Experiment No: 07

Aim: To Determine the C.O.P of the Air Conditioning Test Rig

Apparatus: Compressor, condenser, drier/filter , rotameter, diverting valves , expansion devices ,capillary tube , evaporator , energymeters, condenser fans, pressure gauges, manometer.

The apparatus consist of a duct, in which air flow is generated by an axial flow fan. A cooling coil, air heaters, and a steam injector are fitted in the duct Adjustable flappers are provided in duct to control the air flow. At reduced flow rates of air, cooling coil can be used as dehumidifier. The condensing unit, compressor and steam generator are located below the air flow duct A steam generator is connected to steam injector in die duct The steam injection is controlled by a valve. Various measurements are provided so different processes of air conditioning can be studied.

Introduction:- Air conditioning is making the environment conditions suitable for various applications, like to produce comfortable conditions at home, or to make more complete control of manufacturing processes in industries etc. A complete air conditioning system cleans the air, cools in summer and heats in winter, humidifies in winter and dehumidifies in summer and circulates it through the space where it is required.

Theory:- The hermatic compressor compresses the refrigerant vapour and sends it to condenser, where it is liquified. The liquid refrigerant is throttled by expansion valve to low pressure and temp. This low pressure aid temp, refrigerant goes to evaporator where it boils by collecting heat The low pressure refrigerant vapour coming from the evaporator is sucked by the compressor and again circulated through the system.

Procedure:-

A) Cooling of Air-

1) Fill up water in the wells of DB/WB thermometers.
2) Adjust the flapper opening to a specific degree
3) Put ON main switch. Start air flow through the duct, start the condenser fan and then start the compressor.
4) Wait till steady temperature are reached and note down the observations.
5) Repeat the procedure by changing die air flow.

B) Heating of Air-

1) Put ON main switch and start air flow through the duct
2) Put ON the heaters, as required.
3) Wait till steady state condition is reached and note down die readings.
4) Repeat the procedure at different air flow rates and changing the heat input.

C) Humidfication of Air -

1) Fill up sufficient water in steam generator, and start the steam heater.

2) After some time steam will be generated. Now start air flow through the duct, and slightly open the steam control valve so that steam will be injected in the stream of air.

3) Note down the readings.

D) Dehumidification of Air -

1) Start the air flow in the duct Reduce the flow by partially closing the flapper

2) Start the condenser fan and then start die compressor. Cooling coil now works as dehumidifier. Condensed water will start collecting in collecting tray.

3) Once steady temp, are reached, drain all the condensed water. Then again start collecting die condensate.

4) Collect the condensate for a period of 15 minutes.

5) Note down die temperatures

6) Repeat the procedure by changing air flow.

Observation:

1. Standard barometric pressure: 1.01325 bar

2. Specific heat of water: 4.187kJ/kg.K

3. Gas constant of air: 0.287 kJ/kg.K

4. Specific gravity of R-22 at 40^{o}C.

5. 1KWHr: 3600 kJ.

Observation Table:

A) Cooling of Air-

Sr. No.	Inlet 'C		Outlet "C		Flapper opening angle	Time for 10 Rev. of energymeter	Flow (LPH)
	D.B	W.B	D.B	W.B			

Cooling cycles observations:-

1) Temperatures :-

a) Condenser inlet t_{cj} = ^{0}C

b) Condenser outlet t_{co} = °C

c) Evaporator inlet t_{ei} = °C

d) Evaporator outlet t_{eo} = ^{0}C

2) Pressure

a) Condensing pressure = kg/cm^2

b) Evaporating pressure = kg/cm^2

c) Flapper opening angle =

B) Heating of Air-

Sr. No.	Air inlet 'C		Air outlet ^{B}C		Flapper opening angle	Time for 10 Rev.of Heater Energymeter
	D.B.	W.B	D.B.	W.B.		

C) Humidification of Air –

Sr. No.	Air inlet *C		Air outlet "C		Flapper opening angle
	D.B.	W.B.	D.B.	W.B.	

D) Dehumidification of Air-

Sr. No.	Air inlet ^{0}C		Air outlet °C		Flapper opening angle	Condensate collected in 10 min.
	D.B.	W.B.	D.B.	W.B.		

