Ex/Prod/PC/B/T/212/2023(S)

J A D A V P U R U N I V E R S I T Y

B Production Engineering Supplementary Examination – 2023

2nd Year – 1st Semester

Thermodynamics & Heat Transfer

Time : 3 Hours | Full Marks : 100

[30+30+40 = 100]

Group – A(Compulsory)[(5x2)+(5x4)=30]

All the notations or symbols used in any formula should be explained clearly.

1. Answer the following questions: (2x5=10)

(i) Define COP. Prove that $COP_{Heat\ Pump} = COP_{Refrigerator} + 1$.

(ii) State the different psychrometrics properties of air water-vapour mixture that can be read easily from the psychrometric chart. Mention their units also.

(iii) Prove that the emissivity of a black body is 1.

(iv) A furnace wall has a thickness of 200 mm and the rate of heat conduction is 100 W / m^2 with surface temperatures of 600 °C and 400 °C. Find out the thermal conductivity.

(v) Draw temperature profile diagram of a evaporator where cold fluid is evaporated at constant temperature by using the heat of hot fluid and the temperature of hot fluid decreases from inlet to outlet.

2. Answer the following questions: (4x5=20)

(a) Find the total work done in kJ by a gas system following the quasi-static processes in sequence in P-V diagram as shown in Fig 1.

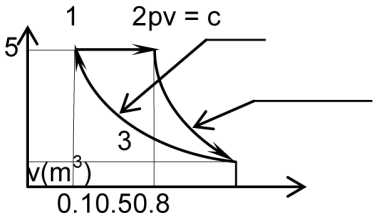

Fig 1

(b) A tank contains a mixture of saturated water and saturated vapour at a temperature of 200°C. The mass of liquid and vapour present are 4 kg and 0.5 kg respectively. Find the enthalpy of the mixture.

(c) Draw the analogous electric circuit of heat flow i.e. thermal circuit diagram for a composite wall of a room as shown in Fig.2. All notations used should be mentioned in details.

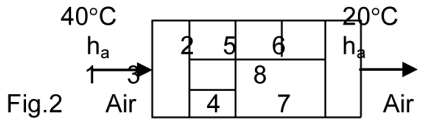

Fig.2

(d) Draw the radiation network diagram for interchanging radiation energy between two infinite parallel gray surfaces with two radiation shields. All notations used should be mentioned in details.

(e) Explain Carnot cycle showing T-S diagram.

Group – B (Answer any Three) [3x10=30]

3. Steam at 250°C flowing in a pipe (k = 80 W / m K) 60 mm inner diameter, 70 mm outer diameter is covered with 30 mm thick insulation (k = 0.04 W / m K). Heat is lost to the surroundings at 5°C by natural convection and radiation with combined h_o = 15 W / m^2 K and h_i = 50 W / m^2 K. Find (a)the rate of heat loss from the pipe per unit length, (b) the temperature drop across the pipe and the insulation. (c) Also draw the thermal circuit diagram. [7+2+1=10]

4. A counter flow heat exchanger is used to heat water from 20°C to 80°C by using hot exhaust gas entering at 140°C and leaving at 80°C. Find log mean temperature difference for the heat exchanger. Draw the temperature profile and also the space diagram.[8+2=10]

5.(a) Draw a neat sketch of a one two heat exchanger indicating all the necessary components. [6+4=10]

(b) Air is flowing in a 0.3 m diameter pipe at a uniform velocity of 0.25 m/sec. The temperature is 30°C and pressure is 2 bar. Determine the mass flow rate.

6.(a) Find the reduction in radiation heat transfer between two parallel plates when three shields are placed between them, with all emissivities assumed to be equal.[4+6=10]

(b)A 100 W electric bulb has a filament temperature at 300°C. Assuming the filament to be black, find the diameter of the wire if the length is 250 mm.

7. A fluid at 20°C is to be heated to 50°C in a tube of 20mm diameter. The outside of the tube is wrapped with an electric heating element that produces a uniform flux of 25 kW/m^2 over the surface and the mass rate of flow is 0.03 kg/s.
(a) Determine the type of flow, (b) heat transfer coefficient and (c) length of pipe.Given the properties of fluid at 25°C, σ = 997 kg/m^3, s = 4180 J/ kgK,k = 0.608 w/mK, μ = 900 x 10^{-6} Poise.[3+4+3=10]

Group - C (Answer any**Four**) [4x10=40]

8. A refrigerator operating on reversed Carnot cycle extracts 450 kJ/min heatfrom a refrigerated space being maintained at –15°C and rejects heat to the atmosphere at 30°C. (i) Determine the work input required to runthe refrigerator. (ii)Also show the block diagram with neat sketch.[8+2=10]

9. Steam at 1.8MPa, 350°C enters a flow device with negligible velocity and leaves at 0.2MPa, 200°C with a velocity of 150 m/s. During the flow heat interaction occurs only with the surroundings at 20°C and steam mass flow rate is 3 kg/s. Estimate the maximum possible output from the device.[10]

10. A tank of volume 5 m^3 contains 10 kg of wet steam at a pressure of 250 kPa. The tank is closed and heated until the steam becomes drysaturated. Determine final pressure of the tank. Also draw P-V diagram for the system. [8+2=10]

11. (a) What is a tonne of refrigeration? What do you understand by dry and wet compression? Which is preferred and why?[6+4=10]

(b) What is the difference between a Heat Engine and Heat Pump? Show with block diagrams.

12. A cylinder of 2.5 m^3 has air at 0.6MPa and temperature of 440K. Air is released in atmosphere through a valve on cylinder so as to run a frictionless turbine. Draw the space diagram and find the amount of work available from the turbine assuming no heat loss and complete KE being used for running turbine. [2+8=10]

13. A Carnot cycle operates between source and sink temperatures of 255°C and -10°C. If the system receives 88 kJ from the source, find (i) efficiency of the system, (ii) the net work transfer, and (iii) heat rejected to the sink. Draw also the block diagram. [3+3+2+2=10]