INSTITUTE OF TEXTILE TECHNOLOGY, CHOUDWAR

RAC LAB MANUAL

5th Semester

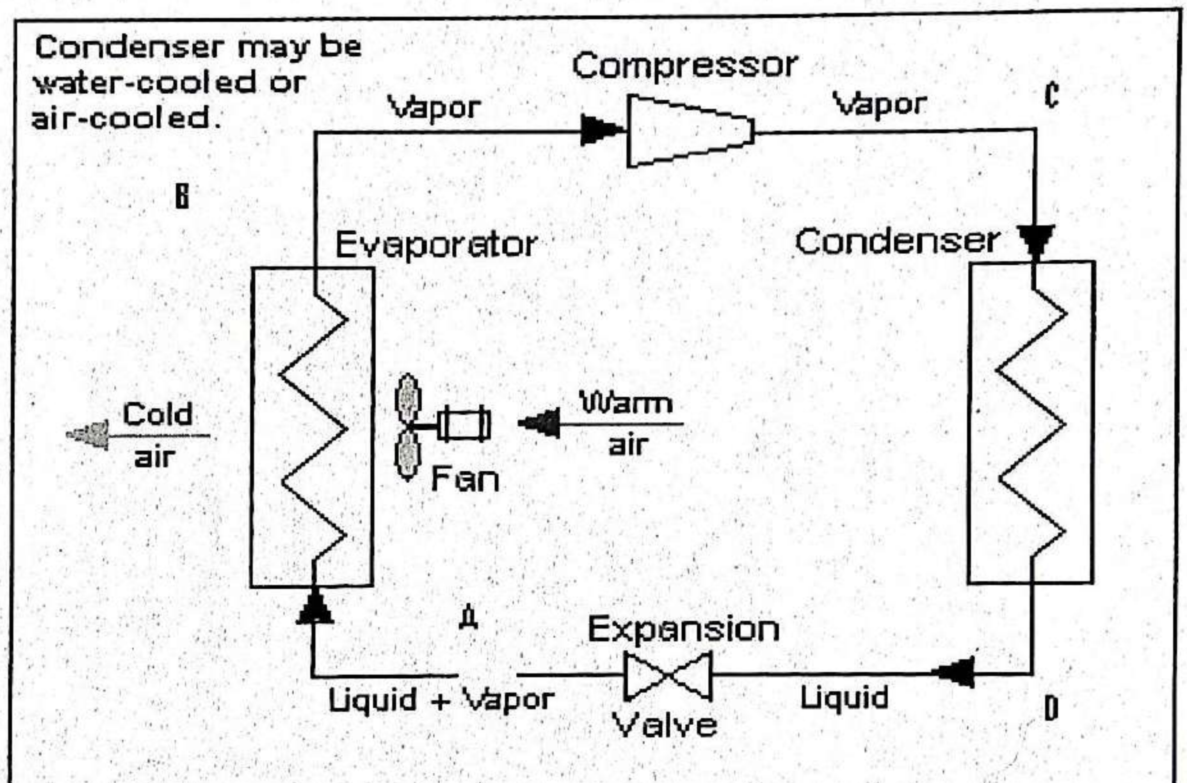
Branch: Mechanical

MANORANJAN PANDA
MECHANICAL INSTRUCTOR
5th Semester

Study the construction features of Domestic Refrigerator.

THEORY

A simple vapor compression refrigeration system consists of the following equipments: i) Compressor ii) Condenser iii) Expansion valve iv) Evaporator



TYPICAL SINGLE-STAGE VAPOR COMPRESSION REFRIGERATION

The low temperature, low pressure vapor at state B is compressed by a compressor to high temperature and pressure vapor at state C. This vapor is condensed into high pressure vapor at state D in the condenser and then passes through the expansion valve. Here, the vapor is throttled down to a low pressure liquid and passed on to an evaporator, where it absorbs heat from the surroundings from the circulating fluid (being refrigerated) and vaporizes into low pressure vapor at state B. The cycle then repeats.

The exchange of energy is as follows:

Compressor requires work, δw. The work is supplied to the system from the surroundings.

During condensation, heat δQ1 the equivalent of latent heat of condensation etc, is lost from the refrigerator.
During evaporation, heat δQ2 equivalent to latent heat of vaporization is absorbed by the refrigerant.

There is no exchange of heat during throttling process through the expansion valve as this process occurs at constant enthalpy.

Factors Affecting the Performance of Vapor Compression

Refrigeration System:

(a) Sub-cooling of Liquids:

In simple vapor compression cycle, condensation process CD resulted in the liquid at saturated state D. If it was possible to further cool down the liquid to some lower value then the net refrigeration effect will be increased as (Hence, the sub cooling of the liquid increases the refrigerating effect without increasing the work requirement. Thus COP is improved. The sub cooling may be achieved by any of the following methods:

By passing the liquid refrigerant from condenser through a heat exchanger through which the cold vapor at suction from the evaporator is allowed to flow in the reversed direction. This process subcools the liquid but superheats the vapor. Thus, COP is not improved though refrigeration effect is increased.

By making use of enough quantity of cooling water so that the liquid refrigerant is further cooled below the temperature of saturation. In some cases, a separate subcooler is also made use of for this purpose. In this case, COP is improved.

Superheating of Vapor:

If the vapor at the compressor entry is in the superheated state , which is produced due to higher heat absorption in the evaporator, then the refrigerating effect is increased .However, COP may increase, decrease or remain unchanged depending upon the range of pressure of the cycle.

Change in suction pressure (PS):

Let the suction pressure or the evaporating pressure in a simple refrigeration cycle be reduced.

Decrease in suction pressure decreases the refrigeration effect and at the same time increases the work of compression. But, both the effects tend to decrease the COP.

Change in discharge pressure (Pd):

let us assume that the pressure at the discharge or the condensing pressure is increased.

Therefore, the increase in discharge pressure results in lower COP. Hence, the discharge pressure should be kept as low as possible depending upon the temperature of the cooling medium available.

(e) Effect of Volumetric Efficiency of Compressor:

The factors like clearance volume, pressure drop through discharge and suction values, leakage of vapor along the piston and superheating of cold vapor due to contact with hot cylinder walls, affects the volume of the vapor actually pumped by the compressor. The volumetric efficiency of a compressor is defined as;

$$\eta vol = \frac{\text{Actual mass of vapor drawn at suction conditions}}{\text{Theoritical mass that can be filled in the displacement volume}}$$

A vapour compression system is improved type of air refrigeration system in which suitable working substance termed as refrigerant is used, it condensates and evaporates at temperature and pressure close to atmospheric conditions. The refrigerants used for this purpose are ammonia, carbon dioxide, and sulphur dioxide.

