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BE (8th Semester)

Examination, April-May, 2021

Branch : Mechanical

REFRIGERATION & AIR CONDITIONING

Time Allowed : Three Hours

Maximum Marks : 80

Minimum Pass Marks : 28

Note : (i) Solve all questions. Part (a) is compulsory but solve any of part (b) or (c).

(ii) Use of steam tables, psychrometric chart and tables are permitted.

(iii) Assume suitable data if necessary to do so.

Q. 1. (a) State difference between compound compression and cascade system of refrigeration. **2**

(b) An ammonia ice plant operates between condenser temperature of +35°C and an evaporator temperature of –15°C. It produces 5 tons of ice per day from water at 25°C to ice at –5°C. The NH_3 enters the compressor as dry saturated vapour and leaves the condenser as saturated liquid. Determine :

(i) The capacity of refrigerating plant

(ii) Mass flow of refrigerant

(iii) Discharge temperature of NH_3 from the compressor is 90%

(iv) Power of the compressor if the isentropic efficiency of the compressor is 85% and mechanical efficiency of the compressor is 90%.

(v) Relative efficiency

Take latent heat of ice = 335 kJ/kg

Specific heat of ice = 1.94 kJ/kg-K, specific heat of air = 4.2 kJ/kg-k. Use the following properties of NH_3. **14**

Saturation	Enthalpy kJ/kg		Entropy kJ/kg		Specific heat kJ/kg-K	
Temp. °C	h_f	h_g	s_f	s_g	Liquid C_{pf}	Vapour C_{pg}
–15	112.3	1426	0.457	5.549	—	—
35	347.5	1427	1.282	4.930	4.6	2.8

(c) Derive C.O.P. of absorption type refrigeration system in an absorption type refrigerator, the heat is supplied to NH_3 generator by condensing steam at 2 bar and 90% dry. The temperature to be maintained in the refrigerator is –5°C. The temperature of

the atmosphere is 30°C. Find maximum C.O.P. possible. If the refrigerator load is 20 tonnes and actual C.O.P. is 70% of maximum C.O.P., find the mass of steam required per hour. Latent heat of steam 2201.6 kJ/kg. **14**

Q. 2. (a) What is dense air system ? **2**

(b) In a Bell-Coleman cycle, environment temperature is 320 K and refrigerant temperature is 120 K. The minimum temperature of the cycle is 80 K. The

pressure in the refrigerator is 1 bar. Find the following : 14

(i) Maximum pressure and temperature of cycle

(ii) Refrigerating effect and heat rejected per kg of air

(iii) Network required per kg of air

(iv) Compressor and expander swept volume per kg of air

(v) C.O.P. of cycle

(vi) η_c

(c) A bootstrap cooling system of 9 tonnes refrigeration capacity is employed in an aeroplane. The ambient air temperature and pressure are 20°C and 0.86 bar respectively. The pressure of air increases from 0.86 bar to 1 bar due to ramming action of air. The pressure of air discharged from the main compressor is 3.2 bar. The discharge of pressure from the auxiliary compressor is 4.2 bar. The isentropic efficiency of each compressor is 82% while that of turbine is

86%. The 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 ramming action to be isentropic, the required cabin pressure of 0.092 bar and temperature of air leaving the cabin not more than 21°C find C.O.P. of the system. For air Cp = 1 kJ/kg-K, Y = 1.4. 14

Q. 3. (a) What are functions of rectifier and analyser vapour absorption system ? 2

(b) Classify refrigerants and explain their numberings. What are their desirable properties ? How are refrigerants selected for appropriate refrigeration systems ? Mention disadvantage of CFC refrigerants. 14

(c) Describe in detail Electrolure refrigerator with figure. How is its C.O.P. determined. Explain role of hydrogen in its system. 14

Q. 4. (a) Explain allignment circle & dew point of apparatus and human confort conditions. 2

(b) Atmospheric air at 0.967 bar has 11°C wetbulb depression from 31°C drybulb temperature during adiabatic saturation process. Determine :

(i) Specific humidity from adiabatic saturation equation

(ii) Vapour pressure and RH at 31°C

(iii) Dew point temperature

Is there any other equation to check the vapour pressure and calculate the same. 14

(c) 108 m^3 of air per minute at 5°C DBT and 2.5° WBT is passed through a heating coil which gives 48.85 kW energy to the air. Saturated steam at 110°C with a rate of 48 kg/h is mixed with the air leaving the heater. Determine the DBT and WBT of the air after mixing with steam, given that the enthalpy of saturated steam at 110°C is 2691 kJ/kg. **14**

Q. 5. (a) List out main parts of split domestic air-conditioner. **2**

(b) Air at 12°C DBT and 70% RH is to be heated and humidified to 36.5° DBT and 21°C WBT. The air is preheated sensibly before passing to the air-washer in which water is recirculated. The relative humidity of the air coming out of the air washer is 70%. This air is again reheated sensibly to obtain the final desired condition. Determine : 14

(i) Temperature to which the air should be preheated

(ii) Total heating required

(iii) Make up water required in the air washer

(iv) Humidification efficiency of the air washer.

(c) The following data relate to a conference room for seating 80 persons.

Inside design condition 22° DBT, 55% R.H.

Outside design condition 38° DBT 28° WBT

sensible & latent heat load per person 75 W and 45 W respectively

Internal electrical appliances lights and fans 12000 W

Sensible heat gain through glass, walls, ceiling 12000 W

Air unfiltration 18 m^3/min

Fresh air supply 80 m^3/min

By pass factor of coils 0.1

Recirculation - two thirds recirculated - air mixed with one third of fresh air before entering the coil.

Draw schematic diagram, rough psychrometric chart showing data and find out :

(i) apparatus dew point

(ii) grand total of heat loud

(iii) effective room sensible heat factor. **14**