Total No. of printed pages = 4

ME 181504

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

1/3/22 2021

B.Tech. 5th Semester End-Term Examination

ME

HEAT TRANSFER – I

(New Regulation & New Syllabus)

Full Marks – 70 Time – Three hours

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

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

1. Choose the correct answer. (10 × 1 = 10)

(i) Heat conduction in gases is due to
- (a) Motion of electrons
- (b) Elastic impact of molecules
- (c) Mixing motion of the different layers of the gas
- (d) Electromagnetic waves

(ii) The relation $\nabla^2 t = 0$ is referred to as
- (a) Fourier heat conduction
- (b) Laplace equation
- (c) Poisson's equation
- (d) Lamped parameter solution for transient conduction

(iii) The thermal conductivity of a material varies with
- (a) Area (b) Thickness
- (c) Temperature (d) All of the above

(iv) Two walls of same thickness and cross-sectional area have thermal conductivities in the ratio 1:2. If same temperature difference is maintained across the wall faces, the ratio of heat flow Q_1/Q_2 will be
- (a) 0.5 (b) 1
- (c) 2 (d) 4

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(v) For steady state and constant value of thermal conductivity, the temperature distribution associated with radial conduction through a cylinder is

(a) Linear
(b) Parabolic
(c) Logarithmic
(d) Exponential

(vi) Upto critical radius of insulation

(a) Heat loss decreases with addition of insulation
(b) Heat loss increases with addition of insulation
(c) There occurs a decrease in heat flux
(d) Conduction heat loss is more than convection heat loss

(vii) In order to achieve maximum heat dissipation the fin should he designed in such a way that it has

(a) Maximum lateral surface area at the root side of the fin
(b) Maximum lateral surface towards the tip side of the fin
(c) Maximum lateral surface near the centre of the fin
(d) Minimum lateral surface near the centre of the fin

(viii) Lumped parameter analysis for transient heat conduction is essentially valid for

(a) $Bi < 0.1$
(b) $0.1 < Bi < 0.5$
(c) $1 < Bi < 10$
(d) $Bi = 0.1$

(ix) For a gray surface

(a) Emissivity is constant
(b) Absorptivity equals reflectivity
(c) Emissivity equals transmissivity
(d) Reflectivity equals emissivity

(x) A radiation shield should

(a) Have high transmissivity
(b) Absorb all the radiation
(c) Have high reflective power
(d) Partly absorb and partly transmit the incident radiation

2. (a) How does the thermal conductivity of solids and liquids vary with temperature? (2)

(b) A square plate heater (15 cm $\times$15 cm) is inserted between two slabs. Slab A is 2 cm thick (k=50 W/m°C) and slab B is 1 cm thick (k=0.2W/m°C). The outside heat transfer coefficients on side A and side B are 200 $W/m^{2^{\circ}}C$ and 50 $W/m^{2^{\circ}}C$ respectively. The temperature of surrounding air is 25°C. If rating of heater is 1 kW, find:

(i) Maximum temperature in the system.

(ii) Outer surface temperature of two slabs.
Draw the equivalent electrical circuit diagram. (10)

3. (a) What is critical thickness of insulation? (2)

(b) An insulated steam pipe having outside diameter of 30 mm is to be covered with two layers of insulation, each having thickness of 20 mm. The thermal conductivity of one material is 5 times that of the other. Assuming that the inner and outer surface temperatures of composite insulation are fixed, how much will heat transfer be changed when better insulation material is next to the pipe than it is outer layer? (10)

4. (a) Write the concept on thermal contact resistance. (2)

(b) A hollow sphere of 12 cm inner diameter and 21 cm outer diameter is made of a material (k=30 W/mK), in which heat is generated uniformly at a rate of 5×10^{6} W/m^{3}. The inside surface is insulated and outer surface is maintained at 360°C. calculate the maximum temperature in the solid. (10)

5. (a) Write the physical significance of thermal diffusivity. (2)

(b) 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 coefficient of 55 $W/m^{2^{\circ}}C$. The temperature at the base of the fin is 95°C. Determine: (10)

(i) The fin efficiency

(ii) The temperature at the edge of the spine

(iii) The heat dissipation.

6. (a) Write the physical significance of Biot number in transient heat conduction. (2)

(b) The steel ball bearing (k = 50 W/mK, α = 1.3 x 10^{-5} m^2/s), 40 mm in diameter is heated to a temperature of 650°C. It is then quenched in an oil bath at 50°C, where the heat transfer coefficient is estimated to be 300 W/m^2K. Calculate: (10)

(i) The time required for the bearing to reach 200°C.

(ii) The total amount of heat removed from the bearing during this time.

(iii) The instantaneous heat transfer rate from the bearings, when they are first immersed in oil bath and when they reach 200°C.

7. (a) Define the term shape factor. (2)

(b) Calculate the following for an industrial furnace in the form of a black body and emitting radiation at 2500°C: (10)

(i) Monochromatic emissive power at 1.2 μm length.

(ii) Wavelength at which the emission is maximum.

(iii) Maximum emissive power.

(iv) Total emissive power.

(v) Total emissive power of the furnace if it is assumed as a real surface with emissivity equal to 0.9

8. (a) What is radiation shield? (2)

(b) The radiation shape factor of the circular surface of a thin hollow cylinder of 10 cm diameter and 10 cm length is 0.1716. What is the shape factor of the curved surface of the cylinder with respect to itself? (10)

9. (a) State Fick's law of diffusion. (2)

(b) A 30mm deep pan is filled with water to a level of 15mm and is exposed to dry air at 40°C. Assuming the mass diffusivity as 0.25 × 10^{-4} m^2/s, calculate the time required for all the water to evaporate. Take the partial pressure of water vapour corresponding to saturation temperature 40°C is 0.07384 bar. (10)