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No. of Printed Pages—7 **ME-606**

B. TECH.

SIXTH SEMESTER EXAMINATION, 2003–2004

REFRIGERATION AND AIR-CONDITIONING

Time : 3 Hours *Total Marks : 100*

Note : (1) Attempt all the **FIVE** questions.

(2) All questions carry equal marks.

(3) Use of steam tables, refrigerant's properties tables and charts, specially P-H chart for R-22 is permitted.

1. Answer any FOUR of the following :— **(5×4=20)**

(*a*) What is the purpose of refrigeration and which are the different systems commonly used in refrigeration ? How will you define C.O.P. of a refrigeration cycle and what is its value for a refrigerator working on a Carnot refrigeration cycle in terms of lower and higher temperatures ?

(*b*) A refrigerating system operating on Carnot refrigeration cycle, is having higher and lower temperatures of 30° C and –10 °C respectively. If the capacity of the system is 10 tons, calculate the C.O.P., the power required by the system in kW and the total amount of heat rejected by the system.

(*c*) With the help of P-V and T-S diagrams, describe the basic difference between a reversed Carnot cycle and a reversed Brayton cycle as used for air-refrigeration system.

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(*d*) Enlist various types of air-refrigeration systems being employed for aircraft refrigeration, and briefly describe any one of them with the help of a neat labelled sketch.

(*e*) In a simple aircraft refrigeration system, air is compressed from a temperature of 27 °C and pressure of 1·2 bar to a pressure of 6 bar. The total load of the passengers of the aircraft is 30 kW, the load of control equipments is 5 kW and miscellaneous load is 3 kW. The exit pressure of the cooling turbine is equal to the cabin pressure of 1 atm. The compressor and turbine efficiencies are 80% and 75% respectively. The rise in the temperature of the cool air in the cabin is 60 °C.

Assuming $C_{p_{air}} = 1{\cdot}005$ kJ/kg - K , determine :

(*i*) the refrigeration capacity,

(*ii*) the mass of air-flow required,

(*iii*) the power required for refrigeration, and

(*iv*) the C.O.P. of the system.

(*f*) What is the importance of refrigerants in a refrigeration system, and what is the basic difference between Primary and Secondary refrigerants ? Enumerate the desired properties of refrigerants giving two examples of common refrigerants.

2. Answer any TWO of the following :— **(10×2=20)**

(*a*) Mention the advantages of 'Vapour compression refrigeration system' over 'air-refrigeration system', and explain the working of a simple vapour compression refrigeration cycle with the help of (T-S) and (P-H) diagrams, showing how C.O.P. of the cycle can be calculated.

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What is the effect of subcooling of condensate and superheating of the refrigerant vapour, on the performance of the cycle ?

(*b*) A simple vapour compression refrigeration system, using R-22 as refrigerant, is working between evaporator and condenser temperatures of –30 °C and 40 °C respectively. The liquid refrigerant after the condenser, is subcooled upto 30 °C before it enters the expansion valve, and the refrigerant vapour is superheated up to –20 °C before entering the compressor. The capacity of the system is 30 tons and the compression is isentropic.

Draw the above cycle on P-H chart of R-22 and determine :

(*i*) the refrigerating effect (in kJ/kg),

(*ii*) the mass of refrigerant to be circulated per min.,

(*iii*) the power required in the compressor (in kW),

(*iv*) the heat removed through condenser, and

(*v*) the C.O.P. of the cycle.

(*c*) (*i*) Show the actual vapour compression cycle on P-H and T-S diagrams, and explain, in brief, the effects of variation of different parameters and also the important points of deviations, from a simple vapour compression refrigeration system.

(*ii*) What are the advantages of compound or multistage compression system over a single-stage compression system ? Explain, in brief, a two-stage compression system with flash intercooler.

