Total number of pages 1

EME 504

(Following Roll No. to be filled by candidate)

Roll No. 1 1 0 4 3 4 0 0 4 3

B. TECH.

FIFTH SEMESTER EXAMINATION 2013-14

EME 504

HEAT AND MASS TRANSFER

Time: 3 Hours

Max. Marks: 100

Note:

- Attempt all questions.
- Marks and number of questions to be attempted from the section is mentioned before each section.
- Assume missing data suitably. Illustrate the answers with suitable sketches

1. Attempt any *Two* parts of the following: [2×10]

a. Derive expressions under one dimensional steady state heat conduction for temperature distribution for the plane wall.

b. A copper conductor (k=385 W/m^2, resistivity = 2.2×10^{-8} Wm) having inner and outer radii 1.0 cm and 2.25 cm respectively is carrying a current density of 4805 amperes/cm^2. The conductor is internally cooled and a constant temperature of 65^0C is maintained at the inner surface and there is no heat transfer through insulation surrounding the conductor. Determine: (i) the maximum temperature of the conductor and the radius at which it occurs, and (ii) the internal heat transfer rate.

c. Explain any two of the following: (i) Discuss the reason of higher thermal conductivity of a material than the fluid. (ii) The physical significance of critical thickness of insulation for a cylinder and also prove that the critical radius of insulation of a pipe is the ratio of thermal conductivity of the pipe material and surface heat transfer coefficient. (iii) Explain the facts of the thermal capacity and thermal diffusivity of a material in the heat transfer.

2. Attempt any *Two* parts of the following: [2×10]

a. A longitudinal fin of rectangular profile is exposed to the surroundings with a temperature of 64^0C and a heat transfer coefficient of 45 W/m^2K. The temperature of the fin base is 100^0C. The fin is made of steel with k=31W/mK and is 11 cm long, 1 cm thick and 1m wide. Using (i) insulated end (ii) heat loss by the e... compare the following: fin efficiency and the temperature at the edge of the fin. If the edge heat transfer coefficient is 85 W/mK.

b. A thermocouple junction of the spherical form is to be used to measure the temperature of gas stream. Calculate the following: (i) junction diameter needed for the thermocouple to have a thermal time constant of 1 second. (ii) time required for the junction to reach 200^0C if the junction is at 27^0C and is placed in a gas stream which is 202^0C. Take ρ=8500 kg/m^3, c=401 J/kg K, h=398 W/m^2K and k(thermocouple)=21 W/mK.

c. Explain the significance of Heisler charts in solving transient conduction problem and show that the temperature distribution is body of surface area As which is initially at temperature t_i and then immersed in a fluid at t_a is given by when neglecting the internal resistance

$$\frac{t - t_a}{t_i - t_a} = \exp\left(-\frac{A_s h}{\rho V c}\tau\right)$$

3. Attempt any *Two* parts of the following: [2×10]

a. Atmospheric air at 275°K and free stream velocity of 20 m/s flows over a 1.5 m long flat maintained at uniform temperature of 325°K, calculate: (i) the average heat transfer coefficient over the region of laminar boundary layer (ii) the average heat transfer coefficient over the entire length of 1.5 m (iii) the total heat transfer rate from the plate to the air over 1.5 m length and 1 m wide. Assume transition occurs at $Re=2 \times 10^5$ The relevant thermo-physical properties of air at 300°K are: $\upsilon=16.8 \times 10^{-6}\ m^2/s$; k_{air}=0.026 W/m.K; Pr=0.708; $\mu=1.98 \times 10^{-5}$ kg/ms $Nu=0.664\ (Re)^{1/2}\ (Pr)^{1/3}$ for laminar flow; $Nu=0.036(\ Re^{0.8}-9200)Pr^{0.43}$ for turbulent flow

b. Experimental results for a heat transfer over a thin flat plate were found to be correlated by the expression of the form

$$Nu_x = 0.332(Re_x)^{0.5}(Pr)^{0.33}$$

Where Nu_x is the local value of Nusselt number at a position x measured from the leading edge of the plate. Obtain an expression for the ratio of the average heat transfer coefficient to the local coefficient.

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

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surface facing down. The physical properties of air at mean film temperature: υ = 2.08×10^{-5} m^2/s; k_{air} = 0.03 W/m.K; Pr=0.697.

The horizontal planes heated surface facing up: Nu=0.27 $(Ra)^{1/4}$ for $10^5 \leq Ra < 10^{10}$

The horizontal planes heated surface facing down: Nu=0.54 $(Ra)^{1/4}$ for $10^4 \leq Ra < 10^7$; Nu=0.14 $(Ra)^{1/3}$ for $10^7 \leq Ra < 10^{11}$

4. Attempt any ***Two*** parts of the following: [2×10]

a. State and explain the Plank's law and show that Plank's law will have the form

$$E_b = \frac{C_1}{\lambda^5} \exp(-C_2/\lambda T) \text{ when } C_2/\lambda T \geq 1$$

b. The flat floor of a hemispherical furnace is at 800°K and has an emissivity of 0.5. The corresponding values for the hemispherical roof are 1200°K and 0.25. Determine the net radiation heat transfer from the roof to the floor.

c. Consider two large parallel plates at temperature t_1=727°C and emissivityε_1=0.8 and other at t_2=227°C and emissivityε_2=0.4. An aluminium radiation shield with an emissivity ε_1=0.04 on both sides is placed between the plates. Calculate the percentage reduction in heat transfer rate between the two plates as a result of the shield.

5. Attempt any ***Two*** parts of the following: [2×10]

a. A home air-conditioning system uses a counter flow heat exchanger to cool 0.8 kg/s of air from 45°C to 15°C. The cooling is accomplished by stream of cooling water that enters the system with 0.5 kg/s flow rate and 8°C temperature. If the overall heat transfer coefficient is 35 W/m^2K, what heat exchanger area is required ? If the same air flow rate is maintained while the water flow rate is reduced to half, how much will be the percentage reduction in heat transfer? Use effectiveness-NTU approach.

b. Discuss in detail the various regimes in boiling and explain the condition for the growth of bubbles. What is effect of bubble size on boiling?

c. Determine the rate of diffusion of water vapour from a pool of water at the bottom of a well which is 6 m deep and 2.5 m in diameter to dry ambient air over the top of the well. The entire system may be assumed at 30°C and one atmospheric pressure. The diffusion coefficient is 0.25×10^{-4} m^2/s