The refrigerant used does not leave the system, alternatively condensing and evaporating. In evaporation, the refrigerant absorbs it's latent heat from which it is used for circulating it around the cold chamber while cost during it gives latent heat to the circulating water of the cooler. The VCS is thus latent heat pump as it pumps
its latent heat from brine end and delivers it to the cooler. It is generally used for all individual purposes from small domestic refrigerator to a big air conditioning plant.

ADVANTAGES:

1. It has similar size for given capacity of refrigerator.
2. It has less running cost.
3. It is employed for large range of temperature.
4. The COP is quite higher.

DISADVANTAGES:

1. The initial cost is higher.
2. The leakage of refrigerant is difficult to avoid.

SYSTEM DESCRIPTION

In refrigeration test rig, working medium is liquid; which involves sensible as well as latent heat. And coefficient of performance of refrigeration test rig is more than that of air compression system. Most of the modern refrigerators work on refrigeration test rig.

Therefore it is necessary for engineering students to Study the performance of refrigeration cycle & its different parameter, performance, calculations is focus of this trainer.

S.P. Engineers have designed this system in such a fashion that, Vapour Compression Refrigeration cycle & its components can be easily understood. The system can be easily operated; demonstrated & requisite experimentation can be performed.

- **Base Stand:**

  This is made up of CRCI square tubes & sheets. This is painted specially with Powder coating. All equipments are mounted on Base stand.

- **Hermetically Sealed Compressor:** This is used to take the refrigerant Vapor at low pressure & low temperature & compress it to a high pressure & high temperature. The capacity of compressor is 0.75 HP
- **Condenser**: The condenser is the forced air-cooled type for which condenser fan and motor has been provided. The function of condenser is to convert high-pressure refrigerant Vapor into high-pressure refrigerant liquid. The outside diameter of condenser is

3/8". Size of condenser as per standard specification is 11" x 10" x 3 Rows

- **Expansion Devices:** (Capillary Tube): Capillary tube is the expansion device which is used for small units of ½ to 3 tons. The purpose of expansion valve in a refrigeration system is to reduce the high side pressure to the low side pressure so that liquid can evaporate by picking up heat. The length and the small diameter reduce the pressure from condensing pressure to evaporator pressure. Overall Dimension is
  (Bore x Length) = 0.50" x 5" x 1

- **Drier:** The primary function of the drier is to separate gas and liquid. The secondary purpose is to remove moisture and filter out dirt.

- **Pt 100-sensors (Pencil Type & Bulb Type):** The temperatures at different points in the system are measured by using RTD (PT – 100) sensors. These are Resistance Temperature Detectors operating on principle of change in Resistance with change in temperature.
- **Evaporator:** This is made up of S.S material having inbuilt coil and heater. It is used as a evaporator in the system.

A. Instrument Panel consists:

The temperatures at different points are recorded in following order

T1 = Temperature at compressor suction

T2 = Temperature at compressor discharge

T3 = Temperature after condenser

T4 = Temperature after expansion

T5 = Temperature of tank water

- **Rotameter**: This is a variable area glass tube liquid flow-measuring device. The glass tube is enclosed in M.S. structure with transparent glass at two sides to read the readings. Calibrated scale is mounted in the enclosure. The float is lifted up as liquid flows through the glass tube and the lift is proportional to the flow rate. Its range is 6.8-68 LPH
- **Pressure Gauge (0 to 300 PSI.)**: It is a Bourdon type pressure gauge. This is used to measure pressures at discharge point of compressor
- **Compound Gauge. (-30 to 150 PSI.)**: This Bourdon type pressure gauge measures both negative pressure (Vacuum) as well as positive pressure. This is used to measure pressures at suction point of compressor.

- **Motor pump** : the pump is used as stirrer in the system so as the refrigeration effect should uniformly done.
- **Energy meter** : its main purpose is to indicate the energy consumed by the compressor
- **Thermostat** : it acts as a cut off of the system it switch off the compressor as soon as the temperature of the evaporator drops below set point.
- **Herter coil** : it acts as the load to the refrigeration effect and the heater is placed inside the evaporator.

EXPERIMENT NO.

Aim:

Determine the capacity and cop of vapour compression Refrigerator test rig.

THEORY:-

System Components:

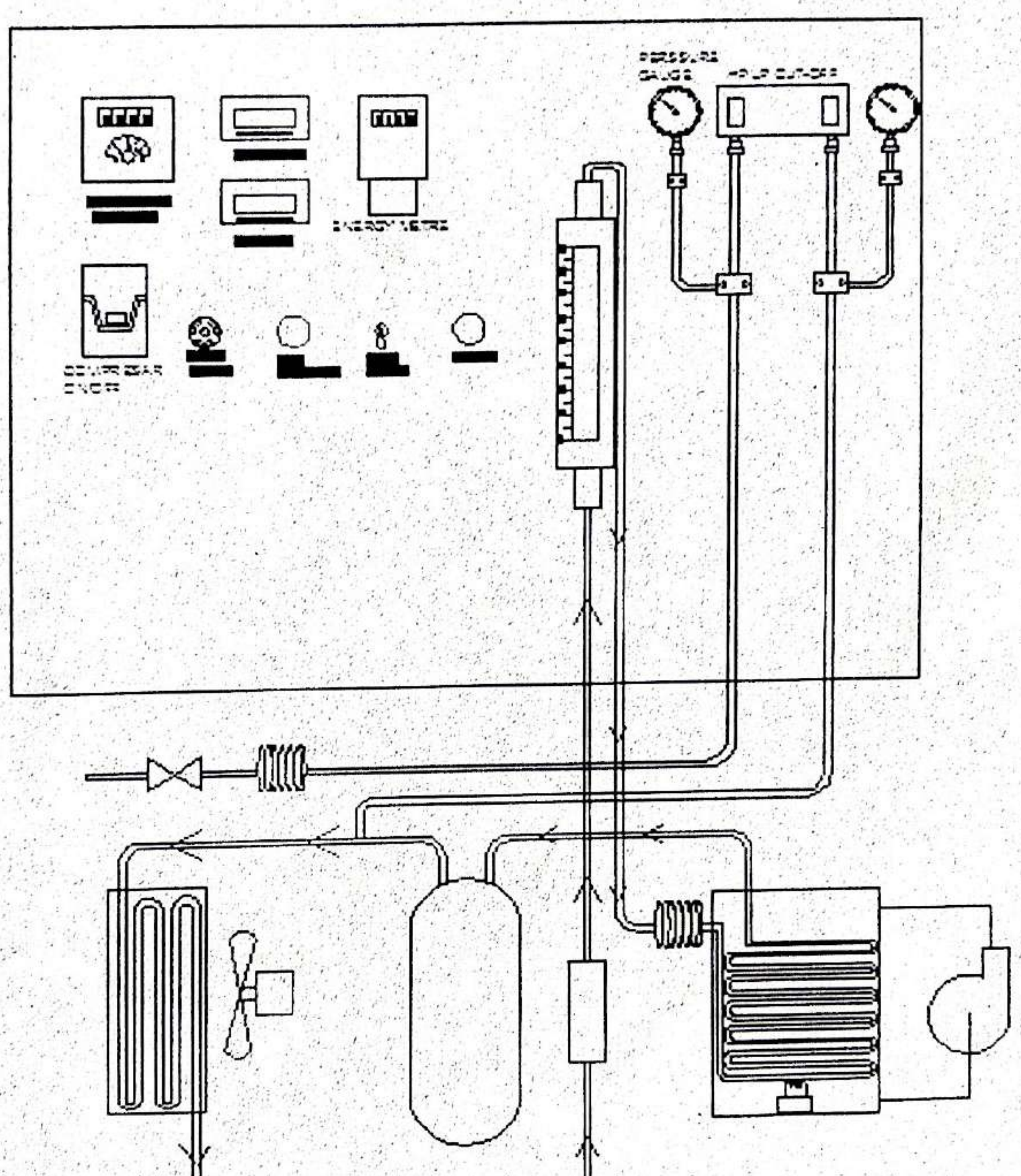
- Compressor
- Condenser
- Rotameter
- Evaporator
- Temperature indicator
- Pressure gauges and compound gauges
- Expansion device
- Energy meter

