USN

10ME63

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

Time: 3 hrs. Max. Marks:100

Note: 1. ***Answer any FIVE full questions, selecting at least TWO questions from each part.***
2. ***Use of heat and mass transfer data book is permitted.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

PART – A

1 a. Define Thermal Diffusivity. **(04 Marks)**

b. The inside temperature of a furnace wall with k = 1.35 N/m.K, 200 mm thick is 1400°C. The heat transfer coefficient at the outside surface is a function of temperature difference and is given by $(h = 7.85 + 0.08\Delta T)$ W/m^2.K. where ΔT is the temperature difference between outside wall surface and surroundings. Determine the rate of heat transfer per unit area, if the surrounding temperature is 40°C. **(08 Marks)**

c. The temperature distribution across a wall, 1 m thick at a certain instant of time is given as $T(x) = 900 - 300x - 50x^2$, where T is in degree Celsius and x in metre. The uniform heat generation of 1000 W/m^3 is present in wall of area 10 m^2 having the properties $\rho = 1600$ kg/m^3, k = 40 W/m.K and C = 4 kJ/kg.K. Determine

(i) The rate of heat transfer entering the wall at x = 0 and leaving the wall at x = 1 m.
(ii) The rate of change of internal energy of the wall
(iii) The time rate of temperature change at x = 0, 0.5 m. **(08 Marks)**

2 a. Define fin effectiveness. When the use of fins is not justified? **(03 Marks)**

b. A plane wall k = 45 W/m.K 10 cm thick, generated at a uniform rate of 8×10^6 W/m^3. The two sides of the wall are maintained at 180°C and 120°C. Neglect end effects, calculate

(i) Temperature distribution across the plate.
(ii) Position and magnitude of maximum temperature.
(iii) The heat flow rate from each surface of the plate. **(09 Marks)**

c. A very long rod, 25 mm in diameter, has one end maintained at 100°C. The surface of the rod is exposed to ambient air at 25°C with convection coefficient of 10 W/m^2.K. What are the heat losses from the rods, constructed of pure copper with K = 398 W/mK and stainless steel with K = 14 W/m.K ? Also, estimate how long the rods must be to be considered infinite. **(08 Marks)**

3 a. Define Biot number and Fourier number. **(03 Marks)**

b. An aluminium wire, 1 mm in diameter at 200°C is suddenly exposed to an environment at 30°C with h = 85.5 W/m^{2}K. Estimate the time required to cool the wire to 90°C. If the same wire to place in air stream (h = 11.65 W/m^{2}K), what would be time required to reach it to 90°C. Assume thermophysical properties C = 900 J/kg.K, ρ = 2700 kg/m^3, k = 204 W/m.K. **(09 Marks)**

c. A long cylindrical shaft 20 cm in diameter is made of steel k = 14.9 W/m.k, ρ = 7900 kg/m^3, C = 477 J/kg.K and $\alpha = 3.95 \times 10^{-6}$ m^2/s. It comes out an oven at a uniform temperature of 600°C. The shaft is then allowed to cool slowly in an environment at 200°C with an average heat transfer coefficient of 80 W/m^{2}K. Calculate the temperature at the centre of the shaft, 45 min after the start of cooling process. Also calculate the heat transferred per unit length of the shaft during this period. **(08 Marks)**

4 a. Explain velocity and thermal boundary layer. **(04 Marks)**

b. A fan provides air speed upto 50 m/s is used in 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 would transition occur, if critical Reynolds number $R_{e_{cr}} = 5 \times 10^5$? **(08 Marks)**

c. Calculate the approximate Reynolds numbers and state if the flow is laminar or turbulent for the following:
   (i) A 10 m long yatch sailing at 13 km/h in sea water, $\rho = 1000\ kg/m^3$ and $\mu = 1.3\times10^{-3}\ kg/m.S$.
   (ii) A compressor disc of radius 0.3 m rotating at 15000 rpm in air at 5 bar and 400˚C and $\mu = \dfrac{1.46\times10^{-6}T^{\frac{3}{2}}}{(110+T)}\ kg/m.S$ **(08 Marks)**

PART – B

5 a. Define Grashof number and Stanton number. **(04 Marks)**
b. Air at 27˚C and 1 atmosphere pressure flows over a heated plate with a velocity of 2 m/s. The plate is at uniform temperature of 60˚C. Calculate the heat transfer rate from first 0.2 m of the plate. **(08 Marks)**
c. Air at velocity of 3 m/s and at 20˚C flows over a flat plate along its length. The length, width and thickness of the plate are 100 cm, 50 cm and 2 cm respectively. The top surface of the plate is maintained at 100˚C. Calculate the heat lost by the plate and temperature of bottom surface of the plate for the steady state conditions. The thermal conductivity of the plate may taken as 23 W/mK. **(08 Marks)**

6 a. Classify heat exchange in three broad classes. **(04 Marks)**
b. Hot engine oil is to be cooled in a double pipe counter flow heat exchanger. The copper tube has a diameter of 2 cm with negligible thickness. The inner diameter of outer tube is 3 cm. The water flow through the inner tube at a rate of 0.5 kg/s and oil flows through the annular space at a rate of 0.8 kg/s. Taking the average temperature of water and oil as 47˚C and 80˚C respectively. Assume fully developed flow, calculate overall heat transfer coefficient of flow conditions of the heat exchanger. **(12 Marks)**
c. Calculate the overall heat transfer coefficient based on outer surface of a steel pipe K = 54 W/mK with inner and outer diameters as 25 mm and 35 mm respectively. The inside and outside heat transfer coefficients are 1200 W/m^2K and 2000 W/m^2K respectively. **(04 Marks)**

7 a. Discuss modes of condensation. **(04 Marks)**
b. Saturated steam at 90˚C and 70 kPa is condensed on outer surface of a 1.5 m long, 2.5 m diameter vertical tube maintained at uniform temperature of 70˚C. Assuming film wise condensation, calculate the heat transfer rate on the tube surface. **(08 Marks)**
c. A tube 13 mm in outer diameter and 1.5 m long is used to condense the steam at 40 kPa $(T_{sat} = 76^0C)$. Calculate the heat transfer coefficient for this tube in : (a) horizontal position (b) vertical position. Take average tube wall temperature as 52˚C. **(08 Marks)**

8 a. State and explain Kirchoff's law of radiation. **(02 Marks)**
b. A pipe carrying steam runs in a large room and exposed to air at 30˚C. The pipe surface temperature is 200˚C. Diameter of the pipe is 20 cm. If the total heat loss per metre length of the pipe is 1.9193 kW/m, determine the emissivity to the pipe surface. **(08 Marks)**
c. In an isothermal enclosure at uniform temperature two small surfaces A and B are placed . The irradiation to the surface by the enclosure is 6200 W/m^2. The absorption rates by the surfaces A and B are 5500 W/m^2 and 620 W/m^2. When steady state is established, calculate the following:
   (i) What are the heat fluxes to each surface? What are their temperatures?
   (ii) Absorptivity of both surfaces.
   (iii) Emissive power of each surface
   (iv) Emissivity of each surface. **(10 Marks)**

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