

d) Evaporator Outlet T_{eo} = _____________0C

4) **a) Refrigerant flow rate** = ______________LPH.

5) **Time for 10 revolutions of**

Compressor energy meter = __________sec.

CONDENSER SIDE

1) **Water Temperature**

a) Inlet = ________^{o}C

a) Outlet = ________^{o}C

2) **Water flow rate** = _________LPH

EVAPORATOR SIDE

1) **Water Temperature**

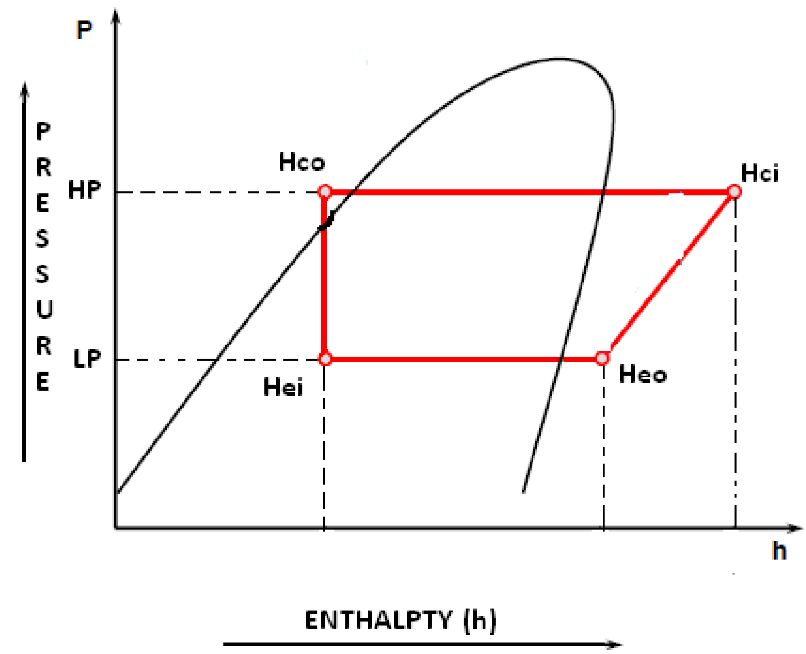
a) Inlet = ________^{o}C

a) Outlet = ________^{o}C

2) **Water flow rate** = _________LPH

Fig. (ph) diagram: -

Plot the operating cycle on p-h chart



CALCULATIONS:

1. **Theoretical COP** = $\frac{Heo - Hei}{Hcl - Heo}$ (Hco = Hei)

2. **Actual COP** = $\frac{\text{Heat absorbed in evaporator from water}}{\text{Compressor Work}}$

3. **Heat absorbed in evaporator from water** = $m_e \times C_p \times T_e$

Where,

m_e = Mass flow rate of water in evaporator Kg / hr

C_p = Specific heat of water 1 Kcal / Kg ^{o}C

T_e = Temp. difference of water in Evaporator

4. **Work done by compressor** = <u>860 X 10 X 3600</u> watt

. T_c x EMC

Where,

T_c = Time for 10 revolutions of energymeter disc sec.

5. Relative COP = $\dfrac{\text{Actual COP}}{\textbf{\textit{Theoretical COP}}}$

6. Carnot COP = $\dfrac{TL}{TH - TL}$

TH = Saturation temperature of condenser pressure in ^{o}K

TL = Saturation temperature of evaporator pressure in ^{o}K

CONCLUSION:

With the help of above information we can evaluate the process of Ice Manufacturing and we can also find out COP of the unit.

9) TECHNICAL REPORT ON VISIT TO REFRIGERATION AND AIR CONDITIONING ESTABLISHMENTS

In this particular visit students are expected to visit the Refrigeration and Air Conditioning unit or Industry. Where they can learn thorough things about the plant and processes of the R&AC. They are also intended to write a Technical Report on the visit.