Experimental Procedure:

1. Fill the evaporator tank up to the end level.
2. Ensure that hand valve is in fully closed.
3. Apply 230 V supply by inserting the three pin top in socket provided on the distribution board in your laboratory.
4. Switch on the mains supply and stirrer on/off switch.

5. Switch on electric heater by rotating dimmer in clockwise direction, and if the ambient temp is less Please load the system initially to 35 ^{0} C before starting the compressor.
6. Switch on the compressor on/off switch.
7. Check that compressor energy meter starts & Rotameter float is lifted up indicating that the compressor is working. The pressure gauge reading is increasing and compound gauge reading is decreasing.
8. Observe that Temperature of load tank (T5) decreases showing cooling effect.
9. Note down the readings according to observation table
10. Switch off the compressor on/off & stirrer on/off switch.
11. Switch off the main switch.
12. Repeat the above procedure for other experiments.

ASSEMBLY DRAWING



OBSERVATION TABLE

Sr. No.	T_1	T_2	T_3	T_4	T_5	Refrigerant flow (lph)
01						
02						
03						
04						

Suction pr. P_1	Discharge pr. P_2	Energy meter reading (W)	Voltage (V)	Current (I)

CALCULATION PROCEDURE

Calculation Procedure for calculating Coefficient Of Performance:

1. **C.O.P (Carnot Cycle)** $= \dfrac{T_1}{T_2 - T_1}$ (Where temperature is in ^{0} K)

    T_1 = Saturation temperature at suction pressure of compressor.

    T_2 = Saturation temperature at Discharge pressure of compressor.

Convert the pressure in psi to pressure in atmosphere

$$P_1 \text{ (bar)} = \frac{P1}{14.5} + 1$$

$$P_2 \text{ (bar)} = \frac{P2}{14.5} + 1$$

Refer table (Saturated properties of R -134 liquid and vapor)

2. **C.O.P. (Theoretical)** $= \dfrac{h_1 - h_4}{h_2 - h_1}$

Find out the enthalpy values using Property chart of R-134

h_1 = Enthalpy (for gas) of R-134 at compressor inlet (P_1)

h_2 = Enthalpy (for gas) of R-134 at compressor exit (P_2)

$h_3 = h_4$ = Enthalpy (for Liquid) of R-134 at condenser exit (P_2)

3. $$COP_{actual} = \frac{\textbf{Refrigeration Effect}}{\textbf{Energy consumed by Compressor}}$$

Refrigeration Effect = $m_{refri.}\ (h_1 - h_4)$

= --------- kW

Where $m_{refri.}$:

$$= \frac{\text{Refrigerant flow rate * density of refrigerant at condenser outlet}}{3600 * 1000}$$

=--------- kg/sec

Energy consumed by Compressor = W_C

$$= \frac{3600 \text{X no of blinks}}{3200 \text{x time for no of blinks}} \ KJ/S^2$$

Calculation of heat balance at evaporator, condenser, and overall system

1. Heat accepted at compressor = $m_{refri.}$ (h2 – h1)

$m_{refri.}$ = {LPH / (1000 X 3600)} x Density of Refrigerant at Condenser Outlet

2. Heat rejected at Condenser = $m_{refri.}$ (h2 – h3)

3. Heat accepted at Evaporator = $m_{refri.}$ (h1– h4)

Refer the Property chart of R-134. to find out the Density at condenser outlet

Find out the enthalpy values using Property chart of R-134

h_1 = Enthalpy (for gas) of R-134 at compressor inlet (P_1)

h_2 = Enthalpy (for gas) of R-134at compressor exit (P_2)

$h_3 = h_4$ = Enthalpy (for Liquid) of R-134 at condenser exit (P_2)

RESULT TABLE

SR. NO.	C.O.P (CARNOT CYCLE)	C.O.P. (THEORETICAL)	C.O.P. (ACTUAL)

CONCLUSION:

EXPERIMENTAL AIR CONDITIONER SPLIT TYPE

1. AIM :

The aim of the test rig is :

(i) To study a vapour compression refrigeration system and to determine its coefficient of the performance.

(ii) To understand the concept of air conditioning.

(iii) To determine the air conditioning capacity.

Figure shows the schematic of the unit with complete description.

2. TOOLS USED: -

(a) Stop watch- To measure the Energy meter readings.

(b) Anemometer – To measure the velocity of air flowing out from duct.

3. DESCRIPTION OF THE EXPERIMENTAL A/C SPLIT TYPE

The unit consists of a Compressor. Both evaporator and the air cooled condenser are mounted as a single box with separate fans. Air is sucked from the room and is given out to the room after cooling (Via the evaporator). The unit also consists of a rotameter to measure the refrigerant flow rate, filter drier, an energy meter. The system is provided with digital voltmeter, ammeter, a digital temperature display and digital air rate indicator.

The system is fully instrumented to measure ;

(i) Pressure at suction and discharge.
(ii) Temperatures at various points.
(iii) Compressor energy consumption (voltmeter and ammeter and energy meter)
(iv) Refrigerant flow rate.
(v) Capacity of the air conditioner.

