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C037613(037)

B. Tech. (Sixth Semester) Examination, April-May 2022

(AICTE Scheme)

(Mech. Engg. Branch)

HEAT & MASS TRANSFER

Time Allowed : Three hours

Maximum Marks : 100

Minimum Pass Marks : 35

Note : *Part (a) of each question is compulsory. Solve any* ***two*** *parts from (b) and (c) and (d).*

Unit-I

1. (a) Explain thermal diffusivity. 4

(b) A composite wall is formed of a 2·5 cm copper plate (k = 355 W/m.K), a 3·2 mm layer of asbestos (k = 0·110 W/m.K) and a 5 cm layer of fiber plate (k = 0·049 W/m.K). The wall is subjected to an overall temperature difference of 560°C (560°C on the Cu plate side and 0°C on the fiber plate side). Estimate the heat flux through this composite wall and the interface temperature between asbestos and fiber plate. 8

(c) A steel tube k = 43·26 W/mK of 5·08 cm ID and 7·62 cm OD is covered with 2·54 cm of asbestos insulation k = 0·208 W/mK. The inside surface of the tube receives heat by convection from a hot gas at a temperature of 316°C with heat transfer coefficient h = 284 W/m^{2}K while the outer surface of insulation is exposed to atmosphere air at 38°C with heat transfer coefficient of 17 W/m^{2}K. Calculate heat loss to atmosphere for 3 m length of the tube and temperature drop across each layer. 8

(d) Derive a 3-dimensional general conduction equation in cylindrical co-ordinates for a homogeneous material. Deduce there from an expression for unidirectional unsteady system when heat is generated within the material. 8

Unit-II

2. (a) Define efficiency and effectiveness of a fin. 4

(b) A steel ball 100 mm diameter was initially at 50 degC and is placed in air which is at 35°C. Calculate time required to attain 400°C and 300°C. K (steel) = 35 W/m.K, c = 0·46 kJ/kgK, p = 7800 kg/m^3 h =10 W/m^{2}K. 8

(c) For a constant cross-sectional area fin, obtain the temperature distribution and total heat flow rate under steady conditions when one end of the fin is attached to a body at high temperature and other end of the fin is insulated. 8

(d) What is meant by lumped capacity? Prove that the temperature of a body at any time τ during Newtonian heating or cooling is given by the relation

$$\frac{t-t_a}{t_i-t_a} = \exp[-\text{BiFo}]$$ 8

Unit-III

3. (a) Explain significance of following dimensionless numbers :

(i) Grashof number

(ii) Prandtl number 4

(b) Prove by Buckingham pi theorem that for forced convection the Nusselt number is a function of Prandtl number and Reynolds number. 8

(c) Air at atmospheric pressure and 20°C flows past a flat plate with a velcocity of 4 m/s. The plate is 30 cm wide, is heated uniformly throughout its entire length and is maintained at a surface temperature of 60°C. Make calculations for the following at 40 cm distance from the leading edge.

(1) Thickness of hydrodynamic and thermal boundary layer

(2) Local and average friction coefficient

(3) Local and average heat transfer coefficient

(4) Total drag force on the plate. 8

(d) A steam pipe 50 mm diameter and 2·5 m long has been placed horizontally and exposed to still air at 25°C. If the pipe wall temperature is 295°C, determine the race of heat loss. 8

Unit-IV

4. (a) Define LMTD and NTU. 4

(b) Discuss in detail the varous regimes in boiling and explain the condition for the growth of bubbles. What is the effect of bubble size on boiling? 8

(c) Derive expression for effectiveness NTU for parallel flow heat exchanger. 8

(d) A concurrent (parallel flow) heat exchanger of 1 m length cools oil from 150°C to 100°C by a stream of cooling water that enters the cooler at 15°C and leaves at 25°C. Subsequently the process conditions demand that the oil be cooled to 75°C and the design engineer suggests that this be done by lengthening the cooler. If the oil and water flow rates, their inlet temperature and other dimensions remain unchanged, determine the lenght and outlet temperature of cooling water of the new cooler. 8

Unit-V

5. (a) Define Burnout point and radiosity. 4

(b) Derive expressions for gray body interchange factor for infinite parallel planes. 8

(c) Express Fick's law of diffusion in terms of mass mole fraction. Develop a relation expressing the equivalence of diffusion coefficients in a binary system. 8

(d) Two large parallel planes with emmisivity 0·4 are maintained at different temperatures and exchange heat only by radiation. What percentage change in net radiative heat transfer would occur if two equally large radiation shields with surface emmisivity of 0·04 are introduced in parallel to the plates? 8