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Sixth Semester B.E. Degree Examination, Dec.2017/Jan.2018
Heat and Mass Transfer

Time: 3 hrs.   Max. Marks:100

Note: 1. ***Answer FIVE full questions, selecting at least TWO questions from each part.***
2. ***Heat Transfer data handbook can be referred.***

PART – A

1 a. What are the basic laws of conduction, convection and radiation? Explain. **(06 Marks)**

b. Arrange the thermal conductivities of the following in the decreasing order at room temperature:
(i) Copper (ii) Silver (iii) Gold (iv) Diamond **(04 Marks)**

c. A large window glass 0.5 cm thick $\left(K = 0.78\frac{W}{m.k}\right)$ is exposed to warm air at 25°C, over its inner surface, with convection co-efficient of $15\ \frac{W}{m^2-K}$. The outside air is at -15^0C with convection coefficient of $50\frac{W}{m^2-K}$. Determine the heat transfer rate and temperatures at the inner and outer surface of the glass. **(10 Marks)**

2 a. Derive a mathematical expression for critical radius of insulation for a hollow cylinder. **(06 Marks)**

b. A copper pipe carrying a refrigerent at $-20°C$ is 10 mm in outer diameter and is exposed to the ambient at 25°C with convective coefficient of $50\ \frac{W}{m^2-K}$. It is proposed to apply an insulation material having thermal conductivity of $0.5\frac{W}{m-K}$. Determine the critical thickness of insulation. Also, calculate heat losses for 2.5 mm, 7.5 mm and 15 mm thick layer of insulation for 1 m length of pipe and comment. **(10 Marks)**

c. Derive relations to find fin efficiency and fin effectiveness of a infinitely long fin of uniform cross section. **(04 Marks)**

3 a. Derive the mathematical expression to find the temperature distribution in a lumped system in the form given below with usual notations:
$\frac{\theta}{\theta_i} = e^{-B_iF_G}$. **(08 Marks)**

b. An aluminium tube, 20 cm long with inner and outer radii as 5 cm and 6 cm respectively, is quenched from 500°C to 30°C in a large reservoir of water at 10°C. Below 100°C, the heat transfer coefficient is $1500\ \frac{W}{m^2-K}$ and above 100°C its value is $500\ \frac{W}{m^2-K}$. The thermophysical properties of aluminium are $\rho = 2700$ kg/m³, $K = 210\frac{W}{m-K}$, $C = 900$ J/kg-K.
Neglecting the internal thermal resistance, calculate the quenching time. **(12 Marks)**

4 a. Draw laminar and turbulent boundary layers for flow over a flat plate. On this sketch, show the following: laminar boundary layer region, transition region, turbulent boundary layer region, viscous sublayer, buffer layer, velocity profile in the laminar region and velocity profile in the turbulent region. **(08 Marks)**

b. Water flows at 20°C with a mass flow rate 8 kg/s through a diffuser having 3 cm diameter at the entrance and 7.0 cm at the end. Calculate the velocity and Reynolds number at the inlet and outlet of the diffuses. **(06 Marks)**

c. A fan provides air speed upto 50 m/s in a low speed wind tunnel with atmospheric air at 27°C. If this wind tunnel is used to study the boundary layer behavior over a flat plate upto $R_e = 10^8$, what should be the minimum plate length? At what distance from the leading edge transition would occur, if $R_{e_{C_L}} = 5\times10^5$? **(06 Marks)**

PART – B

5 a. Define the following, and explain,
(i) Reynolds number (ii) Prandtl number (iii) Grash of number (iv) Nusselt number
(v) Stantow number. **(10 Marks)**

b. Atmospheric pressure at a hill station is 83.4 kPa. Air at this pressure and 20°C flows with a velocity of 8 m/s over a $1.5\text{m}\times6.0\text{m}$ flat plate whose temperature is 134°C. Determine the rate of heat transfer from the plate if air flows parallel to (i) 6 m long side, and (ii) 1.5 m side. **(10 Marks)**

6 a. Derive a mathematical expression to find the log mean temperature difference for a parallel flow heat exchanger. Stating all the assumptions. **(10 Marks)**

b. Water enters the tubes of a small single-pass head exchanger at 20°C and leaves at 40°C. On the shell side, 25 kg/min of steam condenses at 60°C. Calculate the overall heat transfer coefficient and the required flow rate of water, if the area of the heat exchanger is 12 m^2.
h_{fg} of water at 60°C = 2358.7 kJ/kg.
C of water = 4174 J/kg.K **(10 Marks)**

7 a. Draw the typical boiling curve for saturated water at 1 atmosphere depicting all the boiling regimes, and explain the following (i) nucleate boiling and (ii) film boiling. **(10 Marks)**

b. Water is boiled at a rate of 30 kg/h on a copper pan, 30 cm in diameter, at atmospheric pressure. Estimate the temperature of bottom surface of the paw assuming nucleate boiling conditions. Also determine the peak heat flux. **(10 Marks)**

8 a. Define the following in relation to thermal radiation:
(i) blackbody (ii) Emissive power (iii) Absorptivity (iv) Irradiation **(08 Marks)**

b. Calculate the following quantities for an industrial furnace (blackbody) emitting radiation at 2650°C.
(i) Spectral emissive power at $\lambda = 1.2\ \mu$m.
(ii) Wavelength at which the emissive power is maximum.
(iii) Maximum spectral emissive power.
(iv) Total emissive power.
(v) Total emissive power of the furnace, if it is treated as non-black body with an emissivity of 0.9. **(12 Marks)**

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