4. THEORY

The experimental air conditioner split type works as a standard vapour compression cycle. A brief account on the standard vapour compression cycle as follows :

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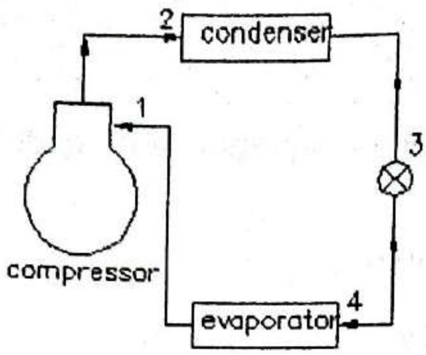
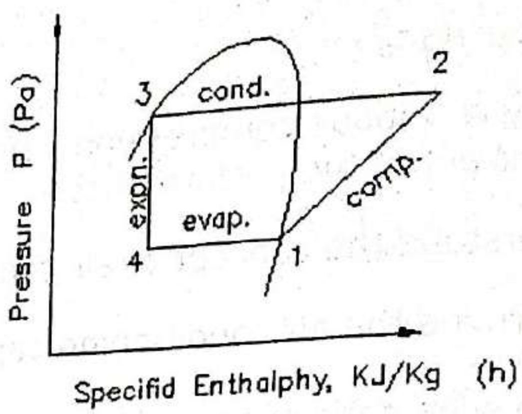
STANDARD VAPOUR – COMPRESSION CYCLE





The SVCC consists of the following processes :

1-2 Reversible adiabatic compression from saturated vapour to a superheated condition (electrical) input.

2-3 Reversible heat rejection at constant pressure (desuperheating and condensation of the refrigeration).

3-4 Irreversible isenthalpic expansion from saturated liquid to a low pressure vapour.

4-1 Reversible heart addition at constant pressure.

The actual cycle differs from the SVCC due to a number of practical consideration.

R12, R22 (Freons) are commonly used as refrigerants due to their special properties.

The coefficient of the performance of any refrigeration cycle is defined as the ratio between net refrigeration (output) and compressor work (input).

$$\text{C.O.P.} = \frac{\text{Net refrigeration}}{\text{Compressor work}}$$

The C.O.P. value is an indication of how well the system is operating.

1. Air Conditioning Process

(a) C.O.P. Determination

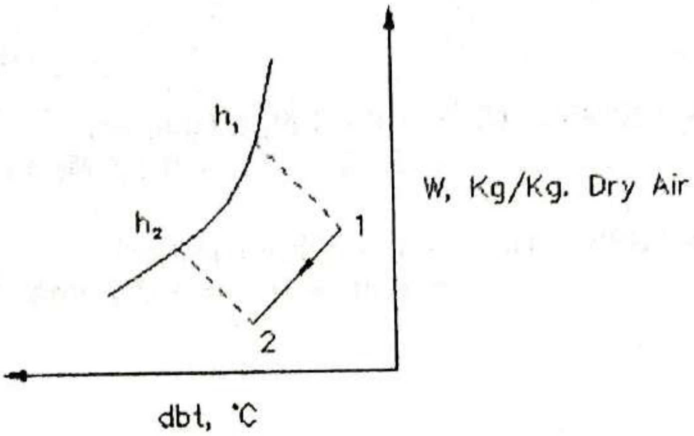
Mark state points 1 (using P_1, T_1), 2. (P_2, T_2), 3. (P_2, T_3), p-h diagram for R-22 read h_1, h_2 and h_3. ($h_3 = h_4$)

$$\text{C.O.P.} = \frac{h_1 - h_4}{h_2 - h_1}$$

Determine the density of the liquid refrigerant from tables and determine the mass flow rate of the refrigerant.

(b) AIR CONDITIONING PROCESS

The air conditioning process in the system can be represented by combination of cooling and dehumidification on a psychometric chart.



Psychrometric Chart

Mark points 1 and 2 using dry and wet bulb temperatures at each point.

On Psychometric Chart

1 – Ambient condition
2 – Average condition at the outlet of evaporator (air conditioned)

5. OPERATING PROCEDURE FOR AIR CONDITIONING TEST RIG

(i) Take all the necessary precautions regarding power supply.
(ii) Make sure the water level in the wet bulb.
(iii) Allow the air conditioner to stabilize.
(iv) Record T_1, T_2 and T_3 and T_4 and P_1, P_2 and the rotameter reading corresponding to the refrigeration system. Also note down the dry and wet bulb temperatures at the exit from evaporator to the room. Measure air flow rate using an anemometer. Note down voltmeter, ammeter on energy meter reading.

6. TABLE OF READINGS

Sl. No.	Pressure in Psi		Temp. in Deg. c				Avg. Air velocity in m/s	Ref. Flow Rate in LPM	V (Volts)	I (Amp)	E/M Reading Comp in sec/rev
	P_1	P_2	T_1	T_2	T_3	T_4					
01	62.5	240	17	79	29	10	8.6	0.9	226	4.79	36 / 10

Sl. No.	Dry Bulb Temp. Inlet	Wet Bulb Temp. Inlet	Dry Bulb Temp. Outlet	Wet Bulb Temp. Outlet
01	25	20	10	9

7. SAMPLE CALCULATIONS :

C.O.P. Evaluation :

$P_1 = 62.5$ psi $= 62.5 \times 6895 \times 10^{-06} = 0.43$ Mpa (gauge)
$= 0.43 + 0.1 = 0.53$ Mpa (absolute)

$P_2 = 240$ psi $= 240 \times 6895 \times 10^{-06} = 1.66$ Mpa (gauge)
$= 1.66 + 0.1 = 1.76$ Mpa (absolute)

T_1 = 17 deg. c
T_2 = 79 deg. c
T_3 = 29 deg. c
T_4 = 10 deg. c

Volume flow rate of refrigerant V = 0.9 lit / min

$$= \frac{0.9}{1000} \times 60 \ m^3 / s$$

$$\mathbf{= 1.5 \times 10^{-5} \ m^3 / s}$$

E/M reading = 36 sec / 10 rev.

