ASSIGNMENT – 1 INTRODUCTION

Theory

1. Define refrigeration. Discussed various methods of producing cooling.
2. Define and explain below terms:
   - Ton of refrigeration (TR)
   - COP of refrigerator
3. Give applications of refrigeration and air conditioning.

ASSIGNMENT – 2 REFRIGERANTS

Theory

1. What is refrigerant? Give classification of refrigerants.
2. How refrigerants are designated? Explain designation of any two refrigerants e.g CCl_2F_2 and $C_2Cl_2F_4$.
3. Give the list of desirable properties of refrigerants. Explain each briefly. OR Explain thermodynamic, chemical and physical properties of refrigerants.
4. What are the secondary refrigerants? How they differentiate from primary refrigerant? Give examples and applications of few recently used refrigerants.

ASSIGNMENT-3 AIR REFRIGERATION

Theory

1. Explain air refrigerator working on reversed Carnot cycle and give comments on its limitations.
2. Derive an expression for COP of Bell-Coleman cycle (Reversed Brayton OR Reversed Joule cycle). Discuss the merits and demerits of the open cycle and close (dense) Bell-Coleman cycle.
3. Give the reasons for poor performance of Bell-Coleman cycle in relation to Carnot cycle. Why Bell-Coleman cycle for refrigeration is no longer used?
4. Enumerate different heat load which must be accounted in an air craft refrigeration systems. OR What is the necessity of cooling the air craft?
5. Explain working and analysis of following aircraft cooling (refrigeration) systems with schematic and T-s diagram.
    a. Simple air cooling system with and without evaporative cooling system
    b. Boot strap air cooling system with and without evaporative cooling system
    c. Reduced ambient air cooling system
    d. Regenerative air cooling system
6. Give comparison of various aircraft refrigeration systems used for aircraft.

Examples (Class)

Bell-Coleman cycle

1. The atmospheric air at pressure 1 bar and temperature -5^{0}C is drawn in the cylinder of the compressor of a Bell-Coleman refrigerating machine. It is compressed isentropically to a pressure of 5 bar. In the cooler, the compressed air is cooled to 15^{0}C, pressure remaining same. It is then expanded to a pressure of 1 bar in an expansion cylinder, from where it is passed to the cold chamber. Find: (1) The work done per kg of air, and (2) C.O.P of the plant. For air assume law for expansion $pv^{1.2}$ = constant; law for compression $pv^{1.4}$ = constant and C_{pa} = 1 kJ/kg K.

   Answer: (1) w = 39.904 kJ/kg; (2) C.O.P = 1.20 R.S Khurmi 56/2.13

   [Note: Give your comments on answers and conclude that which one is more preferable: when, (i) both compression and expansion are isentropic $pv^{1.4}$ = C, (ii) both compression and expansion are polytropic $pv^{1.2}$ = C, (iii) law of compression is polytropic $pv^{1.2}$ = C and law of expansion is adiabatic $pv^{1.4}$ = C.]

2. A refrigerating machine of 6 tonnes capacity working on Bell-Coleman cycle has an upper limit of pressure of 5.2 bar. The pressure and temperature at the start of compression are 1 bar and 16^{0}C respectively. The compressed air is cooled at constant pressure to a temperature of 41^{0}C, enters the expansion cylinder. Assuming both compression and expansion processes to be isentropic with γ = 1.4, calculate:
   1. Coefficient of performance;
   2. Quantity of air in circulation per minute;
   3. Piston displacement of compressor and expander;
   4. Bore of compressor and expander cylinders. The unit runs at 240 r.p.m and is double acting. Stroke length is 200 mm and
   5. Power required to drive the unit. For air take γ = 1.4, and c_p = 1.005 kJ/kg K

   Answer: (1) C.O.P = 1.674; (2) m_a = 13.548 kg/min; (3) v_1 = 11.237 m^3/min; v_4 = 7.63 m^3/min (4) D (compressor) = 0.386 m; d (expander) = 0.318 m; (5) Power = 12.54 kW R.S Khurmi 58/2.14

3. Dense (close) air refrigeration operates between pressure of 4 bar and 16 bar. The air temperature after heat rejection to surrounding is 37^0C and air temperature at exit of refrigerator is 7^0C. The isentropic efficiency of turbine and compressor are 0.85 and 0.8 respectively. Determine (1) Compressor and turbine work per TR; (2) C.O.P and; (3) Power required per TR. For air take γ = 1.4, and c_p = 1.005 kJ/kg K.

   Answer: (1) W_C = 635.6 kJ/min; W_T = 322.3 kJ/min; (2) C.O.P = 0.67; (3) Power/TR = 5.22 kW/TR R.S Khurmi 71/2.21

Simple Air Cooling System

1. The cock pit of a jet plane at a speed of 1200 km/hr is to be cooled by a simple air cooling system. The cock pit is to be maintained at 25^0C and the pressure in the cockpit is 1 bar. The ambient air pressure and temperature are 0.85 bar and 30^0C. The other data available is as follows :

   Cock pit cooling load = 10 TR

   Main compressor pressure ratio= 4

   Ram efficiency = 90%

   Temperature of air leaving the heat exchanger and entering the cooling turbine = 60^0C

   Pressure drop in the heat exchanger = 0.5 bar

   Pressure loss between the cooler turbine and cockpit = 0.2 bar

   Assuming the isentropic efficiency main compressor and turbine as 80%, find the quantity of air passed through the cooling turbine and C.O.P of the system. Take γ = 1.4 and c_p = 1 kJ/kg K. R.S Khurmi/89/3.5

   Answer: (1) m_a = 36.6 kg/min; (2) C.O.P = 0.264

Simple Air Evaporative Cooling System

2. Simple evaporative air refrigeration system is used for an aeroplane to take 20 tonnes of refrigeration load. The ambient air conditions are 20^0C and 0.9 bar. The ambient air is rammed isentropically to a pressure of 1 bar. The air leaving the main compressor at pressure 3.5 bar is first cooled in the heat exchanger having effectiveness of 0.6 and then in the evaporator where its temperature is reduced by 5^0C. The air from the evaporator is passed through the cooling turbine and then it is supplied to the cabin which is to be maintained at a

temperature of 25^0C and at a pressure of 1.05 bar. If the internal efficiency of the compressor is 80% and that of cooling turbine is 75%. Determine: 1. Mass of the air bled off the main compressor; 2. Power required for the refrigeration system and; 3. C.O.P of the refrigeration system.

