1T00535 - T.E.(Chemical Engineering)(SEM-V)(Choice Base Credit Grading System) (R- 19) (C Scheme) / 31722 - Heat Transfer Operations QP CODE: 10028874 DATE: 25/05/2023

[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 20

(a) Explain the Fourier law of Heat Conduction. What is the driving force for heat transfer? 5

(b) Explain absorptivity, reflectivity and transmissivity. 5

(c) Explain effect of non-condensable gases. 5

(d) Explain Thermal and Hydrodynamic Boundary Layer? 5

Q2

(a) What is meant by Critical Radius of insulation? Derive an expression for the same? 10

(b) An exterior wall of a house may be approximated by a 100 mm layer of common brick followed by a 40 mm layer of gypsum plaster. What thickness of loosely packed rock wool insulation should be added to reduce the heat loss through the wall by 80 %? 10

Data: k for common brick = 0.7 W/m K
k for gypsum layer = 0.48 W/m K
k for rock wool = 0.065 W/m K

Q3

(a) Show by dimensional analysis that Nusselt number is a function of Reynold's number & Prandtl number for the case of heat transfer by forced convection. 10

(b) Air stream at 300 K is moving at a velocity of 0.3 m/s across a 100 W electric bulb at 400 K. If the bulb is approximated by a 60 mm diameter sphere, calculate the heat transfer rate and the percentage of power lost owing to convection. The physical properties of air at the film temperature of 350 K are: 10

Kinematic viscosity (ν) = 2.08×10^{-5} m^2/sec, k = 0.03 W/m K, Pr = 0.697

Q4

(a) Air at a temperature of 523K flows over a flat plate 0.3 m wide, 1m long, at a velocity 8m/s. If the plate temperature is 315K, find the rate of heat transfer to the plate. Data at mean temperature: k=0.0364 W/m K. Pr = 0.69. kinematic viscosity = 0.0004 m^2/s. 10

(b) Estimate the total heat loss by convection and radiation from an unlagged steam pipe, 50 mm o.d. at 415 K (142 ºC) to air at 290 K (17 ºC). 10

Data : Take emissivity, e = 0.90

The film coefficient (hc) for calculation of the heat loss by natural convection is given by $hc = 1.18\,(\Delta T/Do)^{0.25}$, $W/(m^2 \cdot K)$

Q5

(a) Derive design equation for heat exchanger "Q= U.A.ΔT_{lm}". 10

(b) An organic liquid flowing at 19,000 kg/hr (Cp = 2.386KW/Kg^{o}C) is to be cooled from 85 to 40^{o}C using 13,500 kg/hr of cooling water at 20 ^{o}C. The film coefficient for carbon tetrachloride, outside the tubes, is 1700 W/m^{2} ^{o}C. The wall resistance is negligible but high on the waterside, including fouling factors, is 11,000 W/m^{2} ^{o}C. What area is needed for a counterflow exchanger? 10

Q6

(a) Hot oil at a rate of 1.2 kg/s [Cp = 2083 J/(kg·K)] flows through a double pipe heat exchanger. It enters at 633 K (360 ^{o}C) and leaves at 573 K (300 ^{o}C). The cold fluid enters at 303 K (30 ^{o}C) and leaves at 400 K (127 ^{o}C). If the overall heat transfer coefficient is 500 W/(m^{2}·K), calculate the heat transfer area for (i) parallel flow and (ii) countercurrent flow. 10

(b) Explain the various types of feed arrangements in detail for the evaporator with a diagram. 10

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