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B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

August 2024 Supplementary Examinations

Programme: B.E. **Semester: IV**
Branch: Chemical Engineering **Duration: 3 hrs.**
Course Code: 19CH4DCHTR **Max Marks: 100**
Course: Process Heat Transfer

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.
3. Use of steam table is allowed.

UNIT - I

Q.No		Question	Marks
1	a)	Consider steady one-dimensional heat transfer through a multilayer medium. If the rate of heat transfer (Q) is known, explain how to determine the temperature drop across each layer.	**06**
	b)	A 2 cm thick copper sheet is maintained at 500^{o}C and 300^{o}C on its two sides by passing a heat flux of 3.63 MW/m^2 through it. The value of k for copper at 150^{o}C is 372 W/mK. Thermal conductivity (k) for copper varies as k = k_o (1 + CT), where k in W/m-K, T is in °C. Determine the constant C.	**04**
	c)	Consider a 2-m-high electric hot water heater that has a diameter of 40 cm and maintains the hot water at 55°C. The tank is located in a small room whose average temperature is 27°C, and the heat transfer coefficients on the inner and outer surfaces of the heater are 50 and 12 W/m^2°C, respectively. The tank is placed in another 46-cm-diameter sheet metal tank of negligible thickness, and the space between the two tanks is filled with foam insulation (k = 0.03 W/m°C). The thermal resistances of the water tank and the outer thin sheet metal shell are very small and can be neglected. Determine the heat loss from the tank per year.	**10**

UNIT - II

Q.No		Question	Marks
2	a)	Derive critical insulation thickness of a sphere and explain its significance.	**08**
	b)	Carbon steel (AISI 1010) shafts of 0.1 m diameter are heat treated in a gas-fired furnace, whose gases are at 1200 K and provide a convection coefficient of 100 W/m^{2}K. If the shafts enter the furnace at 300 K, how long (in sec) must they remain in the furnace to achieve a centerline temperature of 800 K? Given (carbon steel properties: density (ρ) = 7832 kg/m^3, C_P (specific heat) = 541 J/kg-K, k (thermal conductivity) = 51.2 W/m K).	**06**

	c)	A 5-mm-diameter spherical ball at 50°C is covered by a 1-mm-thick plastic insulation (k = 0.13 W/m°C). The ball is exposed to a medium at 15°C, with a combined convection and radiation heat transfer coefficient of 20 $W/m^2°C$. Determine if the plastic insulation on the ball will help or dirt heat transfer from the ball.	**06**

OR

3	a)	Derive the temperature profile and rate of heat transfer of a rectangular fin attached on a hot surface. Assume insulated fin tip.	**10**
	b)	A 15 cm × 20 cm integrated circuit board is to be cooled by attaching 4 cm long aluminum (k= 237 W/mK) fins on one side of it. Each fin has a 2 mm × 2 mm square cross section. The surrounding ambient temperature is 25^{o}C and the convective heat transfer coefficient on each fin surface is 20 W/m^2K. To prevent the circuit board from overheating, the upper surface of the circuit board needs to be at 85^{o}C or cooler. Design a finned surface having the appropriate number of fins, with an overall effectiveness of 3 that can keep the circuit board surface from overheating.	**10**

UNIT - III

4	a)	Warm water is required at rate of 500 kg/h for washing a filter cake, and it is decided to use a 25 mm steam heated tube for the purpose. The wall is maintained at 130^{o}C by condensing steam on the outside surface. Calculate the length of the tube required to heat water from 30^{o}C to 50^{o}C at the required rate. Use the Dittus-Boelter equation to calculate the heat transfer coefficient. The I.D. of the tube is 21.2 mm. Data: $\mu = 6.82\times10^{-4}$ kg/ms; k = 0.63 W/m°C, Cp = 4.174 kJ/kgK. Neglect the resistance of the tube wall.	**10**
	b)	What is LMTD correction factor? Explain its significance.	**03**
	c)	Draw neatly the heat transfer rate with excess temperature graph for pool boiling heat transfer and explain nucleate boiling regime briefly.	**07**

OR

5	a)	Derive the Nusselt's equation for vertical plate condenser.	**12**
	b)	An oil cooler for a large diesel engine is to cool engine oil from 60^{o}C to 45^{o}C, using sea water at an inlet temperature of 20^{o}C with a temperature rise of 15^{o}C. The design heat load is 140 kW and the mean overall heat transfer coefficient based on outer surface area of the tubes is 70 W/m^2 ^{o}C. Calculate the heat transfer surface area for single pass (a) counter flow and (b) parallel flow arrangement.	**08**

UNIT – IV

6	a)	With neat diagrams, differentiate between feed forward and feedback feeding method of multiple evaporators.	**06**
	b)	An evaporator is used to concentrate 4536 kg/h of a 20% solution of NaOH in water entering at 60°C to a product of 50% solids. The temperature of the saturated steam used is 115.6°C and pressure of the evaporator space is 11.7 kPa. The overall heat transfer coefficient is 1560 W/m^2K. Calculate the steam	**10**

used, the steam economy, and the heat transfer area.

Data given: Boiling point of 50% NaOH solution at 11.7 kPa is 89.5°C, enthalpy of feed is 214 kJ/kg, enthalpy of saturated vapor at 89.5°C and 11.7 kPa is 2667 kJ/kg, enthalpy of 50% NaOH solution at 89.5°C is 505 kJ/kg, and latent heat of steam is 2214 kJ/kg.

c) Define economy and capacity of evaporators. **04**

UNIT - V

7 a) i. Explain Wien's displacement law. **04**

ii. What is grey body? Explain its properties.

b) Two parallel grey planes having very large have emissivity $\varepsilon_1 = 0.8$ and $\varepsilon_2 = 0.7$. Planes 1 and 2 are maintained at temperature of 866.5 K and 588.8 K, respectively. Find the heat transfer from plane 1 to 2. **04**

c) Assuming a black body emitting radiation with maximum intensity at $\lambda = 0.71$ μm, calculate the following. **04**

a. The surface temperature of the body

b. Heat flux at the surface of the body

d) A small sphere (outside diameter = 50 mm) with a surface temperature of 320°C is located at the geometric centre of a large sphere (inside diameter = 350 mm) with an inner surface temperature of 25°C. Calculate how much of emission from the inner surface of the large sphere is incident upon the outer surface of the small sphere. Assume that both sides approach black body behavior. What is the net interchange of heat between the two spheres? **08**

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