Answer: (1) m_a = 276 kg/min; (2) P = 746 kW (3) C.O.P = 0.094

R.S Khurmi/100/3.8

Boot Strap Air Cooling System

3. A boot-strap cooling system of 10 TR capacity is used in an aeroplane. The ambient air temperature and pressure are 20^0C and 0.85 bar respectively. The pressure of air discharged from the main compressor is 3 bar. The discharge pressure of air from auxiliary compressor is 4 bar. The isentropic efficiency of each of the compressor is 80%, while that of turbine is 85%. 50% of the enthalpy of air discharged from the main compressor is removed in the first heat exchanger and 30% of the enthalpy of air discharged from the auxiliary compressor is removed in the second heat exchanger using rammed air. Assuming the ramming action to be isentropic, the required cabin pressure are 0.9 bar and temperature of the air leaving the cabin not more than 20^0C. Find: 1. The power required to operate the system; and 2. The C.O.P of the system. Draw the schematic and T-s diagram of the system. Take γ = 1.4 and c_p = 1 kJ/kg K.

   Answer: (1) P = 130 kW; (2) C.O.P = 0.27 R.S Khurmi/103/3.9

Boot Strap Air Evaporative Cooling System

4. The following data refer to a boot strap air cycle evaporative refrigeration system used for an aeroplane to take 20 tonnes of refrigeration load :

   Ambient air temperature = 15^0C

   Ambient air pressure = 0.8 bar

   Mach number of the flight = 1.2

   Ram efficiency = 90%

   Pressure of air bled off the main compressor = 4 bar

   Pressure of air in the secondary compressor = 5 bar

   Isentropic efficiency of the main compressor= 90%

   Isentropic efficiency of the secondary compressor = 80%

   Isentropic efficiency of the cooling turbine = 80%

Temperature of air leaving the first heat exchanger = 170^0C

Temperature of air leaving the secondary heat exchanger = 155^0C

Temperature of air leaving the evaporator = 100^0C

Cabin temperature = 25^0C

Cabin pressure = 1 bar

Find: 1. Mass of air required taking the cabin load, 2. Power required for the refrigeration system, and 3. C.O.P of the system.

Answer: (1) m_a = 120 kg/min; (2) P = 206 kW (3) C.O.P = 0.34

R.S Khurmi/107/3.10

Reduced Ambient Air Cooling System

5. Reduced ambient air refrigeration system used for an aircraft consists of two cooling turbine, one heat exchanger and one air cooling fan. The speed of aircraft is 1500 km/h. the ambient air conditions are 0.8 bar and 10^0C. The ram efficiency may be taken as 90%. The rammed air used for cooling is expanded in the first cooling turbine and leaves it at a pressure of 0.8 bar. The air bled from the main compressor at 6 bar is cooled in the heat exchanger and leaves it at 100^0C. The cabin is to be maintained at 20^0C and 1 bar. The pressure loss between the second cooling turbine and cabin is 0.1 bar. If the isentropic efficiency for the loss main compressor and both the cooling turbine are 85% and 80% respectively. Find: 1.Mass flow rate of air supplied to cabin load of 10 tonnes of refrigeration; 2.Quantity of air passing through the heat exchanger if the temperature rise of ram air is limited to 80 K; 3.Power used to drive the cooling fan; and 4.C.O.P. of the system.

   Answer: (1) m_a = 61 kg/min; (2) m_R = 124.3 kg/min; (3) P = 253 kW; (4) C.O.P = 0.21

   R.S Khurmi/111/3.11

Regenerative Air Cooling System

6. Regenerative air cooling system is used for an aeroplane to take 20 tonnes of refrigeration load. The ambient air at pressure 0.8 bar and temperature 10^0C is rammed isentropically till the pressure rises to 1.2 bar. The air bled off the main compressor at 4.5 bar is cooled by the ram air in the heat exchanger whose effectiveness is 60%. The air from the heat exchanger is further cooled to 60^0C in the regenerative heat exchanger with the portion of the air bled after expansion

in the cooling turbine. The cabin is to be maintained at a temperature of 25^0C and a pressure of 1 bar. If the isentropic efficiencies of the compressor and turbine are 90% and 80% respectively. Find:

1. Mass of air bled from cooling turbine to be used for regenerative cooling;
2. Power required for maintaining the cabin at the required condition; and
3. C.O.P. of the system. Assume the temperature of air leaving to atmosphere from the regenerative heat exchanger as 100^0C. R.S Khurmi/118/3.13

Answer: (1) m_a = 71.7 kg/min; (2) P = 2307 kW; (3) C.O.P = 0.23

Examples (Lab)

Bell-Coleman cycle

1. In an open cycle air refrigerating machine, air is drawn from a cold chamber at -2^{0}C and 1 bar and compressed to 11 bar. It is then cooled at this pressure, in to the cooler at temperature of 20^{0}C and then expanded in expansion cylinder and returned to the cold room. The compression and expansion processes to be isentropic with follow the law of $pv^{1.4}$ = constant. Sketch p-v and T-s diagrams of the cycle. For refrigeration capacity of 15 tonnes, find: 1.Theoritical C.O.P; 2. Rate of circulation of air in kg/min; 3. Piston displacement per minute in compressor and expander; 4. Theoretical power per tonne of refrigeration.

   Answer: (1) Theoretical C.O.P = 1.015; (2) m_a = 25.5 kg/min; (3) v_1 = 19.8 m^3/min; v_4 = 10.8 m^3/min; (4) Power/TR = 3.44 kW/TR R.S Khurmi 64/2.17

   [Note: Solve above problem for close air refrigeration cycle works between pressure limits of 3 bar and 11 bar and work out results.]

2. A dense air refrigeration system of 10 tonnes capacity works between 4 bar and 16 bar. The air leaves the cold chamber at 0^{0}C and discharges air at 25^{0}C to the expansion cylinder after air cooler. The compression and expansion cylinders are double acting. The mechanical efficiency of compressor and expander are 85% and 80% respectively. The compressor speed is 250 r.p.m. and has a stroke of 250 mm. Determine: 1. C.O.P; 2. Power required; and 3. Bore of compressor and expander cylinders. Assuming isentropic compression and expansion as polytropic with n = 1.25.

   Answer: (1) C.O.P = 0.641; (2) P = 54.6 kW; (3) D (compressor) = 0.2976 m; d (expander) = 0.271 m R.S Khurmi 69/2.20

   [Note: Solve above problem for open air refrigeration cycle and work out its consequences on C.O.P]

3. A Bell-Coleman cycle works between 1 bar and 5 bar. The adiabatic efficiency of compressor is 85% and expander is 90%. Find out the C.O.P of the system and its tonnage when the air flow rate is 1 kg/sec. The ambient temperature is 27^{0}C and refrigerator temperature is 0^{0}C.