Calculation :-

A) Cooling of Air-

1) Inlet-D.B. = °C, W.B. = °C

Therefore, from table of Dry / Wet bulb temp.,

Relative Humidity,

RH= %

Now, RH = P_w / P_{sat} x 100

Where, P_w = Partial pressure of water vapour, Kg/cm^2

Psat - Partial pressure of water vapour At

saturation at DBT (to be taken from chart)

Therefore, P_w = RH x P_{sat}/100Kg/cm^2

Now, W = 0.623 x P_w / (P - P_w) Where, W = Weight of moisture Kg/Kg of dry air

P = Atmospheric pressure Kg/cm^2

Now, Total enthalpy of dry air,

Ht = ha + hs + hl + hsh

Where, ha = Enthalpy of dry air

= 1 x (dry bulb temp.) kJ/kg

hs = Sensible heat of water vapour (upto WBT)

= 4.2 x W x (wet bulb temp.)

hl = Latent heat of evaporation of water vapour (at WBT)

= W x 1 (1 is taken from chart)

hsh = Superheat of water vapour (from WBT to DBT)

= W x 1.9 x (DBT - WBT)

Thus, calculate total heat of air at inlet and outlet i.e hti and hto respectively

Air flow-

(See chart -1 showing air velocity 'Va' at a corresponding flapper opening)

Cross- sectional area of duct 0.0625 m^2

Cross -sectional area of DB and WB indicating device = 0.0127S m^2

Density of air, ρ_a = (1.293 x 273) / (273 + DBT_{out})

Therefore, mass flow rate of air

m_a = (0.0625 - 0.01275) x Va x ρ_a x 3600 kg/hr.

Heat recovered by cooling coil

H = ma (h_{ti} - h_{to}) kJ/ hr.

Cooling cycle performance

Evaporating pressure, Peg = kg/cm2 gauge

Therefore, absolute evaporating pressure,

Pea = Peg + 1.033 kg/cm^2 ab

Condensing pressure,

Pcg = kg/cm^2 gauge

Therefore, absolute condensing pressure,

Pca = Pcg+1.033 kg/cm^2 ab.

From the temp., plot the cycle on P-H chart and find out enthalpy values

Hci = kJ/kg

Hco = Hei = kJ/kg

Heo = kJ/kg

Refrigerating effect = Heo - Hei kJ/kg

Compressor work - Hci - Heo kJ/kg

vi)COPtheo = Heo - Hei / Hci - Heo

If time required for 10 Rev. of compressor energymeter is tcom sec.

Compressor work, Cw = 3600 x 10/ tcom x EMCc kw.

Where, EMCc = Compressor energymeter constant = 900 R/ kwh

COPact= H/ Cw

Heating of Air-

In a similar manner to cooling cycle, calculate heat gained by air

H = m_a (hti -hto) kJ/hr

C) Humidiflcation of Air-

At inlet conditions, DB = °C, WB= °C Therefore,

RHi = %

At outlet,

DB = ^{0} C, WB = °C

RHo = %

Therefore increment of relative humidity = RHo - RHi

D) Dehumidification of air-
At inlet, DB = °C, WB= °C

Therefore RH= %

Therefore Wi = kg/kg of air

At outlet RH = %

Therefore Wo = kg/kg of air

Mass flow rate of air = ma kg/hr

Therefore, moisture removed within l0 min.

= ma = (Wi-Wo) x 15/60 kg/hr.

Mass Flow Rate of Refrigerant –

Liquid refrigerant flow, Q = LPH

From table of properties of R-22 find V, specific volume of liquid at condensing pressure

Then mass flow rate m = Q / (1000 x V) kg/hr

Precautions:-

1) Never start the compressor before putting on the duct fan and condenser.

2) Before starting die steam generation, fill up sufficient water in die vessel

3) Fill up wet bulb thermometer well with water, so that the wick covering the bulb is wet

4) Never close the flow control flappers completely.

5) Do not disturb die pressure setting of High/ Low pressure cutout

6) Never start the compressor when heater is put ON.

Results and Conclusion:

1.Tonnage capacity of the plant = --------------------- TR.

2. The actual COP of the system = ---

3. The theoretical COP of the system = ---