Experiment No: 06

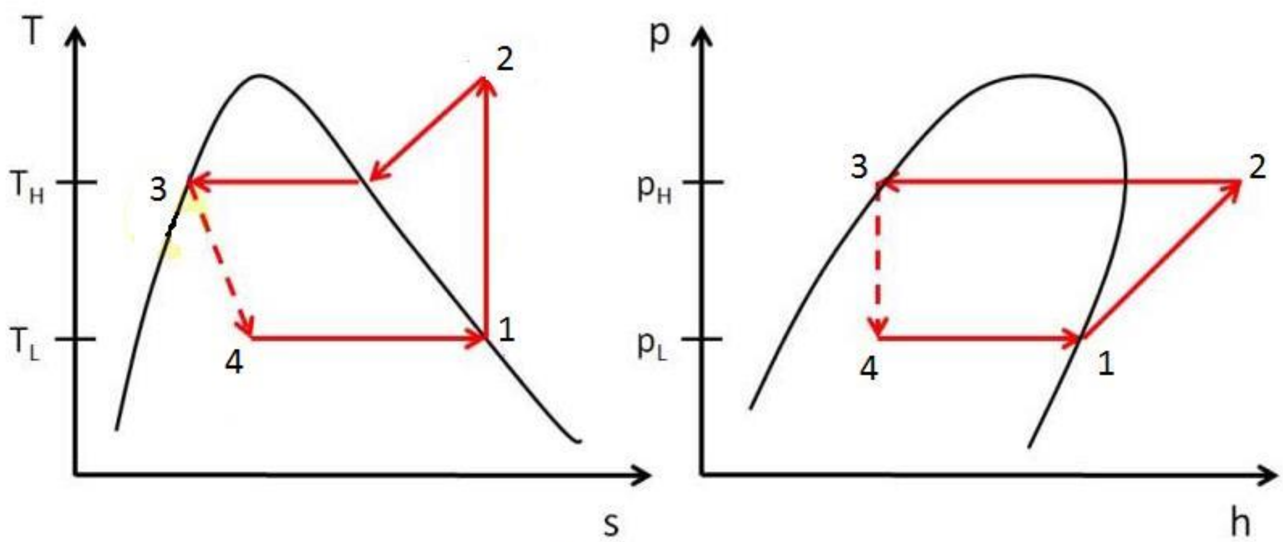
Aim: To perform experiments on vapour compression test rig to determine COP of the system.

Apparatus: Refrigerant R-134a , hermetically compressor, forced convection air cooled, expansion device as capillary tube, refrigerant flow by rotameter, energy meter , heater , temperature control of the calorimeter, temperature indication by digital LED, insulation for water tank by PUF (polyurethane foam) material.

Introduction:- The need of producing cold has found many application in now a days life. A time ago cold was produced by use of natural ice only. But as the mechanical refrigerators were developed, use of ice is significantly reduced. Refrigeration is the process of removing the heat from a substance, which is at ambient temperature and to lower its temperature to desired level . Depending upon the application, the desired temperature vary, which are generally classified in three groups, i.e. high temperature, medium temperature and low temperature group. High temperature group is one in which the object temperature is 22-260C e.g. air conditioning system. In medium temperature, object temperature ranges between 40C -200C e.g. milk chiller or bottle coolers. In low temperature group, temperatures are kept below 00C to lower range of -200C. Applications of these are household refrigerators or ice making plants.

In refrigeration, two systems are used, namely vapour absorption system and vapour compression system. The difference between the system lies in the way of raising the pressure of low pressure vapour. The absorption system dissolves refrigerant in solvent and raises its pressure by a pump while in compression system compressor compresses the refrigerant vapour.

Theory: The process of extracting heat from a lower-temperature heat source, substance, or cooling medium and transferring it to a higher-temperature heat sink is defined as refrigeration. Refrigeration maintains the temperature of the heat source below that of its surroundings while transferring the extracted heat, and any required energy input, to a heat sink, atmospheric air, or surface water. A refrigeration system is a combination of components and equipment connected in a sequential order to produce the refrigeration effect. The refrigeration systems commonly used for air conditioning can be classified by the type of input energy and the refrigeration process as follows: 1. Vapor compression systems. In vapor compression systems, compressors activate the refrigerant by compressing it to a higher pressure and higher temperature level after it has produced its refrigeration effect. The compressed refrigerant transfers its heat to the sink and is condensed to liquid form. This liquid refrigerant is then throttled to a low-pressure, low temperature vapor to produce refrigerating effect during evaporation.