   Answer: (1) C.O.P = 0.815; (2) Tonnage = 21.66 tones Domkundwar 3.61/3.28

4. An air refrigerator works between pressure limits of 1 bar and 4 bar. The temperature of the air entering the compressor is 15^0C and entering the expansion cylinder is 30^0C. The expansion follows the law $pv^{1.25}$ = constant. The compression follows the law $pv^{1.35}$ = constant. Take for air, C_p = 1 kJ/kg K and C_v = 0.7 kJ/kg K. Find the following: (1) C.O.P of refrigerating cycle; (2) If air circulation through the system is 25 kg/min, find the refrigeration capacity of the system.

   Answer: (1) C.O.P = 1.67 (2) Refrigeration capacity = 6.9 TR Domkundwar 3.45/3.17

5. Air refrigerator works between the pressure limits of 1 bar and 5 bar on Bell-Coleman cycle. The temperature of air entering the compressor and expansion cylinder is 10^0C and 25^0C respectively. The expansion and compression follows the law $pv^{1.3}$ = constant. Take for air, C_p = 1 kJ/kg K and C_v = 0.7 kJ/kg K. Find the followings: (1) Theoretical C.O.P. of refrigerating cycle; (2) If the load on refrigerating machine is 10 tones, then find amount of air circulated per minute through the system assuming the actual C.O.P. is 50% of theoretical C.O.P.; (3) The length and diameter of single acting compressor if the compressor runs at 300 rpm and volumetric efficiency is 85%. Take l/d = 1.5 and C_p = 1 kJ/kg K, C_v = 0.7 kJ/kg K for air. Domkundwar 3.49/3.21

   Answer: (1) Theoretical C.O.P. = 1.69; (2) m_a = 54 kg/min (3) d = 0.109, l = 0.164 m

Simple Air Cooling System

6. Ambient conditions for an aircraft cruising at 1000 km/h are 0.35 bar and -15^0C. The cabin temperature is 25^0C and turbine exit pressure is 1.06 bar. The pressure ratio of compressor is 3. Assuming 100% efficiency for ram effect, compressor and turbine and ideal heat exchanger, determine for simple gas refrigeration cycle of 18 tonnes capacity: 1. Temperatures and pressures at all points of cycle; 2. Mass flow rate and volume flow rates at compressor inlet and turbine outlet; 3. Work requirement; and 4. C.O.P.

Answer: (1) T_1 = 258 K, P_1 = 0.35 bar, T_2 = 296.4 K, P_2 = 0.569 bar, T_3 = 405.8 K, $P_3 = P_4$ = 1.707 bar, $T_4 = T_2$ = 296.4 K, T_5 = 258.7 K, P_5 = 1.06 bar (given); (2) m_a = 106.2 kg/min, V_2 = 158.4 m^3/min, V_5 = 74.1 m^3/min (3) W = 194.6 kW.

Rajput 107/2.35

Simple Air Evaporative Cooling System

7. Simple evaporative air refrigeration system is employed for an aeroplane to take 18 tonnes of refrigeration load. The ambient air conditions are 0.9 bar and 23^{0}C. The ambient air is rammed isentropically to a pressure of 1 bar. The air leaving the main compressor at pressure 3.6 bar and it first cooled in the heat exchanger having effectiveness of 0.64 and then in the evaporator where its temperature is reduced by 6.2^{0}C. The air from the evaporator is passed through the cooling turbine and then it is supplied to the cabin which is to be maintained at a temperature of 22^{0}C and pressure of 1.05 bar. If the internal efficiency of the compressor is 82% and that of cooling turbine is 78%. Determine: 1. The mass of air bled off the main compressor; 2. power required for the refrigeration system; 3. C.O.P of the refrigeration system. Answer: (1) m_a = 219.895 kg/min; (2) P = 598.5 kW; (3) C.O.P = 0.105 Rajput/114/2.39

Boot-Strap Air Cooling System

8. A boot-strap cooling system of 9 TR capacity is employed in an aeroplane. The ambient air temperature and pressure are 20^{0}C and 0.86 bar respectively. The pressure of air increased from 0.86 bar to 1 bar due to ramming action of air. The pressure of air discharge from the main compressor is 3.2 bar. The discharge pressure of air from auxiliary compressor is 4.2 bar. The isentropic efficiency of each of the compressor is 82%, while that of turbine is 86%. 45% of the enthalpy of air discharged from the main compressor is removed in the first heat exchanger and 32% of the enthalpy of air discharged from the auxiliary compressor is removed in the second heat exchanger using rammed air. Assuming the ramming action to be isentropic, the required cabin pressure is 0.92 bar and temperature of the air leaving the cabin not more than 21^{0}C, find: 1. The power required to operate the system; and 2. The C.O.P of the system. Draw the schematic and T-s diagram of the system. Take γ = 1.4 and c_p = 1 kJ/kg K.
Answer: (1) P = 132.28 kW; (2) C.O.P = 0.238 Rajput/117/2.40

Boot-Strap Evaporative Air Cooling System

9. A boot strap evaporative air refrigeration system is employed for an aeroplane moving with Mach number of 1.3, to take 18 tonnes of refrigeration load of the cabin. The cooling air is taken from the main compressor at 4.2 bar and further compressed to 5.2 bar which is run by cooling turbine. The following data may be used:

   Ambient conditions = 0.52 bar, -12^{0}C

   Isentropic efficiency of the main compressor = 88%

   Isentropic efficiency of the secondary compressor = 82%

   Isentropic efficiency of the cooling turbine = 80%

   Effectiveness of both heat exchangers = 0.42

   Ram efficiency = 90%

   Temperature of air coming out of the evaporator = 100^{0}C

   Pressure and temperature maintain in the cabin = 1 bar, 27^{0}C

   Determine: 1. Mass of air taken from the main compressor for the cabin cooling; 2. Power required to run the refrigeration system, and 3. C.O.P of the system. Take γ = 1.4 and c_p = 1 kJ/kg K. Rajput/124/2.43

   Answer: (1) m_a = 107.16 kg/min; (2) P = 271.1 kW; (3) C.O.P = 0.232

Reduced Ambient Air Cooling System

10. Reduced ambient air refrigeration system used for an aircraft consists of two cooling turbine with heat exchanger in between. The output of both the turbine is used to run the fan. The speed of aircraft is 1500 km/h. The ambient air conditions are 0.24 bar and -38^{0}C. The air passing through the heat exchanger is discharged to the atmosphere with the help of fan. The compressed air cooled to 48^{0}C in the heat exchanger. The pressure ratio of the main compressor run by a turbine from which air is bled off for the refrigeration purposes is 4.2 bar. There is a pressure loss of 0.06 bar at the supply air nozzle to the cabin. The cabin condition is maintained at 1 bar pressure and 20^{0}C. If the ramming efficiency 88%, isentropic efficiency of compressor 82% and isentropic efficiency of each turbine 80%. Determine: 1. Mass flow rate of air supplied to cabin if the cooling load in the cabin is 22 tonnes; 2. Air flow of ram air passed over the heat exchanger if the maximum rise in temperature is limited to 120 K; 3. Power used

to drive the cooling fan; and 4. C.O.P. of the system. Take γ = 1.4 and c_p = 1 kJ/kg K.

