[Total No. of Questions - 9] [Total No. of Printed Pages - 4]
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B. Tech 7th Semester Examination

Refrigeration and Air-Conditioning (OS)

ME-7003

Time : 3 Hours **Max. Marks : 100**

The candidates shall limit their answers precisely within the answer-book (40 pages) issued to them and no supplementary/continuation sheet will be issued.

Note : (i) Candidates are requested to attempt five questions in all, selecting one question from each section A, B, C & D. Section E is compulsory.
(ii) Use of steam tables, psychometric charts and calculator are allowed.

SECTION - A

1. (a) Explain selection criteria of refrigerants. (10)

(b) A reduced ambient system of air refrigeration for cooling an aircraft cabin consists of two cooling turbines, one intercooler and one fan. The cooling turbine A is supplied with the ram air at 1.1 bar and 15°C and delivers it after expansion to the intercooler at 0.9 bar for cooling air tapped from the engine compressor at 3.5 bar. Finally the cooling air from the intercooler is sucked by a fan and discharged to the atmosphere. The cooled air from intercooler is expanded up to one bar in the turbine B and discharged into air cabin to be cooled. The cabin air in the cabin is exhausted at 22ºC. The refrigerating capacity required is 10 tons. The index of compression for the engine compressor is 1.5 and the index of expansion for both the turbines is 1.33. Find out (a) mass flow rate of cabin air. (b) Combined output of two turbines driving the air fan with transmission efficiency of 60%. (c) If the compressed air is to be cooled to 60°C in the intercooler and temperature rise in the intercooler for the ram air is to be limited to 30°C. Find out the cooling capacity of the intercooler and flow rate of ram air. (d) COP of the system. (10)

2. (a) Explain, with a neat sketch, the working principle of boot strap evaporative type of air refrigeration system. Draw T-S diagram for the system. (10)

[P.T.O.]

(b) For an air refrigeration system of an air-craft flying at an altitude of 2000 (p= 0.8 bar and = 0ºC). ramming increases the pressure to 1.05 bar and temperature of rammed air is 17ºC. It is then compressed isentropically to 4 bar in main compressor and then cooled to 27ºC using ram air and then the air is further compressed isentropically to 20 bar in an auxiliary compressor driven solely by cooling turbine. The compressed air further cooled to 27°C in an auxiliary heat exchanger. Finally isentropic expansion takes place up to cabin pressure of 1 bar and air leaves the cabin at 27°C. Find:
(i) COP of cooling system.
(ii) If the cabin load is 60 TR, the mass flow rate of air.
(iii) Power required to run the system. (10)

SECTION - B

3. (a) Explain with reference to T-S diagram, the stages involved in vapour compression process of refrigeration. Establish an expression for the coefficient of performance. (10)

(b) A two-stage compression m/c with a flash intercooler is to produce 25 ton of refrigeration while working between -30ºC and 42°C, the pressure in the flash intercooler is the geometric mean of the upper and lower pressure limits. Sketch the system and the on P-H diagram. The enthalpy at the end of LP compressor and HP compressor are 105kJ/kg and 211kJ/kg respectively. The working medium is R-12; find out (i) COP (ii) power (iii) rate of refrigerant flow through the LP and HP compressors and (d) volume handled by LP compressor. (10)

4. (a) Explain a three stage compression with multiple expansion valves and flash intercooler. (10)

(b) A R-12 vapor compression unit with flash intercooler is used for the following requirements

Evaporator temperature = -40ºC

Inter stage (intercooler) temperature = -24°C

Condensation pressure = 7.6 bar above.

Calculate

(i) C.O.P. of the system.
(ii) Power required to run the system when the load on evaporator is 20 tones.
(iii) Calculate C.O.P. and power if a single stage compressor is used for the same evaporator and condenser temperature. (10)

SECTION - C

5. (a) A cascade refrigeration system using R-22 and R-13 is required to produce 20 tonnes of refrigeration at -70ºC. Heat is rejected in cascade condenser by R-13 at -5°C to R-22 at 15°C. The condensation in the water cooled condenser is at 40°C. Assume simple saturated cycles for both the circuits.