E/M constant = 1500 rev / KWH

$$\text{Power consumed by compressor} = \frac{10}{36} \times \frac{\sout{3600}\ 3600}{\sout{1500}\ 3200 \text{ Impulse/kwh}}$$

= 0.66 KW = 666.7 W

Locate 1,2,3,4 on p-h chart for R-22 using (P_1, T_1), (P_2, T_2) & (P_2, T_3). Read specific enthalpy values at 1,2,3 and 4.

h_1 = 417 Kj / kg
h_2 = 448 Kj / kg
$h_3 = h_4$ = 236 kj/kg

$$\text{C.O.P.} = \frac{h_1 - h_4}{h_2 - h_1} = \frac{417 - 236}{448 - 419} = \frac{181}{29} = 6.24$$

Density of refrigerant, R-22 at T_3 = 29 deg. c is read from table.

at 28 deg. c $\rho_1 = 1178.9$ kg / m^3

at 30 deg. c $\rho_2 = 1170.8$ kg / m^3

at 29 deg. c

$$\text{ref} = \frac{\rho_1 + \rho_2}{2}$$

$$= \frac{1178.9 + 1170.8}{2}$$

$$\rho = 1174.85 \text{ kg / m}^3$$

Mass flow rate pf refrigerant $M_{ref} = \rho_{ref} \times V_{ref}$

$= 1174.85 \times 1.5 \times 10^{-5}$

= 0.0176 kg / s

AIR CONDITIONING PROCESS

STATE 1 : Ambient

dbt 1 = 25 deg. c , and humidity from hygrometer

to find (wbt 1 = 20 deg. c (from psychrometric chart)

STATE 2 : Air Outlet of Air Conditioner

dbt 2 = 10 deg. c
wbt 2 = 09 deg. c

SENSIBLE COOLING

Sensible Cooling = dbt 1 - dbt - 2
= 25 - 10
= 15 deg. c

State points 1 & 2 on psychometric chart using dbt 1, wbt 1. dbt 2 & wbt 2 and corresponding Humidity Ratio and enthalpy values are read. (humidity ratio).

w_1 = 12.75 g / Kg of dry air
w_2 = 7.5 g / Kg of dry air
h_1 = 58 kj / Kg of dry air
h_2 = 25 kj / Kg of dry air

DEHUMIDIFICATION

Dehumidification = $w_1 - w_2$
= 12.75 - 7.5
= 5.25 g / kg of dry air

dh = $h_1 - h_2$
= 58 - 25
= 33 kj / kg of dry air

Density of air (Page 12) is

at 10 deg. c (283 k)
at 250 k = 1.4128 kg / m³
at 300 k = 1.1774 kg / m³

$$\text{at } 283\text{ k} = 1.1774 + \left(\frac{300 - 283}{300 - 250}\right)(1.4128 - 1.1774)$$

= 1.257436 kg / m^3

A = Area = $9.5 \times 10^{-3}\ m^2$

V = Velocity = 8.6 m / sec

M = Mass flow rate of air = V x A x ρ

= $8.6 \times 9.5 \times 10^{-3} \times 1.257436$

= 0.1027325 kg / sec

Refrigeration effect = M x dh

= 0.1027325 x 33

Refrigeration effect = 3.39017 KW

(1 ton of refrigeration = 3.5 KW)

$$= \frac{3.39017}{3.5}$$

= 0.96 TR

7. PRECAUTIONS :

1. Unit should be kept in a dust free RCC roofed building.
2. Any glass parts are not under guarantee.
3. Unnecessary handling should be avoided.
4. Valves should be operated gently.
5. Stabilized power should be supplied to the unit.

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AIM:

To study function and working of different parts of an Air Conditioning equipment.

APPARATUS:

A model of window room air conditioner.

THEORY:

A room air conditioner is a compact air conditioner unit which can be placed in a particular room for its air conditioning. The room may be an office, a residential room such as bed room, living room etc. The window type units are air cooled and are mounted in a window or wall of room to be air conditioned. They do not need any ductwork. It has a complete refrigeration plane, i. e. compressor, condenser, refrigerant, valves and evaporator coils

The units are also provided with thermostat control and filtering equipment.

A window room air conditioner is shown in Fig.

A window type air conditioner consists of following sub-assembles:

Sub assembly	Parts
1. System assembly	a. Evaporator b. Capillary c. Condenser d. Strainer e. Compressor
2. Motor, fan and blower assembly	a. Fan b. Blower motor c. Motor mounting brackets
3. Cabinet and grill assembly	a. Cabinet b. Grill
4. Switch board panel	a. Selector switch b. Relay c. Thermostat d. Fan motor capacitor

WORKING:

The cool and low pressure vapour refrigerant is drawn from the evaporator to the compressor and it is compressed to high pressure and temperature. Generally, in this refrigerant is Freon gas i.e. R-12 or R-22 and a hermetic compressor is used. The high pressure and temperature gas runs through a set of coils so it can dissipate its heat and it condenses into liquid. The liquid is passed through the capillary and then flows into the evaporator. As refrigerant comes out of capillary, its temperature and pressure falls. This low temperature and pressure gas runs through a set of coils that allow the gas to absorb heat and cool down the air inside the building. The compressor draws this low pressure vapour and cycle is repeated. Most air conditioner also functions as dehumidifiers. They take excess water or moisture from the air and exit to atmosphere through the pipe.

Some factors should be kept in mind while selecting an air conditioner for a room:

1. Size of the room
2. Wall construction, whether light or heavy
3. Heat gain through ceiling and proportion of outside wall area which is covered with glass
4. Whether the room is to be used in the day time or at night only. The exposure to the sun of the walls of the room to be air conditioned and Room Ceiling height
5. Number of persons likely to use the room
6. Miscellaneous heat loads such as wattage of lamps, radio, television, computer, etc.

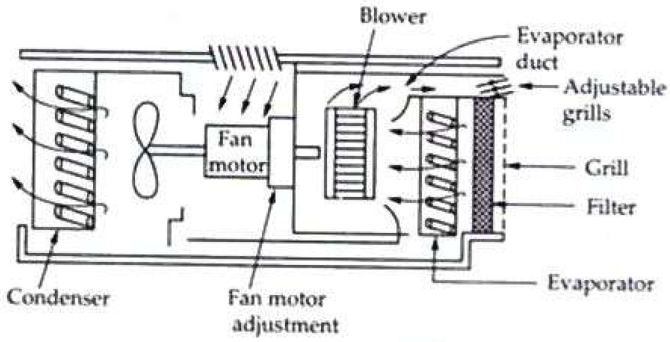

Fig. 1

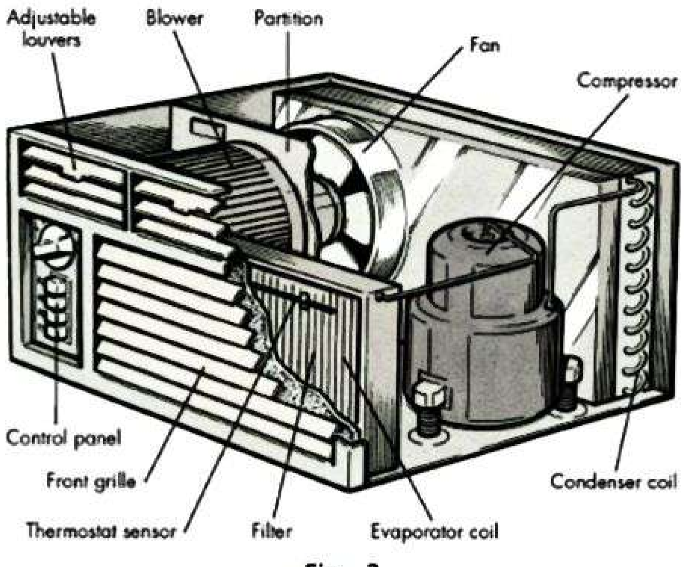

Fig. 2

CONCLUSION:

The model of Air conditioner was demonstrated and its working was studied.

