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10ME63

Sixth Semester B.E. Degree Examination, Jan./Feb. 2021
Heat and Mass Transfer

Time: 3 hrs. Max. Marks:100

Note: ***1. Answer any FIVE full questions, selecting at least TWO full questions from each part.***
2. Use of heat transfer data hand 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. Derive the general three-dimensional conduction equation in Cartesian coordinates and mention the assumptions made. **(08 Marks)**

b. What do you mean by initial and boundary conditions of the three kinds? **(04 Marks)**

c. The diagram in Fig.Q.1(c) shows a conical section made of a material with K = 3.46 W/m.K. It is of circular cross section with diameter D = ax, where a = 0.25 and x is the distance measured from the apex of the cone. The smaller diameter end is at x_1 = 50mm and the larger diameter end is at x_2 = 250mm with the corresponding temperatures being T_1 = 400K and T_2 = 600K. The lateral surface of the cone is well insulated.

i) Derive an expression for the temperature distribution T(x) assuming one dimensional steady state condition in x-direction only.

ii) Calculate the rate of heat transfer through the cone. **(08 Marks)**

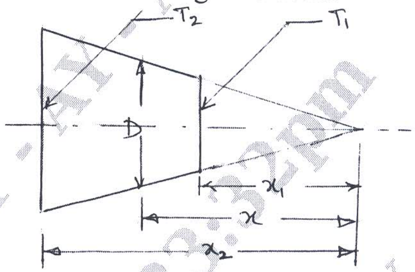

Fig.Q.1(c)

2 a. Obtain an expression for heat transfer through a plane wall in which thermal conductivity is given by $K = K_0 [1 + \beta T]$, where β is constant, K_0 thermal conductivity at some reference temperature and T is the temperature. **(08 Marks)**

b. An electric cable of 10mm diameter is to be laid in atmosphere at 20°C. The estimated surface temperature of the cable due to heat generation is 65°C. Find the maximum percentage increase in heat dissipation when the wire is insulated with rubber having K = 0.155 W/mK. Take h = 8.5W/m^2K. **(06 Marks)**

c. One end of a long aluminum rod is connected to a wall at 140°C; while the other end protrudes into a room whose air temperature is 15°C. The rod is 3mm in diameter and the heat transfer coefficient between the rod surface and environment is 300W/m^2 °C. Estimate the total heat dissipated by the rod taking its thermal conductivity as 150W/m °C. **(06 Marks)**

3 a. A mild steel sphere of 15mm in diameter initially at 625°C is exposed to a current of air at 25°C with convection coefficient of 120W/m^2K. Calculate:

i) Time required to cool the sphere to 100°C

ii) Initial rate of cooling in °C/S

iii) Instantaneous heat transfer rate at the end of one minute after the start of cooling

Take properties of mild steel as

K = 43W/m.K ρ = 7850kg/m^3

C = 474J/kg.K α = 0.045m^2/s. **(10 Marks)**

b. A large slab of wrought iron is at a uniform temperature of 375°C. The temperature of one surface of this slab is suddenly changed to 75°C. Calculate the time required for the temperature to reach 275°C at a depth of 5cm from the surface and the quantity of energy transferred per unit area of the surface during this period. Take K = 60W/mK and $\alpha = 1.626 \times 10^{-5}$ m²/s. **(10 Marks)**

4 a. What do you mean by hydrodynamic and thermal boundary layer? How does the ratio δ/δ_t vary with Prandtl number. **(06 Marks)**

b. Distinguish between laminar and turbulent flow. **(04 Marks)**

c. Air at 20°C and at a atmospheric pressure flows over a flat plate at a velocity of 3m/s. If the plate is 30cm length and at a temperature of 60°C, calculate:

i) Velocity and thermal boundary layer thickness at 0.3m

ii) Average heat transfer coefficient

iii) Total drag force on the plate, per unit width

Take the following properties of air

$\rho = 1.18$kg/cm³, $\upsilon = 17 \times 10^{-6}$m²/s, k = 0.0272W/mK, $C_p = 1.007$kJ/kg K, $P_r = 0.705$ **(10 Marks)**

PART – B

5 a. With the help of dimensional analysis, derive expression for the Reynolds number, Prandtl number and Nusselt number. **(10 Marks)**

b. Assuming that a man can be represented by a cylinder 30cm in diameter and 1.7m high with a surface temperature of 30°C. Calculate the heat he would lose while standing in a 36km/h wind at 10°C. **(10 Marks)**

6 a. Derive an expression for effectiveness of parallel flow heat exchanger. **(10 Marks)**

b. Calculate the surface area required for a heat exchanger which is required to cool 3200kg/hr of benzene, $C_p = 1.74$kJ/kg °C, from 72°C to 42°C. The cooling water $C_p = 4.18$kJ/kg°C at 15°C has a flow rate of 2200kg/hr, for the cases,

i) Single pass counter flow

ii) 1-4 exchange (one shell pass and 4-tube passes)

Overall heat transfer coefficient for each configuration, U = 0.28 kW/m² °C. **(10 Marks)**

7 a. Sketch a pool boiling curve for water and explain briefly various regimes in boiling heat transfer. **(08 Marks)**

b. Write a short note on filmwise and dropwise condensation. **(04 Marks)**

c. Dry saturated steam at a pressure of 2.45 bar condenses on the surface of a vertical tube of height 1m. The tube surface temperature is kept at 117°C. Estimate the thickness of condensate film and local heat transfer coefficient at a distance of 0.2m from the upper end of the tube. **(08 Marks)**

8 a. State the following laws of radiation:

i) Plank's law ii) Kirchoff's law iii) Wein's displacement law **(06 Marks)**

b. Explain the following:

i) Absorptivity ii) Reflectivity iii) Transmissivity **(06 Marks)**

c. An industrial furnace in the form of a black body emits radiation at 3000K. Calculate the following:

i) Mono chromatic emissive power at 1 μm wave length

ii) Wavelength at which the emission is the maximum

iii) Maximum emissive power

iv) Total emissive power. **(08 Marks)**

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