Total No. of Questions :12]

SEAT No. :

P2811

[Total No. of Pages :5

[4958]-113
T.E. (Mechanical)
HEAT TRANSFER [302042]
(2008 Course) (Semester - I)

Time : 3 Hours] ***[Max. Marks :100***

Instructions to the candidates:

1) ***Answer 3 questions from Section I and 3 questions from Sections II.***
2) ***Answers to the Two Sections should be written in separate answer books.***
3) ***Draw Neat diagrams wherever necessary.***
4) ***Figures to the right indicates full marks.***
5) ***Assume suitable data wher ever necessary.***

SECTION - I

Q1) a) Write short notes on the following:- **[12]**

i) Fourier's law of heat conduction

ii) Thermal conductivity

iii) Overall heat transfer coefficient

b) A steel tube with 5 cm ID, 7.6 cm OD and k = 15 W/mK, is covered with an insulation covering of thickness 2cm and k = 0.2 W/mK. A hot gas at 330°C with hg = 400 W/m2K flows inside, the tube. The outer surface of insulation is exposed to cooler air at 30°C with ha = 60 W/m2K. Calculate heat loss from the tube for 10m length. **[6]**

OR

Q2) a) Derive an expression for the rate of heat transfer in case of an infinite slab. Also derive formula for temperature at any intermediate location. **[6]**

b) Explain the analogy between heat and electricity. **[4]**

c) i) Estimate the rate of heat loss through a red brick wall of length 7m, height 5m and thickness 0. 5m, if the temp of the wall surfaces are maintained at 120°C and 50°C. K for red brick is 0.72 W/mK. Also find temp at a distance of 10cm from hot surface.

ii) If it is followed by layer of plaster of paris (K = 1 W/mK) with thickness 1.5 cm and a plastic foam of thickness 3 cm (K = 0.2 W/mK) on outside. Estimate rate of heat transfer. **[8]**

Q3) a) Explain significance of critical radius of insulation. Derive an expression for critical radius of insulation for cylinder using standard notations. **[8]**

b) A long hollow cylinder has inner and outer radii as 10cm and 20cm respectively. The rate of heat generation is 1 KW/m^3. the thermal conductivity of cylinder material is 0.2 W/mK. If the maximum temperature occurs at radius of 15cm and temperature of Outer surface is 60°C, find:- **[8]**

i) Temperature at inner surface.

ii) Maximum temperature in the cylinder.

OR

Q4) a) Derive general three dimensional heat conduction equation in Cartesian coordinates and reduce it to Fourier's equation. **[8]**

b) An electrical conductor of 10mm diameter, insulated by PVC (k = 0.18 W/mK) is located in air at 30°C having convective heat transfer coefficient of 7.8 W/m^2K. If the surface temperature of the base conductor is 85°C, calculate:

i) current carrying capacity of the conductor when 2mm thick insulation is provided (resistivity of the conductor material 70 μΩ cm).

ii) Maximum current carrying capacity. **[8]**

Q5) a) Derive the formula for rate of heat transfer and efficiency for a fin with insulated end (adequately long fin). **[8]**

b) Write a note on:

i) Physical Significance of Biot and Fourier's numbers

ii) Significance of time constant for a thermocouple. **[8]**

OR

Q6) a) State assumptions made in lumped capacity method and using this method derive the following relation with usual notations; **[8]**

$$\frac{T - T_\infty}{T_0 - T_\infty} = e_{-BiF_0}$$

b) An aluminum rod 2.5cm in dia and 10cm long protrudes from a wall maintained at 250°C. Rod is exposed to atm at 15°C with h = 15 W/m2K. Calculate heat loss by rod. Take k = 200 W/mK for aluminum. Also calculate temp at the end of the rod. **[8]**

SECTION - II

Q7) a) Explain in brief: **[8]**

i) Space resistance

ii) Surface resistance

iii) Emissivity

iv) Radiosity

b) A gray opaque surface has an absorptivity = 0.7. It is maintained at 200°C. It receives an irradiation of 1,000 W/m^2. Its surface area is 0.2 m^2. Calculate, **[8]**

i) Radiosity of the surface,

ii) Net radiative heat transfer rate from the surface

Recalculate the above quantities, if the surface is black.

c) List few applications of radiation shield. **[2]**

OR

Q8) a) Write the statements and mathematical expressions of the following laws in radiation heat transfer: **[8]**

i) Planck's law

ii) Wien's law,

iii) Kirchhoff's law,

iv) Lambert's cosine rule

b) What do you mean by radiation shape factor? List any 4 properties/rules of radiation shape factor. **[6]**

c) A long pipe 50 mm in diameter passes through a room which is exposed to air at 20°C. Pipe surface temperature is 93°C. Emissivity of the surface is 0.6. Calculate the net radiant heat loss per metre length of pipe. **[4]**

Q9) a) Liquid mercury flows at a rate of 1.6 kg/s through a copper tube of 20 mm diameter. The mercury enters the tube at 15°C and leaves at 35°C. Calculate the tube length if the tube wall temperature is 50°C. the properties of mercury at 25°C are **[8]**

$\rho = 13582\ kg/m^3$, $Cp = 140\ j/kgK$, $k = 8.69\ W/mK$, $\upsilon = 1.5 \times 10^{-7}\ m^2/s$, $Pr = 0.0248$

Use $Nu = 7+0.025\ (RePr)^{0.8}$

b) Define and give the significance of

i) Nusselt number,

ii) Prandtl number

iii) Grashof number

iv) Reynolds number **[8]**

OR

Q10) a) Draw neat diagrams to show directions of natural convection fluid flow (development of thermal boundary layers) when: **[8]**

i) Plate is kept vertical and surrounding fluid temperature is higher than plate

ii) Cylinder is kept horizontal and surrounding fluid temperature is lower than cylinder

iii) Plate is horizontal and surrounding fluid temperature is lower than the plate

iv) Cylinder is vertical and surrounding fluid temperature is lower than the cylinder

b) Consider a human body in vertical position of height 167 cm at an average temperature of 37.3°C exposed to atmospheric air at – 5.7°C at Nainital during winters. Human body can be approximated to a cylinder of diameter 40 cm. Calculate total heat loss rate from the body by convection. Neglect heat loss from the feet (bottom surface). You may use the following empirical correlation; **[8]**

$Nu = 0.56\ (Gr.\ Pr)^{0.25}$ for vertical surface

$Nu = 0.14\ (Gr.\ Pr)^{0.34}$ for horizontal upper surface

Take the following air properties:

$Pr = 0.715$, $K = 0.025$ W/mK, $\upsilon = 13.55 \times 10^{-6}\ m^2/s$

Characteristic length for horizontal surface can be taken as A/P; where A is the area of the surface and P is its perimeter.

Q11) a) A hot fluid at 200°C enters a heat exchanger at a mass flow rate of 10000 kg/hour. Its specific heat is 2 kJ/kgK. It is to be cooled by another fluid entering at 25°C with a mass flow rate of 2500 kg/hour and specific heat of 4000 J/kg K. The overall heat transfer coefficient based on outside area of 20 m^2 is 250 W/m^2K. Determine the effectiveness of heat exchanger. Also find the exit temperature of both the fluids, considering fluids are in parallel flow arrangement. **[8]**

b) Explain regimes of pool boiling. **[8]**

OR

Q12) a) Explain the following terms related to heat exchangers: **[8]**

i) LMTD

ii) NTU

iii) Effectiveness

iv) Fouling

b) Derive the expression of LMTD for counter flow heat exchanger with usual notations. **[8]**

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