WATER COOLER

1.1 Introduction

Attempts have been made to store and provide cold potable drinking water. These methods range from the traditional use of earthen pot to the use of plastic containers to store water at homes, offices etc. This need for cold portable water led to the development of the water cooler (also called water dispenser or water fountain). The water cooler is a device that cools and dispenses water. They are generally divided into the bottle-less and bottled water coolers. Both bottled water coolers and bottle-less water coolers provide a chilled water supply, but receive the water from a different source. Bottled water coolers are freestanding units that use a large plastic bottle to deliver water, and can be either bottom- or top-loaded. Bottle-less water cooler on the other hand are hooked up to a mains water supply. A modern water cooler has refrigeration units as well as heating filament (water heater) to enable it dispense cold, hot and boiling water.Water cooler was first invented in the early 1906 and is credited to two men - Halsey Willard Taylor and Luther Haws. Haws patented the first drinking faucet in 1911. From those humble beginnings, when water coolers used large blocks of ice to chill the water, to the self-contained electric water cooler in 1938, there are now a plethora of models and types to fit every need. Although first "barrier-free" electric water cooler was invented in 1972 by the Haws Corporation, it was not until the passage of the Americans with Disabilities Act in 1990 that these accessible water coolers came into their own. (Wikipedia, 2014).

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1.1 Principles of Water Cooling

Figure 1below shows some details of a water dispenser.

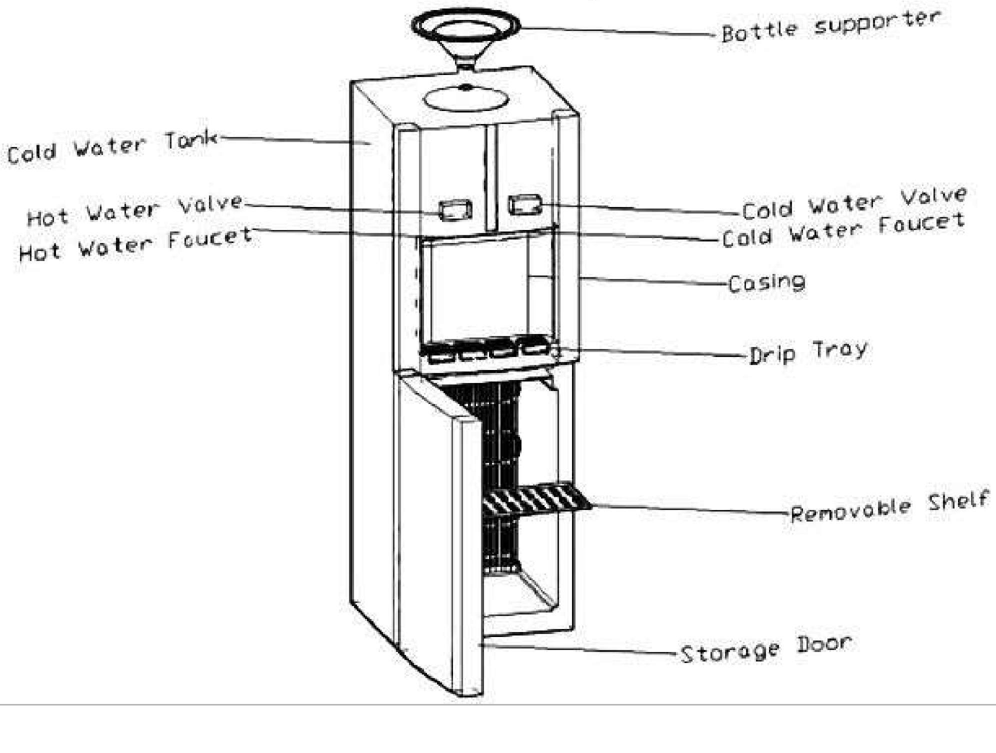


Fig.1: A 3-D View of a cold/hot water dispenser

Water coolers run on refrigeration cycles.The performance of refrigerators are expressed in terms of the coefficient of performance (COP), defined as

$$COP_R = Desired\ output/work\ input = Q_l/W_{net,in}.$$

The cooling capacity of a refrigeration system is the rate of heat removal from the refrigerated space and is often expressed in terms of **tons of refrigeration**. The most frequently used refrigeration cycle is the vapour compression cycle. The water cooler runs on this cycle.

COMPONENTS OF THE WATER COOLER

A vapour compression refrigeration system is usually made up of four essential components, namely:

1. Evaporator
2. Compressor
3. Condenser
4. Expansion valve (Throttling device).

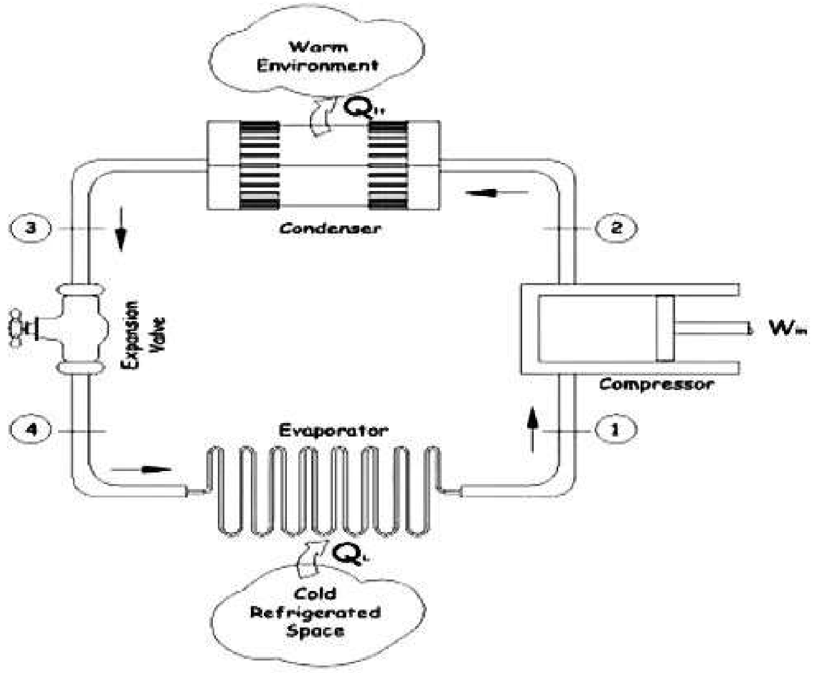


Fig. 2: Schematic Diagram For the Vapour-Compression Refrigeration Cycle

Compressor:

This device is considered as the heart of the refrigeration system. It is described as a vapour pump i.e. it increases the pressure from the suction pressure level to the discharge pressure level. The water cooler has a special kind of compressor called the hermetic compressor. The compressor compresses the vapor refrigerant sucked from the evaporator and discharges it to the condenser (Whitman et-al, 2005).

