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UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

Mid Semester Examination, May 2018

Program Name: B. Tech (APE+GAS) **Semester : IV**
Course Name : Hear Transfer **Max. Marks : 100**
Course Code : GNEG 257 **Duration : 3 hr**
No. of page/s: 03

Note: Assume suitable data wherever necessary. The notations used here have the usual meanings.

Part – A **5 X 12 = 60**

Answer any five questions

1. Obtain a linear expression for the thermal conductivity of the given material as a function of temperature. The material cross-sectional area is 0.1 m^2 with a 2.5 cm thick, has one side maintained at 35°C and the other at 95°C. The temperature at the center plane of the material is 62°C, and the heat flow through the material is 1 kW.
2. Air at 27°C and 1 atm flows over a flat plate at a speed of 2 m/s. The viscosity of air at 27°C is $1.85X10^{-5}$ kg/m· s. Assume unit depth in the z direction. The properties at the film temperature 43.5°C is ν=17.36×10−6 m^2/s, k =0.02749 W/m· ◦C, P_r =0.7 and C_p =1.006 kJ/kg·°C. Calculate the following.
   a. Boundary-layer thickness at distances of 20 cm and 40 cm from the leading edge of the plate.
   b. Heat transferred in the first 20 cm of the plate and the 40 cm of the plate if the plate is heated over its entire length to a temperature of 60◦C
3. Briefly explain about the typical boiling curve for water at 1 atm pressure.
4. A double pipe heat exchanger is made up of a stainless steel of thermal conductivity is 15.1 W/m °C, internal diameter is 1.5 cm and outer diameter is 1.9 cm and an outer shell of inner diameter 3.2 cm. The convection heat transfer coefficient is given to be h_i = 800 W/m^2 °C on the inner surface of the tube and h_o = 1200 W/m^2 °C on the outer surface. For a fouling factor of $R_{f, i}$ = 0.0004 m^2 °C/ W on the tube side and $R_{f, o}$ = 0.0001 m^2 °C/ W on the shell side, determine (a) the thermal resistance of the heat exchanger per unit length and (b) the overall

heat transfer coefficients, U_i and U_o based on the inner and outer surface areas of the tube, respectively.

5. Explain the radiation heat exchange between two surfaces and determine the relations confirm that the view factor between two surfaces depends on their relative orientation and the distance between them?

6. A vertical plate 5m high and 1.5m wide has one of its surfaces insulated. The other surface is maintained at a uniform temperature of 400K is exposed to quiescent atmospheric air at 300K. Calculate the Grashoff number and total rate of heat loss. The relation used is

$$\overline{Nu}^{1/2} = 0.825 + \frac{0.387 \ Ra_L^{1/6}}{\left[1 + (0.492 / Pr)^{9/16}\right]^{8/27}}$$

The properties of condensate at 350 K are:

ν = 20.75 x 10-6 m2/sec, Pr = 0.697, k = 0.03 W/m-K.

Part – B **2 X 20 = 40**

Answer any two questions

7. **(a)** Drive an expression for the one dimensional conduction and convection through a hollow rectangular fin. The end of fin is insulated, so that dT/dx = 0 at x = L. **(12 marks)**

   (b) What is the importance of Critical Radius of Insulation and Derive an expression for the thermal resistance through a cylinder of inside radius r_i and outside radius r_o having a thermal conductivity k. **(8 marks)**

8. **(a)** During air cooling of oranges the heat transfer coefficient for combined convection, radiation, and evaporation for air velocities of $0.11 < v < 0.33$ m/s is determined experimentally and is expressed as $h = 5.05\, k_{air} Re^{1/3}/D$, where the diameter D is the characteristic length. Oranges are cooled by refrigerated air at 5°C and 1 atm at a velocity of 0.5 m/s. The thermal conductivity and kinematic viscosity of air at 10°C are 0.02439 W/m.°C and 1.426×10^{-5} m^2 /s respectively. Determine (a) the initial rate of heat transfer from a 7 cm diameter orange initially at 15°C with a thermal conductivity of 0.50 W/m °C, (b) the value of the initial temperature gradient inside the orange at the surface, and (c) the value of the Nusselt number. **(10 marks)**

(b) When is the LMTD method mostly applicable to heat-exchanger calculations? Derive the log mean temperature difference equation for a double pipe heat exchanger assuming that there is a counter flow arrangement. **(10 marks)**

9. **(a)** A solution containing 10% solids is to be concentrated to a level of 50% solids in a single effect evaporator. The feed rate to the evaporator is 30000 kg/h Steam is available at a pressure of 0.20 MPa (saturation temperature of 393 K) and the evaporator is working at reduced pressure such that boiling point is 323 K. The overall heat transfer coefficient is 2.9 kW/m^2. K. The specific heat of feed is 3.98 KJ/Kg K and can be considered same for thick liquor. The latent heat of condensation of steam at 0.20 MPa is 2202 kJ/Kg and enthalpy of feed and thick liquor are 127 kJ/kg and 514 kJ/Kg. The enthalpy of vaporization is 2672 kJ/Kg. The solution has a negligible elevation in boiling point and a negligible heat of dilution. Radiation losses may be neglected. Calculate the steam consumption, the economy, and the heating surface required if the temperature of the feed is at 323 K. **(13 marks)**

   (b) Derive the expression for effectiveness for parallel flow in double pipe heat exchanger. **(07 marks)**

**********************All The Best*********************