1T00535 - T.E.(Chemical Engineering)(SEM-V)(Choice Base Credit Grading System) (R- 19) (C Scheme) / 31722 - Heat Transfer Operations QP CODE: 10038871 DATE: 24/11/2023.

[03 Hours] **[Total Marks: 80]**

N. B.: (1) Question No. **1** is **Compulsory.**

(2) Attempt any **Three** questions out of the remaining **Five** questions.

(3) Figures to the **right** indicate **full** marks.

(4) Make **suitable** assumptions wherever **necessary.**

Q1 Answer the following sub-questions (**Any Five**) 20

(a) A steel tube having k=46 W/m - °C has an inside diameter of 3.0 cm and a tube wall thickness of 2 mm. A fluid flows on the inside of the tube producing a convection coefficient of 1500 W/m² Con the inside surface, while a second fluid flows across the outside of the tube producing a convection coefficient of 197 W/m². "C on the outside tube surface. The inside fluid temperature is 223°C while the outside fluid Temperature is 57°C. Calculate the heat lost by the tube per meter of length. 4

(b) Give the physical significance of the following numbers- 4

1. Grashoff's Number 2. Prandtl Number
3. Nusselt's Number 4. Stanton Number

(c) Explain Kerns Method for design of heat exchanger. 4

(d) Differentiate between Film wise and Dropwise Condensation. 4

(e) Write a short note on Boiling Point Elevation of solution in Evaporator. 4

(f) Explain the Laws of Radiation 4

Q2

(a) Derive the expression for heat transfer through furnace wall made of three different materials in series. Assume K1, K2, K3, be the thermal conductivities of materials and X1, X2, X3, be the respective thickness. hi, and ho be the convective heat transfer coefficients for inside hot gas and ambient air respectively? 10

(b) A steel ball 50mm in diameter and initially at uniform temp. of 723K is suddenly placed in a controlled environment in which is maintained at 373K. Calculate the time required for a ball to attain a temperature of 423K. 10

Data- K for steel = 35W/mK, Specific heat = 0.16KJ/KgK,
h = 10 W/m2K, Density of steel = 7800Kg/m3

Q3

(a) Derive an expression of LMTD for Counter Current Flow. Clearly state the assumption made. 10

(b) A circular disc insulated from the other side of the diameter is exposed to air at 293 K. If the disc diameter is maintained at 393K, calculate the amount of heat transferred from it when, 10

[1] The Disc is horizontal with a hot surface facing upward.
[2] The Disc is horizontal with a hot surface facing downward.
[3] The Disc is vertical.

Q4

(a) A counter flow heat exchanger is used to heat water from 20°C to 80°C at a rate of 1.2 kg/s. The heating is obtained by using geothermal water available at 160°C at a mass flow rate of 2 kg/s. The inner tube is thin walled, and has a diameter of 1.5 cm. If the overall heat transfer coefficient is 640 W/m^2K. Calculate the length of the heat exchanger required to achieve the desired heating by using effectiveness-NTU method.
Take specific heat of geothermal water as 4.31 kJ/kg K and that of ground water as 4.18 kJ/kg K 10

(b) Liquid oxygen at atmospheric pressure (boiling point = 90 K) is stored in a spherical vessel of 300 mm outside diameter. The system is insulated by enclosing the container inside another concentric sphere of 500 mm inside diameter with the space between them evacuated. Both the sphere surfaces are made of aluminum for which emissivity may be taken as 0.3. The temperature of the outer sphere is 313 K. 10
(i) Calculate the rate of heat flow by radiation.
(ii) What will be the reduction in the heat flow if polished aluminum with an emissivity of 0.5 is used for the container walls?

Q5

(a) A steam condenser consists of 16 tubes arranged in 4 x 4 array. The tubes are 25 mm in diameter and 1.2 m long. Water flows through the tube at 65°C while steam condenses at 75°C over the tube surface. Find the rate of condensation, if (a) tubes are horizontal; (b) tube are vertical. 10
Take latent heat of steam as 2300 kJ/kg and properties of water at 70°C:
$\rho = 977.8\ kg/m^3$, Cp = 4.187 kJ/kg K, $\upsilon = 0.415x10\text{-}6\ m^2/s$, k = 0.668 W/m.K,
$\beta = 5.7x10^{-3}\ K^{-1}$

(b) A heat exchanger contains 4500 tubes, each having a diameter of 2.54 cm, through which 11.3 kg/s of air to be cooled from 538°C to 148°C. Water passes in counter flow over the tubes, rising in temperature from 38°C to 85°C. Determine the tube length required for this duty, if the water side resistance to heat flow is negligible. The physical properties of air at average temperature are as: ρ = 1.009 kg/m³, μ= 2.075 × 10-5 kg/ms, k = 3.003 × 10-5 kW/m.K, Cp= 1.0082 kJ/kg.K. 10
For turbulent flow inside tubes, use relation
Nu= 0.023 Re 0.8Pr 0.4

Q6

(a) A fine wire having a diameter of 0.02 mm is maintained at a constant temperature of 54°C by an electric current. The wire is exposed to air at 1 atm and 0°C. Calculate the electric power necessary to maintain the wire temperature if the length is 50 cm.
Properties at average temperature: 10
β=0.00333, $\vartheta = 15.69x10^{-6}\ m^2/s$, K = 0.02624 W/m°C, Pr = 0.708.

(b) For Parallel flow heat exchanger Show that 10

$$\varepsilon = \frac{e^{-NTU(1+C)}}{1+C}$$

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