Determine

(i) Pressure ratio and mass flow rate of each cascade.

(ii) COP and piston displacement of each cascade cycle.

(iii) COP of the combined system. (10)

(b) Draw a neat diagram of Electrolux refrigeration and explain its working principle. What is the important role of hydrogen in this refrigeration? (10)

6. (a) Explain the term "'Cryogenics". Explain why the vapour compression refrigeration system is not an appropriate solution for the production of low temperature? (10)

(b) A NH_3-water absorption system works using saturated steam supplied at 2 bar with 120°C temperature needed for heat transfer. The evaporator is maintained at 4 bar and the absorber temperature is 30°C. There is negligible pressure drop between them. The generator pressure is 16 bar. The weak solution from the generator, the condensate from the condenser and aqua solution from the absorber are in the saturated state. The aqua solution is heated in a heat exchanger with 35°C temperature rise and the condenser is sub cooled by 25°C by the vapour leaving the evaporator. Flow rate through the evaporator is 1 kg/sec. Determine (i) heat transfer to or from the generator evaporator, condenser and absorber (ii) tonnage (iii) COP (iv) steam consumption per hour. (10)

SECTION - D

7. (a) What are the commonly used duct design methods? Explain all in detail. (10)

(b) A hall is to be maintained at 24°C and 60% RH when the following data are given:

Outdoor conditions 38°C DBT and 28°C WBT.

Sensible heat load in the room 125000 KJ/hr.

Latent heat load in the room 42000 KJ/hr.

ADP temperature 10°C

[P.T.O.]

The recalculated air is mixed with the conditioned air after the cooling coil then, finds the following:

(i) The condition of air leaving the conditioner coil and before mixing with the recalculated.

(ii) Condition of air before entering the hall.

(iii) The mass of air entering the cooler.

(iv) The total air passing through the hall.

(v) BPF of the cooling coil. (10)

8. (a) 3 Moist air at 1 atm. pressure has a dry bulb temperature of 32ºC and a wet bulb temperature of 26ºC. Calculate (i) the partial pressure of water vapour, (ii) humidity ratio, (iii) relative humidty, (iv) dew point temperature, (v) density of dry air in the mixture, (vi) density of water vapour in the mixture and (vii) enthalpy of moist air using perfect gas law model and psychrometric equations. (10)

(b) A winter air conditioning system maintains a building at 21ºC and 40% RH. The outdoor conditions are 0ºC (DBT) and 100% RH. The sensible load on the building is 100 kW, while the latent heating load is 25 kW. In the air-conditioning system, 50% of the outdoor air (by mass) is mixed with 50% of the room air. The mixed air is heated in a pre-heater to 25ºC and then required amount of dry saturated steam at 1 atm. Pressure is added to the pre-heated air in a humidifier. The humidified air is then heated to supply temperature of 45ºC and is then supplied to the room. Find (i) The required mass flow rate of supply air. (ii) Required amount of steam to be added and (iii) Required heat input in pre-heater and re-heater. Barometric pressure=1atm. (10)

SECTION - E

9. (a) What are the general rules for duct design?

(b) Write short note on thermal comfort.

(c) Define the terms: (i) Saturated vapour (ii) Relative humidity (iii) Degree of saturation (iv) Humidity ratio.

(d) Write short note on psychrometric chart.

(e) What are the methods of refrigeration? Explain any one briefly.

(f) What are eco-friendly refrigerants?

(g) What are the limitations of reversed Carnot cycle with vapour as refrigerant?

(h) How do operating conditions affect COP of refrigeration systems?

(i) State relative merit and demerits of steam jet refrigeration system.

(j) What are basic processes in conditioning of air? (2×10=20)