The evaporator:

Whitman et al (2005) described the evaporator in the refrigeration system as the part responsible for absorbing heat into the system from whatever medium that is to be cooled. This heat absorbing process is accomplished by maintaining the evaporator coil at a lower temperature than the medium to be cooled. This happens when a partial liquid-partial vapour mixture enters the evaporator from the throttling device (due to drop in pressure and temperature). As the liquid-vapour mixture moves through the evaporator more liquid changes to a vapour. This is called boiling caused by the heat absorbed into the coil from the medium to be cooled. At the end of the evaporator the refrigerant is changed completely to vapour.For example if a given quantity of water is to be cooled in a water cooler to a temperature of 10°C, the temperature of the evaporator coil should be below 10°C. It is important to note that the boiling temperature of a refrigerant(for example -5°C) determines the evaporator coil operating temperature (Whitman etal, 2005). Whitman et al (2005) explained that the evaporator operating at this low temperature removes both latent and sensible heat from the cooler. The removal of sensible heat changes the temperature of the medium to be cooled while the removal of latent heat changes the state of the medium. The evaporator is a small tank made of non-ferrous metal as copper, brass, or stainless steel. The refrigerant piping is wrapped around it.

Condenser: This is also a heat exchange device; it rejects heat from the system that was absorbed by the evaporator (from the medium to be cooled). Normal functions of a condenser includes de-superheat, condense, and sub-cool. This heat is rejected from a hot super-heated vapor in the first passes of the condenser. The middle of the condenser rejects latent heat from a saturated vapor, which is in the process of phase change to a

OTHER PARTS OF A WATER COOLER

Cold Water Tank: This is made of stainless steel. It serves as the reservoir where the cold water is cooled and stored.

Cold Water Baffle: This is a plate like plastic material that separates the water supplied from the cold water and hot water respectively.

Cold Water thermostat: This senses the temperature of cold water and controls the electric power supply to the compressor automatically in order to keep constant the temperature of the cold water. This device will not be needed in the modified models as it will be replaced by an ice sensor.

PTC Starter: PTC stands for "Positive Temperature Coefficient". The PTC starter starts up the motor of the compressor.

Drier: This removes moisture and dirts inside the refrigeration pipes.

Table 1: Specification of water cooler under study

Voltage	220V,50/60Hz
Heating power	500 Watts
Cooling power	95 Watts
Hot water Temperature	88°C
Cold water temperature	<10°C
Test pressure	15psig
Refrigerant	R134a

Experiment:

Aim:-

Study of Vapour absorption refrigeration system (Electrolux refrigerator)

Apparatus:

Electrolux refrigeration system test rig.

Theory:

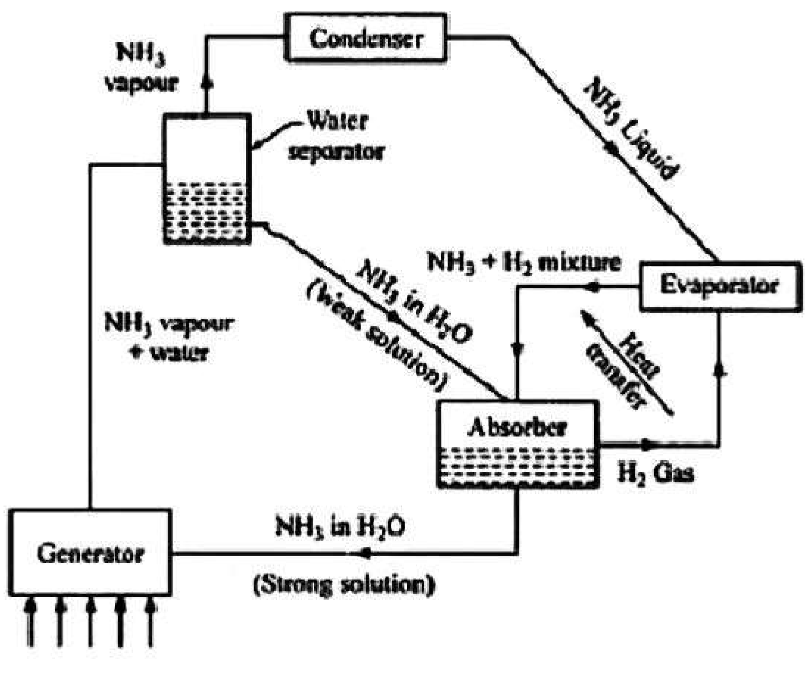
Absorption refrigerators are often used for food storage in recreational vehicles. The principle can also be used to air-condition buildings using the waste heat from a gas turbine or water heater. Using waste heat from a gas turbine makes the turbine very efficient because it first produces electricity, then hot water, and finally, air-conditioning (called cogeneration or trigeneration). Absorption refrigerators are a popular alternative to regular compressor refrigerators where electricity is unreliable, costly, or unavailable, where noise from the compressor is problematic, or where surplus heat is available. The domestic absorption type refrigerator was developed from an invention by Carl Munters and Baltzer Von Platen. This system is often called "Munters Platen System". This type of refrigerator is also called "Three-fluid absorption system". The three fluids used in this system are ammonia, hydrogen and water.

- The "ammonia" is used as a refrigerant because it possesses most of the desirable properties. Though it is toxic, and not otherwise preferred in domestic appliances, it is very safe in this system due to absence of any moving parts in the system and , therefore, there is the least chance of any leakage.
- The "hydrogen" being the lightest gas, is used to increase the rate of evaporation (the lighter the gas, faster is the evaporation) of the liquid ammonia passing through the evaporator. The hydrogen is also non-corrosive and insoluble in water. This is used in the low-pressure side of the system.

- The "water" is used as a solvent because it has the ability to absorb ammonia readily.

Principle and Working of Electrolux Refrigerators.

