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10AU65

Sixth Semester B.E. Degree Examination, Dec.2015/Jan.2016
Heat and Mass Transfer

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions, selecting atleast TWO questions from each part.***

PART - A

1 a. Derive 3 – D heat conduction equation stating all the assumptions made in Cartesian co-ordinates Reduce the general conduction equation to Fourier – Biot equation, Poisson equation, Diffusion equation and Laplace equation. **(10 Marks)**

b. In an attempt to reduce the energy loss from a 2cm outer diameter pipe line with hot water, a plumber decides to insulate the line with 1cm thick insulation having K = 0.1W/mK. The entire metal tube can be considered to remain at a uniform temperature of 70^0C. The line is surrounded by air at 15^0C for which heat transfer coefficient is 6.5W/m^2K. Find the critical thickness of insulation and also justify the plumber's decision. **(10 Marks)**

2 a. Find the temperature distribution and heat transfer for a rectangular cross section fin of infinite length. State all the assumptions. **(10 Marks)**

b. One end of a long rod, 3cm in diameter is inserted into a furnace with outer end projecting into outside air. Once steady state is reached, the temperature of the rod are measured at two points 15cm apart and are found to be 140^0C and 100^0C. The atmospheric air temperature is 30^0C and convective heat transfer coefficient is 20W/m^2K. Calculate the thermal conductivity of the rod. State all assumptions made. **(10 Marks)**

3 a. For a lumped system, find the temperature distribution and heat transfer with usual notations. **(10 Marks)**

b. It is proposed to quench steel balls of a bearing 1cm in diameter, initially at 400^0C. These are placed in a cold chamber maintained at -20^0C. The steel balls pass through the chamber on a conveyor belt. Optimum bearing production requires that 75% of initial thermal energy content of the balls above -15^0C be removed. How long the balls should be placed on the conveyor belt? **(10 Marks)**

4 a. Define the following and mention their significances :
i) Reynold's number ii) Prandtl number iii) Grashof number
iv) Nusselt number v) Stanton number. **(10 Marks)**

b. A circular disc heater 0.2m in diameter is exposed to ambient air at 25^0C. One surface of the disc is insulated and the other surface is maintained at 130^0C. Calculate the amount of heat transferred from the disc when it is i) horizontal with hot surface facing up ii) horizontal with hot surface facing down. **(10 Marks)**

PART - B

5 a. Using Buckingham π – theorem, establish $\pi_3 = f(\pi_1, \pi_2)$ with usual notations for forced convection. **(10 Marks)**

b. Air at 1 atm, 40^0C flows with a velocity 8m/s along a flat plate 3m long, which is maintained at a uniform temperature of 100^0C, calculate the local heat transfer coefficient (h_x) at the end of the plate and also average head transfer coefficient over the entire length of the plate, given $R_{e_{cr}} = 2\times10^5$. **(10 Marks)**

6 a. For a co-axial parallel flow heat exchanger, establish

$\epsilon = \frac{1 - e^{-NTU(1+c)}}{1+c}$ with usual notation. **(10 Marks)**

b. A shell and tube condenser is constructed with 2.5cm OD. Single pass horizontal tube with steam condensing at 54^0C, the cooling water enters the tube at 18^0C at a flow rate of 0.7kg/s for tube and leaves at 36^0C. The overall heat transfer coefficient based on outer surface of the tube is 3509W/m^2 K. Calculate the tube length and heat transfer rate by NTD method. **(10 Marks)**

7 a. Draw the typical boiling curve for water and show all the boiling regimes, natural convection boiling, nucleate boiling, transition boiling and film boiling. Explain. **(10 Marks)**

b. An electric wire of 1.5mm diameter and 20cm length is laid horizontally and submerged in water at 1 atm/pressure. The current flowing through the wire is 40 amps while the voltage drop is 16V. Calculate the heat flux, heat transfer coefficient and excess temperature. Use appropriate correlation.

$[h = 1.54 \left(\frac{Q}{A}\right)^{1/4} = 5.58 (\Delta J_e)^3]$. **(10 Marks)**

8 a. Define the following : i) Black body ii) Emissive power iii) Irradiation iv) Gray body v) Diffuse and specular reflections. **(10 Marks)**

b. Two large parallel planes with emissivity 0.6 are at 900K and 300K. A radiation shield with on side polished and having emissivity of 0.05 and the other side with emissivity 0.4 is proposed. Which side of the shield must face the hotter plane in order to keep the temperature of shield minimum? Justify your answer. **(10 Marks)**

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