P-H and T-S diagram of simple vapour compression system

Procedure:

1. Put the machine in the proper position where its position is horizontal and is well ventilated.
2. Start water flow in the evaporator. Keep water flow about 3 to 4 lit/min.
3. Depending upon expansion device to be used, open inlet valve for thermostatic expansion valve, if experiment is to be conducted on thermostatic expansion valve. Start condenser fan and compressor.

2. Start the compressor by putting switch on. The calorimeter temperature will start dropping down. When it reaches 15oC start heater.

3. Allow at least 30 min running time for correct results.

4. Wait till the temperature and pressure becomes steady. It should take around 20 to 30 minutes.
5. Check time required for compressor energy meter disc to make 10 revolution.
6. As the evaporator temperatures remains steady, note down the readings and fill up observation table.
7. Take readings after regular intervals say 10 to 15 mins.
8. Repeat the experiment with other expansion device.

Observations:

1. Standard barometer pressure: 1.013 bar.
2. Specific heat of water : 4.18 kJ/kg K.
3. Specific constant of air: 0.287 kJ/kg K.
4. Specific gravity of R-134a at 40oC=1.2.

Observation table:

Sr. No.		Capillary	Thermostatic expansion valve
1.	Time for 10 revolution of compressor energymeter t_c sec		
2.	Evaporator water flow- time for 1 ltr. ,sec.		
3.	Supply voltage, volts		
4.	Compressor current, Amp		
5.	Condenser inlet temperature t_{ci}, ^{0}C		
6.	Condenser outlet temperature t_{co}, ^{0}C		
7.	Evaporator inlet temperature t_{ei}, ^{0}C		
8.	Evaporator outlet temperature t_{eo}, ^{0}C		
9.	Water inlet temperature t_{wi} ^{0}C		
10.	Water outlet temperature t_{wo} ^{0}C		
11.	Condensing pressure, Pc, Kg/cm^2		
12.	Evaporating pressure,Pe,Kg.cm^2		
13.	Refrigerant flow,Q,LPH		

Calculation:

Actual Refrigeration effect = Heater Load
Compressor work = Final Energy meter reading – Initial energy meter reading.
Actual coefficient of performance = Actual refrigerant effect / Actual compressor work.

Sample Calculation

1. Refrigerating effect is balanced by water circulation

So, heat given by water =refrigerating effect.

Therefore, R.E. = m×Cp×ΔT

Where, m- mass flow rate of water = 1/time for 1 lit kg/s (Density of water is assumed 1kg/m^3)

Cp- specific heat of water = 4.2 kJ/kg

$\Delta T = t_{wi} - t_{wi}$

2. Compressor work

$C_W = n \times 3600/t_c \times EMCc$ kw

Where, t_c = Time for compressor energy meter disc ,sec.

EMCc- Compressor energy meter constant = 900 Rev/Kwh

3. Actual COP

C.O.P = R.E/C.W

4. Theoretical C.O.P

Condensing pressure = (gauge reading x 0.981) + 1.014 bar

Evaporating pressure = (gauge reading x 0.981)+1.014 bar

Plot the cycle on P-H chart as shown and find out,

H_{ci} =

$H_{co} = H_{ci}$ =

H_{eo} =

RE theo = $H_{eo} - H_{ei}$

C_W theo = $H_{ci} - H_{co}$

Therefore $COP_{theorotical} = H_{eo} - H_{ei} / H_{ci} - H_{eo}$

5. Carnot COP

For the cycle operating between the saturation temperature of T_H and T_L

Where T_H and T_L are saturation temperature in K corresponding to condensing & evaporating pressure respectively

COP(carnot) = $T_L / T_H - T_L$

6. Mass flow rate of refrigerant

Liquid refrigerant flow, Q = LPH

From table of properties of R-12 find V, specific volume of liquid at condensing pressure

Then mass flow rate,

m = Q/(1000 × V) kg/hr.

7. Theoretical refrigerant effect

$R.E_{theo} = m(H_{eo} - H_{ei})$ kJ/s

8. Capacity of the system = P = RE/3.5 tons of refrigeration

9. Volumetric efficiency of compressor

Compressor swept volume is $V_2 = 2.18\ m^3/hr$

Volume discharged by compressor is $V_1 =$ m^3/hr

$$V_1 = m \times V_s$$

Where, m = mass flow rate

V_s= specific volume of vapour at suction (evaporation) pressure

$\eta_v = V1/V2$

Result and Conclusion:

Capacity of the system = -------------------------------- in TR

Actual COP = --

Theoretical COP = --