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Name.....

Reg. No.....

FIFTH SEMESTER B.TECH. (ENGINEERING) DEGREE EXAMINATION, DECEMBER 2007

ME 04 502—HEAT AND MASS TRANSFER

(2004 admissions)

Time : Three Hours

Maximum : 100 Marks

Answer **all** *questions.*
Use of Heat and Mass Transfer Data Book and character are permitted.
Any standard data can be suitably assumed if necessary.

Part A

1. (a) How is thermal resistance defined ? What is the driving force for heat transfer ?
   (b) Describe the different types of boundary conditions applied to heat conduction problems.
   (c) What is lumpability ? When and how does it work ?
   (d) How does film thickness change if the velocity of a fluid flowing over a surface increases ?
   (e) Explain Local and average heat transfer coefficient in boundary layer flow over a flat plate.
   (f) With the help of a neat sketch explain the flow regimes in high speed flow.
   (g) Discuss the heat transfer coefficients in single-phase flow and two-phase flow.
   (h) What is Wein's displacement law ? At what wavelength does a body at 2000 K emit maximum radiation ?

(8 × 5 = 40 marks)

Part B

2. (a) Discuss which property of a material determines the rate at which it will react to transient temperature conditions.

(5 marks)

(b) A 15 cm. schedule 40 steam main carries saturated steam at 10.7 bar (gauge), and the temperature is 190° C. The inside and outside diameters of the pipe are 15.4 cm. and 16.8 cm. respectively. The thermal conductivity of the pipe wall is 51.1 W/m° C. The pipe is insulated with a 10 cm. thick fibre glass blanket (k = 0.072 W/m° C). If the outer surface temperature of the insulation is 41° C, calculate the rate of heat loss over a 10 m. section of the pipe. Also calculate the fraction of the total thermal resistance offered by the pipe wall. Is it justified to neglect the resistance of the metal wall in this type of problem ?

(10 marks)

Or

(c) A long cylindrical rod is to be annealed by putting it in a furnace. The initial temperature of rod is 30° C and its average temperature increases to 700° C in half an hour. If the surface heat transfer coefficient is 100 W/m.^{2} °C, calculate the diameter of the rod and the temperature of the furnace. Given : density 7900 kg/m^3, specific heat 0.21 kJ/kg. K, and Thermal conductivity 0.2 W/-m K.

(15 marks)

Turn over

3. (a) The exhaust gas from a furnace flows across the tube bundle at an undisturbed velocity of 15 m/s. The bundle consists of 7 transverse rows and six longitudinal rows of 38.1 mm. o.d. and 34 mm. i.d. tubes. and carries process water for heating. If the gas temperature is 260° C and the tube wall temperature 70° C, calculate : (i) the gas side film coefficient, (ii) the heat flux to water. The exhaust has thermophysical properties like air.

(15 marks)

Or

(b) 50 kg. of water per minute is heated from 30° C to 50° C by passing through a pipe of 2 cm. diameter. The pipe is heated by condensing steam on its surface at 100° C. Find the length of the pipe required. Use the relation.

$$N = 0.023\ Re^{0.8}\ Pr^{0.4}$$

The properties of water are density 975 kg/m^3 kinematic viscosity 0.3641×10^{-6} m.^{2}/s, specific heat 4.18 kJ/kg. K. Thermal conductivity 668.7 10^{-3} W/m-K.

(15 marks)

4. (a) Saturated steam at 4 bar (gauge) pressure flows through a pipe of outside diameter 60 mm. bare horizontal pipe in a room at 28° C. Neglecting the resistance of the pipe wall, calculate the rate of heat loss by combined convection and radiation from pipe and also the rate of condensation of steam. The emissivity of the pipe surface is 0.791 and that of the wall of the room is 0.751.

Calculate the percentage reduction in the heat loss, and the corresponding radiation heat transfer coefficient, if the pipe is coated with an aluminium paint having $\varepsilon = 0.35$.

(15 marks)

Or

(b) A 40 W incandescent electric bulb has a surface temperature of 100° C. The bulb is in a large room at 30° C. If the bulb is considered as a 6 cm. diameter sphere having a surface emissivity of 0.8, calculate the rate of thermal energy loss by radiation and by natural convection from the bulb. If the filament temperature is 3000 K, calculate the average transmissivity of higher wavelength radiation through the glass. Glass may be assumed to be transparent to visible wavelength radiation.

(15 marks)

5. (a) Hot water at 10,000 kg/h. and 100° C enters a concentric tube counter flow heat exchanger having a total area of 20 m.^{2} Cold water at 15° C enters at 20,000 kg/h. and overall heat transfer coefficient is 1000 W/m.^{2} K. Determine the total heat transfer rate and the outlet temperature of the hot and cold fluids.

(15 marks)

Or

(b) Write short note on Fouling factor. (5 marks)

(c) Define Fick's first and second laws of diffusion. (5 marks)

(d) How does Fick's law relate to Fourier's law ? (5 marks)

[4 × 15 = 60 marks]