3. Answer any TWO of the following :— **(10×2=20)**

(*a*) Explain, in brief, as to how the basic function of the compressor in vapour compression refrigeration cycle is achieved in a vapour absorption refrigeration system, and by which components. Also, describe the working principle of a 'continuous vapour absorption system', with the help of a neat sketch.

(*b*) (*i*) State the relative merits and demerits of vapour absorption and vapour compression refrigeration systems.

(*ii*) In a vapour absorption refrigeration system, the generator temperature is 100 °C, evaporator temperature is –10°C and condenser/absorber temperature is 35 °C. Calculate the maximum possible C.O.P. of the system.

Also calculate the variation in C.O.P. of the system, if the generator temperature is increased to 125 °C, the absorber/ condenser temperature is increased to 40 °C and the evaporator temperature is reduced to –15 °C.

(*c*) With the help of a neat labelled sketch, describe the working principle of a lithium bromide-water absorption refrigeration system in brief, and also compare it with Ammonia-watervapour absorption refrigeration system.

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4. Answer any TWO of the following :— **(10×2=20)**

(*a*) What do you understand by Psychrometrics ? Define the terms — Dry bulb temperature, wet bulb temperature, dew point temperature, specific humidity, relative humidity and degree of saturation, as related to psychrometrics. In a laboratory test, on a particular day, a psychrometer recorded the dry bulb and wet bulb temperatures for atmospheric air as 35°C and 25 °C respectively. The atmospheric pressure is 1·013 bar. Using STEAM TABLES only (psychrometric chart not allowed), calculate :

(*i*) the relative humidity,

(*ii*) the specific humidity,

(*iii*) the dew point temperature, and

(*iv*) the degree of saturation.

The partial pressure of water vapour (p_v) can be calculated with the help of Carrier's Equation, given as ;

$$p_v = \left[p_{wb} - \frac{(P - p_{wb})\,(t_{db} - t_{wb})}{1547 - 1{\cdot}44\ t_{wb}} \right]$$

where;

p_{wb} = Saturation pressure corresponding to wet bulb temperature,

P = Barometric pressure, and

t_{db} and t_{wb} are the dry bulb and wet bulb temperatures of air (in 0° C).

Gas constant of air, R_a = 0·287 kJ/kg-K.

(*b*) With the help of a neat sketch, explain the importance of a 'Psychrometric Chart' in

solving the problems of air-conditioning.

Draw the following processes on psychrometric chart and describe them in brief :—

(*i*) Sensible heating and cooling

(*ii*) Latent heating and cooling, i.e. humidification and dehumidification

(*iii*) Heating and humidification

(*iv*) Cooling and dehumidification

(*c*) (*i*) What do you understand by comfort air-conditioning and how does it differ from industrial air-conditioning in terms of basic requirements for each of them ? Explain, in brief, the concept of 'comfort chart'.

(*ii*) What do you understand by the terms, cooling and heating loads ? Discuss, in brief, the different components which have to be taken into consideration for estimation of total cooling load for summer air-conditioning.

5. Answer any FOUR of the following :— **(5×4=20)**

(*a*) Enumerate the functions of expansion devices in a vapour-refrigeration system and explain the working principle of a thermostatic expansion valve, with the help of a neat sketch, in brief.

(*b*) Why are 'Ducts' used in an air-conditioning system and how do they help in proper air distribution ? Describe, in brief, the concept of air-flow through ducts, explaining the

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different factors, which lead to pressure drop in ducts.

(*c*) What do you understand by food preservation and what are its advantages ? Explain, in brief, as to how refrigerators and freezers are used for food preservation.

(*d*) What effect does infiltration or ventillation air have on cooling loads ? Enumerate few empirical methods being used to evaluate heat transfer through walls and roofs of the buildings, in brief.

(*e*) Explain the application of refrigeration for food preservation in 'Cold storages', discussing the various factors to be kept in mind while storing food products in cold storages. What do you understand by long-term and short-term storages ?

(*f*) Explain, in brief, how thermal analysis of a human body is being done for providing comfort according to body requirements in air-conditioning systems.