Experiment No. 1

1.0 Title of Experiment:

To calculate Coefficient Of Performance for Vapour compression refrigeration test Rig

2.0 Prior Concept:

V.C.R. cycle, Representation of V.C.R. on P-H diagram,
ton of refrigeration, C.O.P.

3.0 New Concept:

Propositions

Proposition 1. Theoretical C.O.P. is the C.O.P. calculated on the basis of Refrigerating effect and compressor work obtained from P-H (pressure -enthalpy) diagram.

Theoretical C.O.P.

Refrigerating effect / kg of Refrigerant from P-H diagram

Ratio

Compressor work / kg of Refrigerant from P-H diagram

Proposition 2. Actual C.O.P. is based on actual Refrigeration effect and actual energy supplied to the compressor both measured experimentally.

Actual C.O.P.

Refrigerating effect by actual measurement

Ratio

Compressor work by actual measurement

4.0 Learning Objectives :

4.1 Intellectual skills

1. To plot V.C.R. cycle on P-H diagram.
2. To calculate refrigerating effect, compressor work and C.O.P. from P-H diagram.
3. To calculate C.O.P. based on Carnot cycle.
4. To calculate actual Refrigerating effect, energy supplied and C.O.P. of the refrigerating unit.

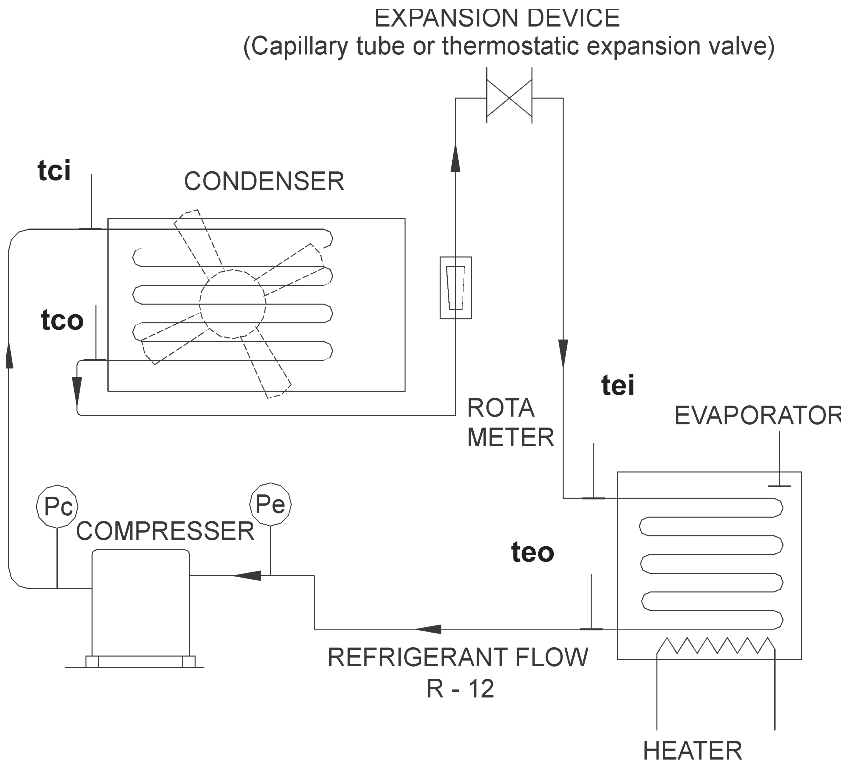
4.2 Motor skills

1. To measure actual Refrigerating effect by nullifying the cooling effects by electrical heating.
2. To measure the energy input to the Refrigerating unit by using energy meter.
3. To measure pressure and temperature at salient points of the system.

5.0 Apparatus:

Vapour compression test rig, Thermometers.

6.0 Diagrams:



SCHEMATIC ARRANGEMENT OF THE VAPOUR COMPRESSER

7.0 Stepwise Procedure:

Refrigeration test rig consists of a hermetically sealed compressor, air-cooled condenser, and capillary and thermostatic expansion valve (only one of the two throttling devices should be used at a time. By using shut off valves, one of the throttling devices can be isolated, keeping only one in use) and an evaporator.

The evaporator cools the water in a calorimeter. A heater is provided at a bottom of the calorimeter, whose output can be varied by a dimmer stat.

Separate pressure gauges are provided to measure Condenser & Evaporator pressures. Five suitable thermometers are provided to measure temperatures at various locations (refer the layout). Two energy meters are provided to measure energy supplied to compressor and heater. Suitable H.P.L.P. cutout, thermostat, solenoid valve, (to stop liquid Refrigerant flooding the evaporator while operating on T.E.V), Voltmeter and ammeter are provided in the unit.

1. Refer the manual supplied by the manufacturer and identify different components and controls of the refrigeration test.
2. Read the precautions to be taken as specified by the manufacturer and follow them. eg. Don't start the unit if voltmeter on the panel reads less than 220V or more than 240V. Never operate the unit, keeping the condenser fan switched off.
3. From the manual note down the technical specification of the unit.
4. Select capillary tube or TEV by using manually operated shut off valves.
5. Fill three fourth of calorimeter with water.
6. Switch on the condenser fan and after two minutes switch on the compressor.
7. As the unit runs, watch the thermometer reading of the water in the calorimeter. It will go on falling.
8. As the temperature of the water reaches around 20°C, switch on the heater unit.
9. Adjust the dimmerstat of the heater such that the temperature of water does not further fall.
10. Let the unit run for sufficient time till steady state is reached and temperature of water remains constant.
11. Read the condenser and evaporator pressures from pressure gauges. Enter in observation table after converting them in bar.