Answer: (1) m_a = 134.4 kg/min; (2) m_R = 223.855 kg/min; (3) P = 394.5 kW; (4) C.O.P = 0.195 Rajput/132/2.45

Regenerative Air Cooling System

11. Regenerative air cooling system is used for an areoplane to take 20 tonnes of refrigeration load when the plane is moving at Mach number. The ambient air at pressure 0.8 bar and temperature 20^0C is rammed isentropically till the pressure rises to 1.2 bar. The air bled off the main compressor at 4.5 bar is cooled by the ram air in the heat exchanger whose effectiveness is 60% of the total heat of the air leaving the main compressor is removed in the heat exchanger and then it is passed through the cooling turbine. The temperature of rammed air which is used for cooling purpose in heat exchanger and then it is passed through the cooling turbine. The temperature of the rammed air which is used for cooling purposes in heat exchanger is reduced to 40^0C by mixing the air coming out of the cooling turbine. If the isentropic efficiencies of the compressor and turbine are 90% and 80% respectively. Find: 1. Ratio of the bypassed air to ram air used for cooling purpose; 2. Power required for cooling and pressurization of the cabin; 3. C.O.P. of the system. Assume the temperature of air leaving the cabin should not exceed 25^0C.

Answer: (1) m_r/m_b = 3.24 kg/min; (2) P = 251.4 kW; (3) C.O.P = 0.278

Domkundwar 3.82/3.40

ASSIGNMENT – 4 VAPOUR COMPRESSION REFRIGERATION SYSTEM

Theory

1. Explain mechanism of a simple vapour compression refrigeration system with neat sketch and p-h and T-s diagram. Mention the advantages and disadvantages of vapour compression system over air refrigeration system.
2. Explain types of vapour compression refrigeration cycles with expression of C.O.P and with help of p-h and T-s diagram:
    a. Theoretical vapour compression cycle with dry saturated vapour after compression
    b. Theoretical vapour compression cycle with wet vapour after compression
    c. Theoretical vapour compression cycle with superheated vapour after compression
    d. Theoretical vapour compression cycle with superheated vapour before compression
    e. Theoretical vapour compression cycle with subcooling of refrigerant
3. Discuss various factors affecting the performance of vapour simple compression refrigeration cycle.
4. How actual vapour compression refrigeration cycle differs from theoretical vapour compression refrigeration cycle? Explain with T-s diagram.
5. Explain following simple saturation cycle with p-h diagram:
    a. Simple saturation cycle with flash chamber
    b. Simple saturation cycle with accumulator OR pre-cooler
    c. Simple saturation cycle with subcooling of liquid refrigerant by vapour refrigerant
    d. Simple saturation cycle with subcooling of liquid refrigerant by liquid refrigerant.
6. Mention the limitations of simple vapour compression refrigeration cycle. Give Advantages of compound vapour compression (or Multi-stage) refrigeration system with intercooler.

7. Explain following types of compound vapour compression with intercooler with schematic and p-h diagram:
    a. Two stage compression with liquid flash intercooler
    b. Two stage compression with flash chamber
    c. Two stage compression with flash chamber as liquid subcooler
    d. Two stage compression with water intercooler and liquid subcooler
    e. Two stage compression with water intercooler, liquid subcooler and liquid flash chamber
    f. Two stage compression with water intercooler, liquid subcooler and flash intercooler
8. Explain Cascade refrigeration system with neat sketch.
9. Explain following types of Multiple evaporators and compression system with schematic and p-h diagram:
    a. Multiple evaporators at same temperature with single compressor and expansion valve
    b. Multiple evaporators at different temperatures with single compressor, individual expansion valves and back pressure valves
    c. Multiple evaporators at different temperatures with single compressor, multiple expansion valves and back pressure valves
    d. Multiple evaporators at different temperatures with individual compressors and individual expansion valves
    e. Multiple evaporators at different temperatures with individual compressors and multiple expansion valves
    f. Multiple evaporators at different temperatures with compound compression, individual expansion valves
    g. Multiple evaporators at different temperatures with compound compression, individual expansion valves and flash intercoolers
    h. Multiple evaporators at different temperatures with compound compression, multiple expansion valves and flash intercoolers

Examples (Class)

Theoretical Vapour Compression Cycle with Dry Saturated Vapour after Compression

1. The temperature limits of an ammonia refrigeration system are 25^0C and -10^0C. If the gas is dry at the end of compression. Calculate the coefficient of performance of the cycle assuming no undercooling of the liquid ammonia. Use the following table for properties of ammonia:

Temperature (^{0}C)	Liquid heat (kJ/kg)	Latent heat (kJ/kg)	Liquid entropy (kJ/kg K)
25	298.9	1166.94	1.1242
-10	135.37	1297.68	0.5443

Answer: (1) C.O.P = 6.8 R.S Khurmi 130/4.2

Theoretical Vapour Compression Cycle with Wet Vapour after Compression

2. Find the theoretical C.O.P for a CO_2 machine working between the temperature range of 25^0C and -5^0C. The dryness fraction of gas during the suction stroke is 0.6. Use the following table for properties of CO_2:

Temperature (^{0}C)	Liquid		Vapour		Latent heat (kJ/kg)
	Enthalpy (kJ/kg)	Entropy (kJ/kg K)	Enthalpy (kJ/kg)	Entropy (kJ/kg K)	
25	164.77	0.5978	282.23	0.9918	117.46
-5	72.57	0.2862	321.33	1.2146	248.76

