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10AU65

Sixth Semester B.E. Degree Examination, July/August 2021
Heat and Mass Transfer

Time: 3 hrs. Max. Marks:100

Note:* 1. *Answer any FIVE full questions.
2. *Use of heat transfer data book and steam tables is permitted.*

1 a. Stating clearly the assumptions made, derive the general three dimensional unsteady state heat conduction equation with uniform heat generation for homogeneous and isotropic material in Cartesian coordinates. **(08 Marks)**

b. An exterior wall of a house may be approximated by a 10 cm layer of common brick (K = 0.7 W/m°C) followed by 4 cm layer of gypsum plaster (K = 0.48 W/m°C). What thickness of loosely packed rock wool insulation (K = 0.065 W/m°C) should be added to reduce the heat loss (or gain) through the wall by 80 percent? **(06 Marks)**

c. Determine the rate of heat flow through a spherical boiler wall which is 2m in diameter and 2.0 mm thick steel (K = 58 W/mK). The outer surface of boiler wall is covered with asbestos (K = 0.116 W/mK) 5 mm thick. The temperature of outer surface of insulation and that of fluid inside are 50°C and 300°C respectively. Consider, there is inner film resistance of 0.0023 K/W. **(06 Marks)**

2 a. Derive an expression for temperature distribution and heat flow in an extended surface of uniform cross section without heat generation. Consider one end of extended surface is attached to a heat source at temperature T_0 and the other end is insulated. **(08 Marks)**

b. A 10 mm cable is to be laid in atmosphere of 20°C with outside heat transfer coefficient 8.5 W/m^2°C. The surface temperature of cable is likely to be 65°C due to heat generation within. If the rubber insulation (K = 0.155 W/m°C) is applied to cable, will it be effective? If yes, how much maximum heat dissipation /m length of cable will be obtained? **(06 Marks)**

c. Compute the heat loss per square meter of the surface area of a furnace wall 25 cm thick. The inner and outer surface temperature are 400°C and 40°C respectively. The variation of thermal conductivity of furnace wall with temperature is given as $K = 0.002T - 10^{-6}T^2$ where K is in W/mK and temperature T is in °C. **(06 Marks)**

3 a. Derive an expression for variation of temperature with time for heating of solid with negligible internal temperature gradients. Also obtain an expression for instantaneous heat flow rate of solid. **(08 Marks)**

b. A steel ball, 50 mm diameter and initially at a uniform temperature of 450°C is suddenly placed in a controlled environment in which the temperature is maintained at 100°C. the convection heat transfer coefficient is 10 W/m^2°C. Calculate the time required for the ball to attain a temperature of 150°C. Take, for steel, ρ = 7800 kg/m^3, C = 0.46 kJ/kg°C, K = 35 W/m°C. **(06 Marks)**

c. A 50 mm thick iron plate is initially at temperature 225°C suddenly both surfaces are exposed to an ambient at temperature 25°C with a neat transfer coefficient of 500 W/m^{2}K. Determine:
(i) The centre temperature at two minute after the start of cooling and
(ii) The temperature at a depth of 10 mm from the surface at the two minutes after the start of cooling.
Take for iron: K = 60 W/mK, C = 460 J/kgK, ρ = 7850 kg/m^3 **(06 Marks)**

4 a. Explain the following:
(i) Velocity boundary layer
(ii) Thermal boundary layer
(iii) Local and average heat transfer coefficient **(06 Marks)**

b. Using dimensional analysis obtain the dimensionless numbers in Natural Convection heat transfer. **(06 Marks)**

c. A plane wall of 80 cm height and 4 m wide is maintained at 40°C in an atmospheric air of 20°C. Determine the heat loss by natural convection from both the sides of wall. Neglect end effects. Also find the variation in heat transfer if the plane wall is made 400 cm height and 80 cm wide. **(08 Marks)**

5 a. Explain the physical significance of:
(i) Reynold's number (ii) Nusselt number (iii) Prandtl number **(06 Marks)**

b. Estimate the heat transfer form a 40 W incandescent bulb at 120°C to 20°C air steam moving at 0.3 m/s. The bulb may be approximated as 50 mm dia sphere. Also calculate the percentage of power lost by convection. **(06 Marks)**

c. 50 kg of water/min is heated from 30°c to 50°C by passing through a pipe 20 mm in diameter. The pipe is heated by condensing the steam on its surface at 100°C. Calculate the length of pipe required. **(08 Marks)**

6 a. Explain in detail: (i) Classification of heat exchangers (ii) Effectiveness and NTU **(05 Marks)**

b. Stating the assumptions made, derive an expression for LMTD of counter flow heat exchanger. **(07 Marks)**

c. A shell and tube heat exchanger is to be designed for heating water from 25°C to 50°C with the help of the steam condensing at atmosphere pressure and temperature of 100°C. Water flows through tubes (ID = 2.5 cm, OD = 2.9 cm, L = 4m) and the steam condenses on the outside. Water flows at a rate of 500 kg/min. The heat transfer coefficients on the steam and water side are 5515 and 872 W/m^2K respectively. Neglecting all the other resistances, calculate the number of tubes required for single pass. **(08 Marks)**

7 a. With a neat sketch, explain different regimes of pool boiling. **(08 Marks)**

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

c. Saturated water at temperature 100°C in boiled with copper heating element having surface area of 0.04 m^2 which is maintained at a uniform temperature of 115°C. Calculate the surface heat flux and rate evaporation. Take for water n = 1 and $C_{S_f} = 0.013$. Assume nucleate pool boiling. **(08 Marks)**

8 a. Define the following as applied to radiation heat transfer:
(i) Absorptivity (ii) Gray body (iii) Emissivity
(iv) Intensity of radiation (v) Black body (vi) Transmittivity **(06 Marks)**

b. State and explain the following laws of radiation:
(i) Stefan Boltzman's law (ii) Kirchoff's law (iii) Planck's law **(06 Marks)**

c. Two large parallel planes are at 1000 K and 600 K. Determine the heat exchanger per unit area:
(i) If surfaces of planes are black
(ii) If the hot surface has emissivity 0.8 and the cooler surface has emissivity 0.5
(iii) If a large plate having emissivity of 0.2 is inserted between the two plates of condition (ii). **(08 Marks)**

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