12. Note five thermometer readings (four temperature on V.C.R. system and one of water in calorimeter)
13. With help of stopwatch, measure the time taken for 10 revolutions of energy meter discs of the compressor and heater. (i.e. Tc and Th)
14. Switch off the unit in the following order - heater, compressor and condenser fan.
15. Technical specification of the test rig (To be filled by the student)

Compressor Make ______________________________

Cooling capacity ______________________________ Ton

Power ______________________________ Hp/KW

Refrigerant used ______________________________

NC = Energy meter constant for compressor ________________ Rev/ KW Hr

NH = Energy meter constant for heater ________________ Rev/ KW Hr

8.1 Observation table

Sr. no.	Description	Symbol	Reading
1	Condenser pressure	P_c	bar
2	Evaporator pressure	P_e	bar
3	Condenser inlet Temp.	t_{ci}	°C
4	Condenser outlet Temp.	t_{co}	°C
5	Evaporator inlet Temp.	t_{ei}	°C
6	Evaporator outlet Temp.	t_{eo}	°C
7	Time for 10 revolutions of energy meter of compressor	T_c	sec
8	Time for 10 revolutions of energy meter of heater	T_h	
9	Temp. of water	t_w	°C

Plot the cycle on P-H diagram and fill the table given below.

Enthalpy values from P-H diagram

Sr. no.	Description	Symbol	Reading KJ/Kg
1	Enthalpy at evaporator inlet	H_{ei}	
2	Enthalpy at evaporator outlet	H_{eo}	
3	Enthalpy at condenser inlet	H_{ci}	
4	Enthalpy at condenser outlet	H_{co}	

9.0 Sample calculations

Theoretical COP = $\dfrac{\text{Theoretical refrigerating effect}}{\text{Theoretical Compressor Work}}$

$$= \frac{He_o - He_i}{Hc_i - Hc_o} =$$

Carnot COP $= \dfrac{T_{Low}}{T_{Low} - T_{High}} =$

$T_{low} = (t_{saturation}$ corresponding to $P_e) + 273 =$ k

$T_{high} = (t_{saturation}$ corresponding to $P_c) + 273 =$ k

Actual COP -

R_{act} = Actual Refrigerating heat = heat produced by heater

$R_{act} = \dfrac{10}{N_H} \times \dfrac{3600}{T_h}$ KW = ______________ KW

W = actual energy supplied to compressor = $\dfrac{10}{NC} \times \dfrac{3600}{TC}$ KW = ____________ KW

Actual COP = $\dfrac{R_{act}}{W}$ = ____________

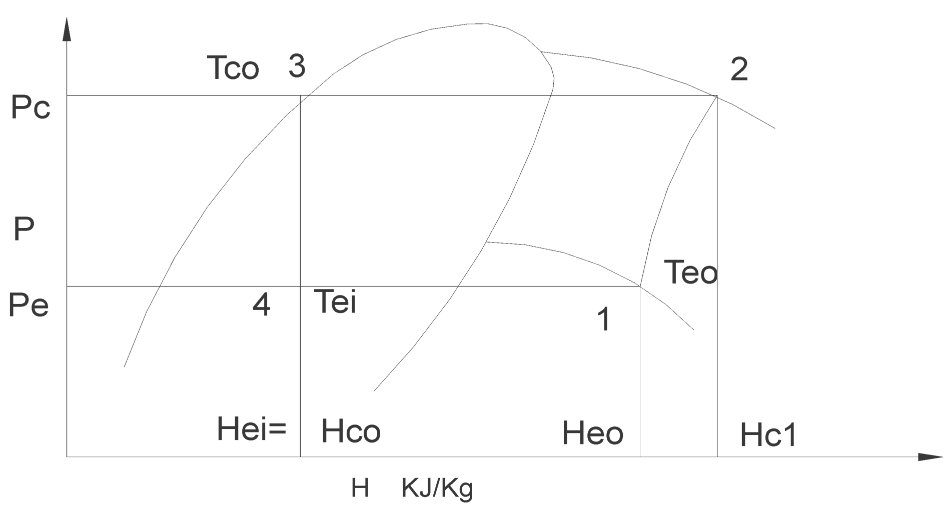
10.0 Result

Actual Refrigerating effect = ________________ KW

Carnot C.O.P. = ________________

Theoretical C.O.P. = ________________

Actual C.O.P. = ________________



p-h diagram

11.0 List of Questions: - (Attempt 3-5 questions as directed by teacher)

1. Why dews are not formed on transparent glass doors of commercial refrigerators?
2. On the basis of results obtained, compare the different C.O.P. Why actual C.O.P. is less than theoretical C.O.P.? Why theoretical C.O.P. is less than Carnot C.O.P.?

3. What will be effect on C.O.P. if evaporator is operated at still lower temperature?
4. What will happen if the compressor is started with condenser fan switched off?
5. Name the safety device provided in the test rig and state its function.
6. Why evaporator inlet/ outlet is covered with cotton/fiber?
7. Interpret the graph plotted above with respect to standard graph.
8. Enlist various manufacturers of the domestic refrigerators.
9. Collect the information regarding cost of various refrigerants and charging.

Note: -

If heater and dimmer stat arrangement is not available, the Refrigerating effect can be found by mass rate of flow of water x specific heat x drop in temperature.

The teacher should design observation table accordingly.

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