Answer: (1) Theoretical C.O.P = 3.57 R.S Khurmi 135/4.5

Theoretical Vapour Compression Cycle with Superheated Vapour after Compression

3. A simple refrigerant 134a (tetraflouroethane) heat pump for space heating, operates between temperature limits of 15^0C and 50^0C. The heat required to be pumped is 100 MJ/h. Determine: (1) The dryness fraction of refrigerant entering the evaporator; (2) The discharge temperature assuming specific heat of vapor as 0.996 kJ/kg K; (3) The theoretical piston displacement of the compressor; (4) The theoretical power of the compressor; and (5) The C.O.P. The specific volume of refrigerant 134a saturated vapour at 15^0C is 0.04185 m^3/kg. Use the following table for properties of R-134a:

Temperature (^{0}C)	Pressure (bar)	Specific Enthalpy (kJ/kg)		Specific Entropy (kJ/kg K)	
		Liquid	Vapour	Liquid	Vapour
15	4.887	220.26	413.6	1.0729	1.7439
50	13.18	271.97	430.4	1.2410	1.7312

Answer: (1) x_4 = 0.2675; (2) T_2 = 327.13 K; (3) Piston disp. = 4.29 m^3/min; (4) P = 3.57 kW; (5) C.O.P = 6.8 R.S Khurmi 139/4.8

Theoretical Vapour Compression Cycle with Superheated Vapour before Compression

4. A vapour compression refrigeration plant works between temperature limits of 5.3 bar and 2.1 bar. The vapour is superheated at the end of compression, its temperature being 37^{0}C. The vapour is superheated by 5^{0}C before entering the compressor. If the specific heat of superheated vapour is 0.63 kJ/kg K. Find the coefficient of performance of the plant. Use the data given below:

Pressure (bar)	Saturation temperature (^{0}C)	Liquid heat (kJ/kg)	Latent heat (kJ/kg)
5.3	15.5	56.15	144.9
2.1	-14	25.12	158.7

Answer: (1) C.O.P = 4.735 R.S Khurmi 146/4.12

Theoretical Vapour Compression Cycle with Undercooling OR Subcooling of Refrigererant

5. A vapour compression refrigerator uses R-12 as refrigerant and the liquid evaporates at -15^{0}C. The temperature of this refrigerant at the delivery from the compressor is 15^{0}C when the vapour is condensed at 10^{0}C. Find: (1) C.O.P. if there is no undercooling; and (2) The liquid is cooled by 5^{0}C before expansion by throttling. The specific heat at constant pressure for the superheated vapour as 0.64 kJ/kg K and that for liquid as 0.94 kJ/kg K. Following properties of R-12 are given:

Temperature (^{0}C)	Enthalpy (kJ/kg)		Entropy (kJ/kg K)	
	Liquid	Vapour	Liquid	Vapour
-15	22.3	180.88	0.0904	0.7051
10	45.4	191.76	0.1750	0.6921

Answer: (1) C.O.P (w/o undercooling) = 9.27; (2) C.O.P (with undercooling) = 9.59 R.S Khurmi 148/4.13

6. A vapour compression refrigerator uses methyl chloride (R-40) and operates between pressure limits of 177.4 kPa and 967.5 kPa. At entry to the compressor, the methyl chloride is dry saturated and after compression has a temperature of 102^0C. The compressor has bore and stroke of 75 mm and runs at 8 r.p.s. with a volumetric efficiency of 80%. The temperature of liquid refrigerant as it leaves the condenser is 35^0C and its specific heat capacity is 1.624 kJ/kg K. The specific heat capacity of the superheated vapour may be assumed to be constant. Determine: 1. Refrigerator C.O.P.; 2. Mass flow rate of refrigerant; and 3. Cooling water required by the condenser if its temperature rise is limited to 12^0C. Take c_{pw} = 4.187 kJ/kg K. Following properties of methyl chloride are given: R.S Khurmi 153/4.16

Temperature (^{0}C)	Pressure (kPa)	Specific volume (m^3/kg)		Specific enthalpy (kJ/kg)		Specific entropy (kJ/kg K)	
		Liquid	Vapour	Liquid	Vapour	Liquid	Vapour
-10	177.4	0.00102	0.233	45.38	460.76	0.183	1.762
45	967.5	0.00115	0.046	132.98	483.6	0.485	1.587

Answer: (1) C.O.P = 2.98; (2) m_R = 0.55 kg/min; (3) m_w = 5.03 kg/min

Actual Vapour Compression Refrigeration Cycle

7. A simple ammonia compression system operates with a capacity of 150 tonnes. The condensation temperature in the condenser is 35^0C. The evaporation temperature in brine cooler is -25^0C. The ammonia leaves the evaporator and enters the compressor at -8^0C. Ammonia enters the expansion valve at 30^0C. Wire drawing through the compressor valves: suction = 0.118 bar; discharge = 0.23 bar; compression index = 1.22; volumetric efficiency = 0.75. Calculate: (1) Power; (2) Heat transfer to cylinder water jacket; (3) Piston displacement; (4) Heat transfer in condenser; and (5) C.O.P.

   Answer: (1) P = 148.3 kW; (2) Q =3838 kJ/min; (3) Piston disp. = 30 m^3/min; (4) Q_R = 36556 kJ/min; (5) C.O.P = 3.54 R.S Khurmi 175/4.25

Simple Saturation Cycle with Sub-Cooling Of Liquid Refrigerant by Vapour Refrigerant

8. A vapour compression refrigeration system using R-22 as refrigerant, condenser outlet temperature in the condenser is 40^0C. The evaporation inlet temperature is -20^0C, in order to avoid flashing of the refrigerant, a liquid-suction vapour heat exchanger is provided where liquid is subcooled to -26^0C. The refrigerant leaves the evaporator as saturated vapour. The compression is isentropic find the power requirement and C.O.P if capacity of the system is 10 kW at -20^0C. Show the cycle on T-s and p-h diagrams. The specific heat of vapour is 1.03 kJ/kg K. Use below table.