Figure drawn below shows a schematic diagram of an Electrolux refrigerator. It is a domestic refrigerator and is the best known absorption type of refrigerator. Here pump is dispensed with. The small energy supply is by means of a heater which may be through electricity or gas.



Principle:

The principle involved makes use of the properties of gas-vapor mixtures. If a liquid is exposed to an inert atmosphere, it will evaporate until the atmosphere is saturated with the vapor of the liquid. This evaporation requires heat which is taken from the surroundings in which the evaporation takes place. A cooling effect is thus produced. The partial pressures of the refrigerant vapor (in this case ammonia) must be low in the evaporator, and higher in the condenser. The total pressure throughout the circuit must be constant so that the only movement of the working fluid is by convection currents. The partial pressure of ammonia is kept low in requisite parts of the circuit by concentrating hydrogen in those parts.

Working:

The ammonia liquid leaving the condenser enters the evaporator and evaporates into the hydrogen at the low temperature corresponding to its low partial pressure. The mixture of ammonia and hydrogen passes to the absorber into which is also admitted water from the separator. The water absorbs the ammonia and the hydrogen returns to the evaporator. In the absorber the ammonia therefore passes from the ammonia circuit into water circuit as ammonia in water solution. This strong solution passes to the generator where it is heated and the vapor given off rises to the separator. The water with the vapor is separated out and a weak solution of ammonia is passed back to the absorber, thus completing the water circuit. The ammonia vapor rises from the separator to the condenser where it is condensed and then returned to the evaporator. The actual plant includes refinements and practical modifications (which are not included here). The following points are worth noting:

1. The complete cycle is carried out entirely by gravity flow of the refrigerant.
2. The hydrogen gas circulates only from the absorber to the evaporator and back.
3. With this type of machine efficiency is not important since the energy input is small.
4. It has not been used for industrial applications as the C.O.P. of the system is very low.

Role of Hydrogen.

By the presence of hydrogen it is possible to maintain uniform total pressure throughout the system and at the same time permit the refrigerant to evaporate at low temperature in the evaporator corresponding to its partial pressure. Thus the condenser and evaporator pressures of the refrigerant are maintained as below:

i. In the condenser only ammonia is present, and the total pressure is the condensing pressure.
ii. In the evaporator hydrogen and ammonia are present; their relative masses are adjusted such that the partial pressure of ammonia is the required evaporator pressure.

These are achieved without the use of pumps or valves.

Advantages and Disadvantages of Electrolux Refrigerator over Conventional Refrigerators:

Advantages:

1. No pump or compressor is required.
2. No mechanical troubles, maintenance cost is low.
3. No lubrication problem; no wear and tear.
4. Completely leak proof.
5. Noiseless.
6. No chance of pressure unbalancing and no need of valves.
7. System may be designed to use any available source of thermal energy-process steam, exhaust from engines or turbines, solar energy etc.
8. Easy control, simply by controlling heat input.

Disadvantages:

1. More complicated in construction and working.
2. C.O.P. very low.
3. The major disadvantages of this type of refrigerator are that if it is spoiled once, it cannot be repaired and has to be replaced fully

AIM:
Study the Complete charging of a domestic refrigerator and its leak test.

Objective:

- To study the charging, testing, evacuating, and pumping down in a refrigeration plant.
- To study leak detection techniques in a refrigeration plant.

Theory:

Charging and Evacuating Techniques:

Charging and evacuating techniques are the method of charging the plant with refrigeration. The detailed procedure of charging the plant is as under:

Initially there may be air entrapped in the piping circuit of the plant. Thus before charging the plant with the refrigerant, it is essential to remove entrapped air. For removing this air and thereby to create a vacuum, a vacuum pump is used, which sucks the air.

A vacuum pump fitted with a compound gauge is connected to the suction line. As the air is sucked the pointer on the compound gauge keeps on falling steady and vacuum is created. The pump is run for a while till the compound gauge reads. The system is left as it is for some hours at a stretch and the compound gauge reading is observed. If the pointer starts climbing towards zero there, it would be ascertained that there is a leakage and if there is no change in the reading, then we can conclude that the piping is leak proof.

If there is any leakage i.e. if the compound gauge reading slowly rises to higher values, then this leakage has to be detected and plugged properly. For this the plant is pressurized with the air at high pressure, so that the leakage may be removed. This completes the evacuating process.

Now the vacuum pump is disconnected and the suction line is connected to the cylinder containing the refrigerant. There is a valve, provided at the suction line, which is closed before disconnecting the vacuum pump. After connecting the cylinder to the suction line of the compressor, the cylinder valve is opened and the nut joining the pipe to the suction is kept slightly loose. So that when the valve is opened the refrigerant rushes out and forces the air entrapped in the pipe to the atmosphere. Now the suction line is opened. There is vacuum inside, it sucks the refrigerant from the refrigerant cylinder very rapidly. At the same time a pressure gauge indicates the pressure developed in the compressors due to a charging of pipe attached to the suction line is disconnected and back pressure is measured. The correct charging pressure is 175 to 200 lb/in^2 and the back pressure is about 20-25 lb/in^2. The correct charging pressure is of importance because if the pressure is more i.e. more refrigerant is charged, then the handling of the refrigerant is not proper, thereby affecting the performance of the plant.

Once the charging is over the plant is ready for service.

Testing :

When the refrigerant plant is newly set-up, the pipe joints and other connections of the system have to be tested for leakage. For that in beginning CO_2 and N_2 is passed through the system and pressure gauge reading is noted. Then at the joint, some soap solution is applied. If no bubbles are formed at the joint and pressure remains constants then we can conclude that the joints are free from any leakage and if bubbles are formed then the joint has to be tightened more. The second method is used to detect the leakage.

The system is completely evacuated after performing leakage test and this is done with the help of a vacuum pump. Whether the system is completely evacuated or not is determined by the pressure gauge readings. Then the plant will be evacuated and charged with refrigerant.

Pumping Down:

Pumping down means collecting all the refrigerant of the plant into its receiver tank. It is useful when there is some minor repair of the plant is to be done. So refrigerant is not required to be removed of the plant which is otherwise necessitates recharging.

For this the delivery valve of the receiver tank is closed and the plant is run for few minutes. After some time all the refrigerant will be collected in the receiver tank and after rectifying the fault, by opening the delivery valve of the plant refrigerant is charged in the line. If necessary, extra amount of refrigerant should be added from the refrigerant cylinder.

Leak Detection:

If there is any leakage i.e. if the compound gauge reading slowly rises to higher values, then this leakage has to be detected and plugged properly

Leak Test Methods :

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

1. Ammonia, R12, R22:

A. 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.

B. 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.

C. 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

A. 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.