337712 (37)

BE (7th Semester)

Examination, Nov.-Dec., 2021

Branch : Mechanical

HEAT & MASS TRANSFER

Time Allowed : Three Hours

Maximum Marks : 80

Minimum Pass Marks : 28

Note : (i) Answer all questions.

(ii) Part 'a' is compulsory.

(iii) Answer any two questions from part b, c, & d.

(iv) Use of heat transfer data book is permitted.

Assume suitable data if necessary.

Q. 1. (a) Explain lumped system. 2

(b) Derive general equation for Fourier's Law of Heat Conduction. 7

(c) The interior of a refrigerator having inside dimensions of 0.5 m × 0.5 m base area and 1 m height, is to be maintained at 6°C. The walls of the refrigerator are constructed of two mild steel sheets 3 mm thick (k = 46.5 W/m°C) with 50 mm of glass wool insulation (k = 0.046 W/m°C) between them. If the average heat transfer co-efficients at the outer and inner surfaces are

11.6 W/m^2°C and 14.5 W/m^2°C respectively,

calculate :

(i) The rate at which heat must be removed from the interior to maintain the specified temperature in kitchen at 25°C and

(ii) The temperature on the outer surface of the metal sheet. 7

(d) The following data relate to furnace of a steam boiler :

Temperature of gases in the furnace....1300°C

Temperature of air in the boiler room....30°C

Thickness of the refractory material.....250 mm

The heat transfer co-efficient from gases to refractory wall..........30 $W/m^2{}^\circ C$

The heat transfer co-efficient from outside surface to surrounding air.......10 $W/m^2{}^\circ C$

Thermal conductivity of refractory material, $k = 0.28\ W/m^2{}^\circ C$

Thermal conductivity of diatomite layer, $k = 0.113\ W/m^2{}^\circ C$.

Estimate the thickness of the diatomite layer of setting so that the loss of heat to the surroundings should not exceed 750 W/m^2. 7

Q. 2. (a) Explain thermal diffusivity. 2

(b) Explain various modes of heat transfer and their law's involved (Fourier's, Newton's & Stefan Law's). 7

(c) Steam at 320°C flows in a cast iron pipe whose inner and outer diameter are D_1 = 5 cm and D_2 = 5.5 cm respectively. The pipe is covered with 3 cm thick glass wool insulation with k = 0.05 W/m°C Heat is lost to the surroundings at 5°C by natural convection and radiation with a combined heat transfer co-efficient of 18 $W/m^2 °C$. Taking the heat transfer co-efficient inside the pipe to be 60 $W/m^2 °C$, determine the rate of heat loss from the steam per unit length of pipe. Also determine the temperature drop across the pipe shell and the insulation. **7**

(d) A steel rod (k = 32 W/m°C), 12 mm in diameter and 60 mm long with an insulated end is to be used as a spine. It is exposed to surroundings with a temperature of 60°C and a heat transfer co-efficient of 55 W/m^2°C. The temperature at the base of fin is 95°C. Determine : 7

(i) The fin efficiency

(ii) The temperature at the edge of the spine

(iii) The heat dissipation.

Q. 3. (a) Explain Prandtl number (Pr) and its physical significance. 2

(b) Air at atmospheric pressure and 200°C flows over a plate with a velocity of 5 m/s. The plate is 15 mm wide and is maintained at a temperature of 120°C. Calculate the thickness of hydrodynamic and thermal boundary layers and the local heat transfer co-efficient at a distance of 0.5 m from the leading edge. Assume, that flow is on one side of the plate.

($\rho = 0.815$ kg/m^3, $\mu = 24.5 \times 10^{-6}$ Ns/m^2, Pr $= 0.7$, k $= 0.0364$ W/m k) 7

(c) Calculate the heat transfer from a 60-W incandescent bulb at 115°C to ambient air at 25°C. Assume, the bulb as a sphere of 50 mm diameter. Also, find the percentage of power lost by free convection. The correlation is given by,

$$Nu = 0.60\,(Gr.\,Pr.)^{1/4}$$ 7

(d) Derive a relation between Grashoff's and Reynolds numbers assuming the heat transfer co-efficient over vertical plates for pure forced and free convection are equal in laminar flow. **7**

Q. 4. (a) Explain types of Heat Exchangers. **2**

(b) Water at atmospheric pressure is to be boiled in a polished copper pan. The diameter of the pan is 350 mm and is kept at 115°C. Calculate the following : 7

(i) Power of the burner

(ii) Rate of evaporation in kg/hr.

(iii) Critical heat flux for these conditions.

(c) A horizontal tube of outer diameter 20 mm is exposed to dry steam at 100°C. The tube surface temperature is maintained at 24°C by circulating water through it. Calculate the rate of formation of condensate per meter length of the tube. **7**

(d) In a certain double pipe heat exchanger hot water flows at a rate of 5000 kg/h and gets cooled from 95°C to 65°C. At the same time 50000 kg/h of cooling water at 30°C enters the heat exchanger. The flow conditions are such that overall heat transfer co-efficients remains constant at 2270 W/m^2k. Determine the heat transfer area required and the effectiveness, assuming two streams are in parallel flow. Assume for the both the streams, C_p = 4.2 kJ/kg K. **7**

Q. 5. (a) Explain Kirchhoff's Law & Planck's Law. **2**

(b) Determine the rate of heat loss by radiation from a steel tube of outside diameter 70 mm and 3 m long at a temperature of 227°C if the tube is located within a square brick conduit of 0.3 m side and at 27°C. Take E(steel) = 0.79 and E(brick) = 0.93. **7**

(c) The large parallel plates with emissivities 0.3 and 0.8 exchange heat. Find the percentage reduction when a polished aluminium shield of emissivity 0.04 is placed between them. Use the method of electrical analogy. **7**

(d) Air at 1-atm and 25°C, containing small quantities of iodine, flows with a velocity of

6.2 m/s inside a 35 mm diameter tube. Calculate mass transfer co-efficients for iodine. The thermophysical properties of air are : **7**

$\nu = 15.5 \times 10^{-6}$ m^2/s; D = 0.82 × 10^{-5} m^2/s