Temperature (^{0}C)	Pressure (bar)	Specific volume of vapour m^3/kg	Specific enthalpy (kJ/kg)		Specific entropy (kJ/kg K)	
			Liquid	Vapour	Liquid	Vapour
-20	2.458	0.093	22.21	243.25	0.0908	0.9638
26	10.189	0.0218	79.74	260.64	0.2935	0.9014
40	14.489	0.0148	97.94	263.21	0.3563	0.8822

Answer: (1) P = 3.22 kW; (2) C.O.P = 3.1 R.S Khurmi 183/4.26

Multiple Evaporators at Different Temperatures with Single Compressor, Individual Expansion Valves and Back Pressure Valves

9. A single compressor using R-12 as refrigerant has three evaporators of capacity 30 TR, 20 TR and 10 TR. All the evaporators operate at -10^0C, 5^0C and 10^0C respectively. The condenser pressure is 9.609 bar. The liquid refrigerant leaving the condenser is subcooled to 30^0C. The vapour leaving the evaporators is dry and saturated. Assuming isentropic compression, find: 1. The mass of refrigerant flowing through each evaporator; 2. The power required to drive the compressor; and 3. The C.O.P. of the system. R.S. Khurmi 240/6.2

Multiple Evaporators at Different Temperatures with Single Compressor, Multiple Expansion Valves and Back Pressure Valves

10. A single compressor using R-12 as refrigerant has three evaporators of capacity 30 TR, 20 TR and 10 TR. The temperature in three evaporators is to be maintained at -10^0C, 5^0C and 10^0C respectively. The system is provided with multiple expansion valves and back pressure valves. The condenser temperature is 40^0C. The liquid

refrigerant leaving the condenser is subcooled to 30^{0}C. The vapour leaving the evaporators is dry and saturated. Assuming isentropic compression, find: 1. The mass of refrigerant flowing through each evaporator; 2. The power required to drive the compressor; and 3. The C.O.P. of the system. R.S. Khurmi 245/6.3

Multiple Evaporators at Different Temperatures with Individual Compressors and Individual Expansion Valves

11. A refrigeration system using R-12 as refrigerant has three evaporators of capacity 20 TR, 30 TR and 10 TR with individual expansion valves and individual compressors. The temperature in three evaporators is to be maintained at -10^{0}C, 5^{0}C and 10^{0}C respectively. The condenser temperature is 40^{0}C. The liquid refrigerant leaving the condenser is subcooled to 30^{0}C. The vapour leaving the evaporators is dry and saturated. Assuming isentropic compression, find: 1. The mass of refrigerant flowing through each evaporator; 2. The power required to drive the compressor; and 3. The C.O.P. of the system. R.S. Khurmi 249/6.4

Multiple Evaporators at Different Temperatures with Individual Compressors and Multiple Expansion Valves

12. A refrigeration system using R-12 as refrigerant has three evaporators of capacity 20 TR at -10^{0}C, 30 TR at 5^{0}C and 10 TR at 10^{0}C. The vapour leaving three evaporators are dry and saturated. The system is provided with individual expansion compressors and multiple expansion valves. The condenser temperature is 40^{0}C. The liquid refrigerant leaving the condenser is subcooled to 30^{0}C. Assuming isentropic compression in each compressor, find: 1. The mass of refrigerant flowing through each evaporator; 2. The power required to drive the compressor; and 3. The C.O.P. of the system. R.S. Khurmi 254/6.5

Multiple Evaporators at Different Temperatures with Compound Compression, Individual Expansion Valves

13. A compound refrigeration system with R-12 as refrigerant is used for multi-load purposes, as shown in figure. Find the power required to run the system. Use p-h chart. There is no undercooling. R.S. Khurmi 258/6.6

Multiple Evaporators at Different Temperatures with Compound Compression, Individual Expansion Valves and Flash Intercoolers

14. A compound refrigeration system using R-12 as refrigerant has three evaporators of capacity 20 TR at -5^{0}C, 30 TR at 0^{0}C and 10 TR at 5^{0}C. The vapour leaving three evaporators are dry and saturated. The system is provided with individual expansion valves and flash intercoolers. The condenser temperature is 40^{0}C. The liquid refrigerant leaving the condenser is subcooled to 30^{0}C. Assuming isentropic compression in each stage. Find: 1. The mass of refrigerant flowing through each compressor; 2. The power required to drive the compressor; and 3. The C.O.P. of the system. R.S. Khurmi 262/6.7

Multiple Evaporators at Different Temperatures with Compound Compression, Multiple Expansion Valves and Flash Intercoolers

15. A compound refrigeration system using R-12 as refrigerant has three evaporators of capacity 30 TR at -10^{0}C, 20 TR at 5^{0}C, and 10 TR at 10^{0}C. The vapour leaving three evaporators are dry and saturated. The system is provided with multiple expansion valves and flash intercoolers. The condenser temperature is 40^{0}C. The liquid refrigerant leaving the condenser is subcooled to 30^{0}C. Assuming isentropic compression in each stage, find: 1. The mass of refrigerant flowing through each compressor; 2. The power required to drive the compressor; and 3. The C.O.P. of the system. R.S. Khurmi 267/6.8

Examples (Lab)

Theoretical Vapour Compression Cycle with Dry Saturated Vapour after Compression

1. 28 tonnes of ice from 0^0C is produced per day in an ammonia refrigerator. The temperature range in the compressor is 25^0C to -15^0C. The vapour is dry and saturated at the end of compression and an expansion valve is used. There is no liquid subcooling. Assuming actual C.O.P. of 62% of the theoretical, calculate the power required to drive the compressor. Take latent heat of for ice = 335 kJ/kg. Following properties of ammonia are given:

Temperature (^{0}C)	Enthalpy (kJ/kg)		Entropy (kJ/kg K)	
	Liquid	Vapour	Liquid	Vapour
25	298.9	1465.84	1.1242	5.0391
-15	112.34	1426.54	0.4572	5.5490

Answer: (1) P = 30 kW R.S Khurmi 133/4.4

Theoretical Vapour Compression Cycle with Wet Vapour after Compression

2. Ammonia refrigerating machine fitted with an expansion valve works between the temperature ranges of -10^0C to 30^0C. The vapour is 90% dry at the end of isentropic compression and the fluid leaving the condenser is at 30^0C. Assuming actual C.O.P. as 60% of the theoretical, calculate the kilograms of ice produced per kW hour at 0^0C from water at 10^0C. Latent heat of ice is 335 kJ/kg. Following properties of ammonia are given:

Temperature (^{0}C)	Liquid heat (h_f) (kJ/kg)	Latent heat (h_{fg}) (kJ/kg)	Liquid entropy (s_f) (kJ/kg K)	Total entropy of dry saturated vapour
30	323.08	1145.80	1.2037	4.9842
-10	135.37	1297.68	0.5443	5.4770

Answer: (1) Ice produced = 33.2 kg/kW hour R.S Khurmi 136/4.6

Theoretical Vapour Compression Cycle with Superheated Vapour after Compression

3. A simple saturation cycle using R-12 is designed for taking a load of 10 tonnes. The refrigerator and ambient temperature are 0^0C and 30^0C respectively. A minimum

temperature difference of 5^0C is required in the evaporator and condenser for heat transfer. Find: (1) Mass flow rate through the system; (2) Power required; (3) C.O.P.; and (4) Cylinder dimensions assuming L/D = 1.2, for a single cylinder, single acting compressor if it runs at 300 r.p.m. with volumetric efficiency of 90%.

