Exam Date & Time: 02-Dec-2023 (02:30 PM - 05:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

DEPARTMENT OF MECHANICAL AND INDUSTRIAL ENGINEERING
SEVENTH SEMESTER B.TECH END SEMESTER EXAMINATIONS, NOV 2023

Refrigeration and Air Conditioning [MME 4051]

Marks: 50 **Duration: 180 mins.**

A

Answer all the questions. Section Duration: 180 mins

Instructions to Candidates: Answer ALL questions Missing data may be suitably assumed

1) Justify why cabin cooling is required in an aircraft? (2)

A)

B) With a neat diagram explain the working principle of a bootstrap aircraft system. Also derive an expression for the COP of the system (3)

C) A regenerative air cooling system is used for an airplane to take 20TR. The ambient air is at 0.8 bar and 10^0C. It is rammed isentropically till the pressure rises to 1.2 bar. The air bled from 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 air bled after expansion in the cooling turbine. The temperature of air leaving the regenerative heat exchanger is 100^0 C. The cabin is to be maintained at 25^0C and 1 bar. If the isentropic efficiency of the compressor and turbine are 90% & 80% respectively, find; (i) Mass of air bled from cooling turbine to be used for regenerative cooling (ii) Power required. (iii) COP (5)

2) Discuss the influence of superheating and subcooling on the performance of vapor compression refrigeration system (2)

A)

B) Explain with a neat sketch and p-h diagram, the working of a two stage cascade refrigeration system. List the advantages of the system over the simple vapor compression system when both are operating at the same temperature limits (3)

C) Compare the coefficient of performance of a refrigeration cycle for 12 TR that uses wet compression with that of one that uses dry compression. In both cases use ammonia as the refrigerant, a condensing temperature of 30 ºC, and an evaporating temperature of –20 ºC; assume that the compressors are isentropic and that the liquid leaving the condenser is saturated. In the wet compression cycle the refrigerant enters the compressor in such a condition that it is saturated vapor upon leaving the compressor. Also compare the cylinder diameters for both cases if the L/d ratio is 1.2, with a volumetric efficiency of 87% and compressor runs at 300 rpm (5)

3) With a neat sketch explain the working a steam jet refrigeration system (2)

A)

B) With an appropriate sketch explain ammonia-based vapor absorption system and derive an expression for the maximum COP (3)

C) A compound refrigeration system using R-12 as the refrigerant consists of evaporators of capacities 30 TR at -10°C, 20 TR at 5°C and 10 TR at 10°C. Vapors leaving the evaporators are dry and saturated. The system is provided with multiple compressors, multiple expansion valves and flash intercoolers. Condenser temperature is 40°C. Assuming isentropic compression at each stage find (5)

a. Mass of the refrigerant through each compressor

b. Total power required

c. COP

4) Discuss the influence of various refrigerants on the ozone depletion potential and global warming (2)

A)

B) A sample of moist air has a dry bulb temperature of 25°C and a relative humidity of 50%. Barometric pressure is 740 mm of Hg. Calculate (3)

a. Partial pressure of water vapor and air

b. Dew point temperature and specific humidity of air

c. Specific enthalpy of air

C) Calculate the power needed to compress 20 kg/min of ammonia from saturated vapor at 1.44 bar pressure to a condensing pressure of 10.34 bar by two-stage compression with intercooling by liquid refrigerant at 3.98 bar. Assume liquid to leave the condenser as saturate liquid and as dry saturated vapor when leaves the evaporator. Also compare this with the power needed when intercooling is not employed (5)

5) Distinguish between the following

a. Sensible heat factor and bypass factor of a heating coil (2)

A)

b. Relative humidity and dew point temperature

B) With a schematic representation explain the working of a winter air conditioner and show the processes on a psychrometric chart (3)

C) A small auditorium is required to be maintained at 22^0 C dry bulb temperature and 70% RH. The ambient conditions are 30^0C dry bulb temperature and 75% RH. The amount of free air circulated is 200 m^3/min. The required conditions are achieved by first cooling and dehumidifying through a cooling coil having an apparatus dew point temperature of 14^0C and then by heating. With the help of psychrometric chart, find: (i) The capacity of the cooling coil in tones of refrigeration and its by-pass factor (ii) The amount of water vapor removed by the cooling coil in kg/h (iii) The capacity of the heating coil in kW and its surface temperature if its bypass factor is 0.15 (5)

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