Total No. of printed pages = 7

ME 131505

Roll No. of candidate | | | | | | | | | | |

2017

B.Tech. 5th Semester End-Term Examination

Mechanical

HEAT TRANSFER — I

Full Marks – 100 Time – Three hours

The figures in the margin indicate full marks for the questions.

Answer Question No.1 and any *six* from the rest.

1. Answer the following questions : (10 × 1 = 10)

   (a) Thermal conductivity is lower for
   (i) steam at 1 atm pressure
   (ii) wood
   (iii) air
   (iv) water at 100°C

   (b) If the heat flow and thickness of the material are kept constant, then the maximum temperature drop will be witnessed across which of the following material?
   (i) Copper
   (ii) Steel
   (iii) Refractory brick
   (iv) Glass wool

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(c) In case of one dimensional heat conduction through an isotropic material, if at any time t the temperature is T at any position x. Then $\frac{\delta T}{\delta t}$ is proportional to:

(i) $\frac{T}{x}$ (ii) $\frac{\delta T}{\delta x}$

(iii) $\frac{\delta^2 T}{\delta^2 x}$ (iv) $\frac{\delta^2 T}{\delta x^2}$

(d) If the temperature increases, then the thermal resistance of gas will

(i) increase
(ii) decrease
(iii) doesn't change
(iv) first increases and then decreases

(e) A fin will be necessary and effective only when

(i) the thermal conductivity of the fin material is small and convective heat transfer coefficient between the fin surface and environment is large
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(iii) the thermal conductivity of the fin material is small and convective heat transfer coefficient between the fin surface and environment is small
(iv) the thermal conductivity of the fin material is large and convective heat transfer coefficient between the fin surface and environment is small

(f) A fin protrudes from a surface which is held at a temperature higher than that of its environments. The heat transferred away from the fin is

(i) heat escaping from the tip of the fin
(ii) heat conducted along the fin length
(iii) convective heat transfer from the fin surface
(iv) sum of heat conducted along the fin length and that convected from the surface

(g) For a fluid flowing over a flat plate with Pr = 0.7, if δ & δ_T denote, the hydrodynamic and thermal boundary layer respectively, then:

(i) $\delta = \delta_T$
(ii) $\delta > \delta_T$
(iii) $\delta < \delta_T$
(iv) $\delta = 0 ; \delta_T \neq 0$

(h) In a laminar forced convection flow over a flat plate, if the free stream velocity increases by a factor of 4, the average heat transfer coefficient

(i) remains constant
(ii) rises by 2
(iii) rises by 4
(iv) rises by 16

(i) Which of the following heat flow situations can be considered to be an example of free convection?

(i) cooling of billets in atmosphere

(ii) cooling of engines of car when it is running

(iii) air — conditioning installations

(iv) flow of water inside the condenser tubes

(j) The Grashoff number is the ratio of

(i) thermal diffusivity to mass diffusivity

(ii) internal force to surface tension

(iii) sensible heat to latent heat

(iv) buoyancy force to viscous force

Answer any *six* of the following questions :

2. (a) Derive general heat conduction equation in Cartesian coordinates. (10)

(b) 'The inner surface of a plane brick wall is at 50°C and the outer surface is at 30°C. Calculate the rate of heat transfer per unit surface area of the wall, which is 250 mm thick. The thermal conductivity of the brick is 0.52 W/m°C. (5)

3. (a) A circular pipe of radius r_0 is being lagged with insulation of thermal conductivity k. If convective heat transfer coefficient is h, derive the expression for critical insulation thickness. (10)

(b) A 3 mm diameter and 5 m long electric wire is tightly wrapped with a 2 mm thick plastic cover whose thermal conductivity is 0.15 W/m-K. Electrical measurements indicate that a current of 10 A passes through the wire and there is a voltage drop of 8V along the wire. If the insulated wire is exposed to a medium at 30°C with a heat transfer coefficient of 12 W/m^2-K, determine whether doubling the thickness of the plastic cover will increase or decrease the temperature at the interface of the wire and the plastic cover - in steady state. (5)

4. A furnace wall consists of 200 mm layer of refractory brick, 6 mm layer of steel plate and a 100 mm layer of insulation brick. The maximum temperature of the wall is 1150°C on the furnace side and the minimum temperature is 40 °C on the outermost side of the wall. Heat loss from the wall is 400 W/m^2. There is a layer of air between the layers of refractory brick and stell plate. Thermal conductivities for the three layers are 1.52,45 and 0.138 W/m°C respectively. Find :

(a) Equivalent length of air layer to length of insulation brick (in millimeters).

(b) The temperature of the outer surface of the stell plate. (9 + 6 = 15)

5. (a) List the seven assumptions that are made for the analysis of heat flow through a fin. (7)

(b) An electronic semi-conductor device generates heat equal to 480×10^{-3} W. In order to keep the surface temperature at upper safe limit of 70°C. The generated heat has to be dissipated to

surroundings at 30°C. To accomplish the task, aluminium fins of 0.7 mm^2 area and 12 mm length, are attached to the surface. The thermal conductivity of aluminium is 170 W/m-K and heat transfer coefficient is 12 W/m^2 — K. Find the required number of fins. Assume insulated tips of fins. (8)

6. (a) What is the physical significance of Biot number? When is lumped system analysis valid? (3 + 2 = 5)

(b) A thermocouple whose junction can be approximated as a 1.2mm diameter sphere, is used to measure temperature of a gas stream. If the properties of the junction are $k = 35\ W/m-^\circ C$; $\rho = 8500\ kg/m^3$; $c_p = 320\ J/kg-^\circ C$ and the heat transfer coefficient between the junction and the gas is h = 90 W/m^2 – °C, how long will it take for the thermocouple to read 99% of the initial temperature difference? (10)

7. The velocity distribution in the boundary layer is given by : $\frac{u}{U} = \frac{y}{\delta}$

where, u is the velocity at a distance y from the plate and $u = U$ at $y = \delta$, δ being boundary layer thickness. Find :

(a) The displacement thickness,

(b) The momentum thickness,

(c) The energy thickness. (3 × 5 = 15)

8. Answer the following questions in brief :

(a) Explain why the vessels which are used to store cold liquid, have to be made spherical in shape.

(b) Why the thin shape of fins preferred?

(c) Two walls of same thickness and cross — sectional area have thermal conductivities in the ratio 1:2. If the same temperature difference is maintained across the two faces of both the walls, what is the ratio of thermal resistances $\frac{R_{th_1}}{R_{th2}}$. (3 × 5 = 15)

9. Write short notes on the following :

(a) Critical radius of insulation.

(b) Response of temperature measuring instruments.

(c) Fick's law. (3 × 5 = 15)

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