Answer: (1) m_R = 18.26 kg/min; (2) P = 6.4 kW; (3) C.O.P = 5.476 Khurmi 142/4.10

Theoretical Vapour Compression Cycle with Superheated Vapour before Compression

4. A refrigerating machine using Freon-12 as working fluid works between the temperature -18^0C and 37^0C. The enthalpy of liquid at 37^0C is 78 kJ/kg. The enthalpies of Freon-12 entering and leaving the compressor are 200 kJ/kg and 238 kJ/kg respectively. The rate of circulation of refrigerant is 2 kg/min and efficiency of compressor is 0.85. Determine: (1) Capacity of the plant in TR; (2) Power required to run the plant; (3) C.O.P of the plant. Domkundwar 4.35/4.12

Answer: (1) Capacity = 1.16 TR; (2) P = 1.5 kW; (3) C.O.P = 2.7

Theoretical Vapour Compression Cycle with Undercooling OR Subcooling of Refrigerant

5. In a 15 TR ammonia refrigeration plant, the condensing temperature is 25^0C and evaporative temperature -10^0C. The refrigerant ammonia is sub-cooled by 5^0C before passing through the throttle valve. The vapour leaving the evaporator is 0.97 dry. Find: (1) Coefficient of performance; and (2) Power required. Following properties of ammonia are given:

Saturation temperature (^0C)	Enthalpy (kJ/kg)		Entropy (kJ/kg K)		Specific heat (kJ/kg K)	
	Liquid	Vapour	Liquid	Vapour	Liquid	Vapour
25	298.9	1465.84	1.1242	5.0391	4.6	2.8
-10	135.37	1433.05	0.5443	5.4770	-	-

Answer: (1) C.O.P = 6.93; (2) P = 7.55 kW R.S Khurmi 161/4.20

6. A refrigeration system of 10.5 tonnes capacity at an evaporator temperature of -12^0C and condenser temperature of 27^0C is needed in a food storage locker. The refrigerant ammonia is subcooled by 6^0C before entering the expansion valve. The vapour is 0.95 dry as it leaves the evaporator coil. The compression in the compressor is isentropic. Find: 1. Condition of vapour at outlet of the compressor; 2.

Condition of vapour at entrance to the evaporator; 3. C.O.P; and 4. Power required in kW. Neglect the valve throttling and clearance effect. R.S Khurmi 163/4.21

Answer: (1) T_2 = 326.7 K; (2) x_4 = 0.1187; (3) C.O.P = 6.137; (4) P = 5.987 kW

Simple Saturation Cycle with Sub-Cooling Of Liquid Refrigerant by Vapour Refrigerant

7. A refrigerant R-12 vapour compression includes a liquid to vapour heat exchanger in the system. The heat exchanger cools saturated liquid coming out of condenser from 32^0C to 22^0C with the help of vapour coming out of evaporator at -12^0C saturated. The compression is isentropic. Draw the line diagram of components, represents the processes on p-h diagram and find: (1) C.O.P of the system; (2) Refrigerating capacity of system if the compressor displacement is 1.2 m^3/min and; (3) C.O.P of the system without the heat exchanger. Domkundwar5.33/5.5

   Answer: (1) C.O.P = 5.57; (2) 7.8 TR; (3) C.O.P (w/o heat exchanger) = 3.77

ASSIGNMENT-5 VAPOUR ABSORPTION REFRIGERATION SYSTEM

Theory

1. Explain construction and working of simple vapour absorption refrigeration system with schematic diagram.
2. Explain construction and working practical Ammonia-Water (NH_3-H_2O) vapour absorption refrigeration system with schematic diagram. Also mention the advantages of this system.
3. Discuss desirable characteristics of refrigerant-absorbent mixture.
4. Advantages of vapour absorption refrigeration system over vapour compression refrigeration system.
5. Prove the expression for C.O.P for ideal vapour absorption refrigeration system.
6. Explain domestic Electrolux (Ammonia-Hydrogen) refrigerator.
7. Describe with neat sketch Li-Br and water system. What are its limitations?

Examples

Simple Vapour Absorption Refrigeration System

1. In an aqua- ammonia absorption refrigeration system of 10 TR capacity, the vapours leaving the generator are 100% pure NH_3 saturated at 40^0C. The evaporator, absorber, condenser and generator temperature are -20^0C, 30^0C, 40^0C and 70^0C respectively. At absorber exit (strong solution), the concentration of ammonia is solution is X = 0.38 and enthalpy h = 22 kJ/kg. At generator exit (weak solution) X = 0.1 and h = 695 kJ/kg. Find:
    1. Mass flow rate of ammonia in the evaporator;
    2. Mass flow rates of weak and strong solution;
    3. Heat rejection to condenser and absorber;
    4. Heat added in generator;
    5. C.O.P. R.S Khurmi 281/7.3

Answer: (1) m_1 = 2 kg/min; (2) m_2 (weak) = 7.636 kg/min; m_4 = 5.636 kg/min; (3) Q_C = 2202 kJ/min; Q_A = 6589 kJ/min; (4) Q_A = 6695 kJ/min; (5) C.O.P = 0.3137

Electrolux Refrigerator

2. The total pressure maintained in an Electrolux refrigerator is 14.71 bar. The temperature obtained in the evaporator is -15^0C. The quantities of heat supplied in the generator are 418.7 kJ to dissociate 1 kg vapour and 1465.4 kJ/kg for increasing the total enthalpy of NH_3 entering the evaporator is 335 kJ/kg. Take the following properties of NH_3 at -15^0C.Pressure = 2.45 bar; enthalpy of NH_3 vapour = 1666 kJ/kg; specific volume = 0.5 m^3/kg. The hydrogen enters the evaporator at 25C. Gas constant for H_2 = 4.218 kJ/kg K' c_p for H_2 = 12.77 kJ/kg K. Find the C.O.P. of the system. Assume NH_3 leaves the evaporator is saturated condition.

