BENGAL ENGINEERING & SCIENCE UNIVERSITY, SHIBPUR

B.E./B.Arch. (Part IV) 7th Semester Examination, Nov. 2013

Refrigeration & Air-Conditioning (ME-702)

Semester: 7th Semester **Branch: ME**
Time: 3 hrs **Full Marks: 70**

Attempt any three from each half. All questions are of equal value. Unassigned marks reserved for neatness. Use of property tables/diagrams permitted.

First Half

1. (a) When can a cooling coil act as a dehumidifying apparatus for moist air? Define bypass factor for a cooling coil.

   (b) Ambient air at 28°C DBT and 40% RH is passed over a cooling coil. The ADP of the coil is 7°C and its air bypass factor is 15%. Estimate the coil exit air temperature and RH and the SHF for the process. If the air flow rate is 2 kg/s, estimate the cooling capacity of the coil. Assume moist air C_p as 1.021 kJ/kg-K and h_{fg} for vapor as 2501 kJ/kg. Psychrometic diagram may also be used.

   [4 + 7]

2. (a) Explain the principles of direct and indirect evaporative cooling with suitable schematics and property diagrams

   ((b) A large hall with is ventilated with conditioned outside air at arate of 200 cmm. The supply air condition is 20°C DBT, 60% RH while the outside air is at 40°C DBT, 20°C WBT. The supply condition is achieved by applying adiabatic humidification first, followed by sensible cooling. Find the capacity of the humidifier and also that of the cooling coil. [5 + 6]

3. ((a) Explain RSHF and CSHF with respect to a summer air conditioning system involving partial recirculation of indoor. Draw the process lines for the room as well as the cooling coil on a psychrometric diagram without considering any coil bypass. State the relevant energy equations for the sensible and latent heat transfers for the room and the cooling coil.

   (b) An air-conditioning system maintains an indoor air condition of 25°C DBT and 50% RH while the outdoor condition is 40°C DBT, 27°C WBT. Recirculated air is mixed with outdoor air at 1:1 ratio, each having a rated flow of 100 cmm. The coil ADP is 10°C. Determine, assuming a zero coil bypass factor, the sensible and latent heat loads on the cooling coil.

   [5 + 6]

4. (a) Briefly mention how solar heat gain and internal heat gains are estimated for a room with fenestration. What is balance point outside temperature? Give its mathematical expression and its significance in selecting air conditioning system.

   (b) Explain, with neat diagrams, the all-air and all-water air-conditioning systems and mention the respective disadvantages of each

   [6 + 5]

Second Half

Answer any THREE Questions

6. (a) Describe, with a neat sketch and TS diagram, the function of a reduced ambient system.

(b) A boot-strap evaporative air refrigeration system is used for an air plane to take 22 tons of refrigeration load (22 TR). The ambient conditions are -10°C and 0.5 bar. The speed of the plane is 1.3 Mach. The pressure of the air bled off the main compressor is 4 bar and this is further compressed in the secondary compressor to 5 bar. The internal efficiency of main compressor is 90 % and that of secondary compressor is 80%. The internal efficiency of cooling turbine is 80 %. Heat exchanger effectiveness of both primary and secondary ram air heat exchangers are 0.4. The air is further cooled in the evaporator to 100°C. Ram efficiency may be assumed as 90%. Assume γ=1.4 and C_p= 1 kJ/kgK and cabin to be maintained at 25°C and 1 bar. Determine:

(i) Mass flow rate bled off the compressor

(ii) Main compressor power used for refrigeration system

(iii) COP

7. (a) Describe a simple vapor compression refrigeration system using p-h and T-s representations.

(b) A refrigerating plant of 28 kW (8 ton) capacity has its evaporation temperature -8°C and condenser temperature of 30°C. The refrigerant, R12 is sub cooled 5°C before entering the expansion valve and the vapor is superheated 6°C before leaving the evaporator coil. The compression of the refrigerant in the compressor is isentropic. If there is a suction pressure drop of 0.2 bar through the valve and discharge pressure drop through the valve of 0.1 bar, determine the COP of the plant, theoretical piston displacement/min and the heat removed in the condenser. Solve the problem with the help of p-h chart and label all values diagrammatically on the p-h chart. Give also a diagrammatic sketch of this cycle on the T-s chart.

8. (a) What are the types of refrigerant compressor? Why is intercooling done for compound compression?

(b) A reciprocating compressor operates on 1 mm^3/min of gas at 2 bar and delivers it at 12 bar. The clearance is 6 %. The adiabatic compression and expansion index is 1.31. Determine the change in work of compressor if the compression is reversible adiabatic but the expansion is polytropic with index of 1.1.

9. (a) What are the general types of condensers? Describe in brief the water cooled condensers.

(b) What are the common expansion devices? Describe with a neat sketch the operation of a thermostatic expansion valve.

(c) Describe with neat sketches the function of a liquid chiller and a direct expansion coil evaporator.

10. (a) Describe with a neat sketch the operation of a simple vapor absorption refrigeration system.

(b) Steam at 3 bar and 0.85 dry is used in the generator of vapor absorption system. The evaporator of the refrigeration system is maintained at -10°C. The circulating cooling water rejects heat at 30°C in the condenser. Determine $(COP)_{max}$ for the system. Also, if the steam leaves the generator as saturated liquid, determine the consumption of steam per hour for 10 ton refrigeration plant. Assume relative COP as 0.4.