    Answer: C.O.P = 0.5536 R.S Khurmi 286/7.5

Lithium- Bromide Absorption Refrigeration System

3. The following data refer to LiBr + H_2O absorption system:

    Generator temperature = 80^0C; condenser temperature = absorber temperature = 30^0C; Evaporator temperature = 10^0C; condensate temperature = 25^0C.Steam enters the generator heating coil at 120^0C (dry saturated state steam) and leaves it at 100^0C as condenser. The concentration of liquid leaving the generator is 0.65 and its enthalpy is -75 kJ/kg. The concentration of liquid leaving absorber is 0.51 and its enthalpy is 170 kJ/kg. The enthalpy of vapour leaving the generator is 2620 kJ/kg. The flow rate through the evaporator is 0.4 kg/s. Find:

1. Pressure in generator, condenser, evaporator and absorber in mm of mercury head;
2. Tonnage;
3. Heat rejection to condenser and absorber;
4. C.O.P;
5. Relative C.O.P. R.S Khurmi 289/7.6

Answer: (1) p_G = 355.3 mm of Hg; p_C = 31.82 mm of Hg; p_E = 9.2 mm of Hg; p_A = 31.82 of Hg; (2) 276 TR; (3) Q_C = 1006 kJ/s; Q_A = 1214.36 kJ/s; (4) C.O.P = 0.77; (5) $(C.O.P)_{rel}$ = 0.384

ASSIGNMENT – 6 REFRIGERATION SYSTEM COMPONENTS

Theory

1. Explain construction and working of following types of refrigerant compressors with neat sketch:
    a. Reciprocation compressor (hermetically sealed)
    b. Centrifugal compressor
    c. Rotary compressor (e.g rolling piston type, rotating vane type, screw type)
2. Explain working of a condenser. Describe the factor affecting heat transfer capacity of condenser.
3. Explain construction and working of following types of air cooled refrigerant condensers with neat sketch:
    a. Natural convection air cooled condensers
    b. Forced convection air cooled condensers
4. Write short note on following water cooled refrigerant condensers with neat sketch:
    a. Double tube or tube-in-tube type
    b. Shell and coil type, Shell and tube type
5. State the functions of expansion device. Explain construction and working of on following types of expansion devices with neat sketch.
    a. Capillary tube
    b. Hand operated expansion valve
    c. Automatic (constant pressure) expansion valve
    d. Thermostatic expansion valve
    e. Low side float valve
    f. High side float valve
6. Explain working of an evaporator. Describe the factor affecting heat transfer capacity of an evaporator.
7. Write short note on following types of refrigerant evaporators with neat sketch.

a. Bare tube and finned type
b. Plate type
c. Shell and tube type
d. Shell and coil type
e. Double tube or tube-in-tube type
f. Flooded type & dry expansion type (DX)
g. Natural convection & forced convection
h. Frosting, non-frosting and defrosting type

ASSIGNMENT-7 Psychrometric properties

Theory

1. Define following terms:
   Saturated air (ii) Specific humidity (iii) Relative humidity (iv) Absolute humidity (v) Dry bulb temperature (vi) Dew point temperature (vii) Wet bulb depression
2. With neat sketch explain construction and working of any one type of humidifier.
3. With neat sketch explain construction and working of any one type of dehumidifier.
4. With neat sketch explain the sling- psychrometer.

Examples

1. Moist air at 30°C, 1.01325 bar has a relative humidity of 80%. Determine without using the psychometry chart
   1) Partial pressures of water vapour and air
   2) Specific humidity
   3) Specific Volume and
   4) Dew point temperature
2. Atmospheric air at 101.325 kPa ha 30°C DBT and 15°C DPT. Without using the psychrometric chart, using the property values from the table, Calculate
   1. Partial pressure of air and water vapour
   2. Specific humidity
   3. Relative humidity
   4. Vapour density and
   5. Enthalpy of moist air

3. Air at 30°C DBT and 25°C WBT is heated to 40°C. if the air is 300 m3/min, find the amount of heat added/min and RH and WBT of air. Take air pressure to be 1 bar.
4. One stream of air at 5.5m3/min at 15°C and 60% RH flows into another stream of air at 35m3/min at 25°C and 70%RH, calculate for the mixture

   1) Dry bulb temperature, 2) Wet bulb temperature 3) Specific Humidity and 4) Enthalpy
5. An air conditioning system is designed under the following conditions Outdoor conditions: 30°CDBT, 75% RH Required indoor conditions: 22°CDBT,70% RH Amount of Free air circulated 3.33 m3/s Coil dew point temperature DPT=14° The required condition is achieved first by cooling and dehumidification and then by heating. Estimate

   1) The capacity of the cooling coil in tons of refrigeration

   2) Capacity of the heating coil in kW

   3) The amount of water vapour removed in kg/hr

ASSIGNMENT-8 AIR REFRIGERATION CYCLE

Theory

1. Define Effective Temperature. Explain various factors governing effective temperature.
2. Explain the factor affecting human comfort.
3. Write brief note on human comfort chart

ASSIGNMENT-9 LOAD ANALYSIS

Theory

1. State and explain various heat loads to be considered for cooling load calculations of a typical building.
2. Write short note on Sources of Heat load.
3. Explain flywheel effect as applied to cooling load calculation with neat labeled diagram.
4. Explain the procedure for calculating cooling load due to infiltration air.

Examples

5. A summer air –conditioning system for a small office building is to be designed. The design is to be based on the following information: Outside design condition 35oC Tdb ,28oC Twb Inside design condition 26oC Tdb, 50% RH, Room sensible heat gain 45 Kw, Room latent heat gain 9 kW, Ventilation air 0.95 m3/s, A four row direct expansion refrigerant 134a coil with bypass factor of 0.2 is to be used. Analyze the problem on a psychrometric chart and determine the following:
   a) The room apparatus dew point (ADP)
   b) The temperature of the air leaving the coil
   c) The total quality of air required (m3/s)
   d) The temperature of mixed air entering the coil
   e) The coil apparatus dew point temperature.
6. A small office hall of 25 persons capacity is provided with summer air conditioning system with the following data:
   Outside conditions = 34^0 C DBT and 28^0 C WBT
   Inside conditions = 24^0 C DBT and 50 % RH

Volume of air supplied = 0.4 m3/min/person

Sensible heat load in room = 125600 kJ/h

Latent heat load in the room = 42000 kJ/h

Find the sensible heat factor of the plant.

ASSIGNMENT-10 DUCT DESIGN

Theory

1. Describe different methods of duct design.
2. Explain with neat sketch various terms used in air distribution.

Examples

1. A circular duct of 40 cm is selected to carry air in an air conditioned space at a velocity of 440 m/min to keep the noise level at desired level. If this duct is replaced by a rectangular duct of aspect ratio of 1.5, find out the size of rectangular duct for equal friction method when (a) the velocity of air in two ducts is same, (b) the discharge rate of air in two ducts is same.

ASSIGNMENT-11 AIR CONDITIONING SYSTEM

Theory

1. With line diagram explain Central Air-conditioning system of any multi storey building
2. Write short note on Split air conditioner.
3. Classify air conditioning systems. Explain Central air conditioning system with a neat sketch.
4. Explain All water air conditioning system with neat diagram.