Total No. of Questions : 10]

SEAT No. :

P1692

[Total No. of Pages : 4

[5058]-313
T.E. (Mechanical)
HEAT TRANSFER
(2012 Course) (Semester - I) (End Sem.) (302042)

Time : 2½ Hours] *[Max. Marks : 70*

Instructions to the candidates:

1) ***Solve Q.1 or Q.2, Q.3 or Q.4 ,Q.5 or Q.6, Q.7 or Q.8, Q.9 or Q.10.***
2) ***Draw neat diagrams wherever necessary.***
3) ***use of scientific calculator is allowed.***
4) ***Assume suitable data wherever necessary.***
5) ***Figures to the right indicate full marks.***

Q1) a) Differentiate between steady state and unsteady state heat transfer. Give examples of each. **[4]**

b) A furnace wall lining in made up of a material with k = 2.5 W/mK. The temperatures of the inner and outer surfaces of this plane wall lining are 810°C and 330°C respectively. The outer surface is exposed to ambient air at 30°C with convective heat transfer coefficient = 10 W/m^{2}K. **[6]**

Calculate:

i) The rate of heat flow per unit area

ii) Thickness of lining in given situation.

iii) The thickness of lining required if the heat flow rate is to be reduced by 50%.

OR

Q2) Heat is generated uniformly in a stainless steel plate having k = 20 W/mK. The thickness of the plate is 1 cm and the heat generation is 500 MW/m^3. If the two sides of the plate are maintained at 100°C and 200°C, respectively. Solving the governing differential equation, calculate the temperature at the centre of the plate. **[10]**

Q3) a) Derive the expression for Lumped heat capacity with usual notations. **[8]**

b) In what medium is the lumped system analysis more likely to be applicable : in water or in air? Why? **[2]**

OR

Q4) a) An electric motor is to be connected by a horizontal steel shaft (k = 42.56 W/mK), 25 mm in diameter to an impeller of a pump, circulating liquid metal at a temperature of 540°C. If the temperature of electric motor is limited to a maximum value of 52°C with the ambient air at 27°C and heat transfer coefficient of 40.7 W/m^2K, what length of shaft should be specified between motor and pump? Assume insulated tip condition, for fin analysis. **[6]**

b) In some cases, addition of fins may actually decrease the heat transfer from a surface. Justify the statement. **[4]**

Q5) a) Define and explain the significance of Prandtl number. **[4]**

b) Identify the characteristics dimension for following cases in Natural convection:
   i) Vertical cylinder,
   ii) Horizontal cylinder,
   iii) Horizontal plate,
   iv) Sphere. **[4]**

c) Water is flowing at the rate of 50 kg/min through a tube of inner diameter 2.5cm. The inner surface of tube is maintained at 100°C. If the temperature of water increases from 25°C to 55°C, find length of tube required. **[8]**

$Nu = 0.023\ Re^{0.8}\ Pr^{0.4}$, Properties of water : $\rho = 977.8\ kg/m^3$,

$k = 0.6672\ W/m°C$, $\mu = 405 \times 10^{-6}\ Ns/m^2$, $Cp = 4.187 kJ/kg\ °C$.

OR

Q6) a) Explain the significance of thermal boundary layer and velocity boundary layer. **[4]**

b) A hot plate 1m × 0.5 m at 130° C is kept vertically in still air at 20°C.

Find : i) Heat transfer coefficient,
   ii) Initial rate of cooling the plate in °C/min.

Assume 0.5 m side is vertical and heat transfer takes place from both the sides of the plates.

Take properties of air as Cp = 1007 J/kg °C, k = 0.029 W/m°C,

$\upsilon = 19.1 \times 10^{-6}\ m^2/s$, Pr = 0.7

Assume mass of plate = 20 kg and specific heat of plate = 400 J/kg °C

Use $Nu = 0.59\ (GrPr)^{1/4}$. **[8]**

c) Define and explain significance of Nusselt number. **[4]**

Q7) a) If the shape factor of a surface with respect to itself is 0.6, what may be the nature of this surface? Explain with the help of sketch. Also sketch and explain the types of surface which has no (zero) shape factor with respect to itself. **[4]**

b) A gray opaque surface has an absorptivity = 0.8. It is maintained at 100°C . It receives an irradiation of 1,000 W/m^2. Its surface area is 0.1 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) What is the significance of radiation shield? List few applications of radiation shield. **[4]**

OR

Q8) a) Explain with suitable illustration how the concept of surface resistance and space resistance is used for solving radiation heat transfer problems? **[8]**

b) Determine the heat lost by radiation pre meter length of a 100 mm diameter pipe at 300 °C if it is. **[8]**

i) Located in a large room of brick wall whose temperature is 20°C.

ii) Located in a 200 mm diameter brick conduit at a temperature of 20°C.

$\varepsilon_{pipe} = 0.79$, $\varepsilon_{brick} = 0.93$.

Q9) a) Write a note on Forced convection boiling (Flow boiling). **[6]**

b) A chemical having specific heat of 3.3 kJ/kgK flowing at the rate of 20,000 kg/hr enters a parallel flow heat exchanger at 120°C. The flow rate of cooling water is 50,000 kg/hr with an inlet temperature of 20°C. The heat transfer area is 10m^2 and overall heat transfer coefficient is 1050 W/m^2 °C. Taking specific heat of water as 4.186 kJ/kgK, find **[8]**

i) Effectiveness of heat exchanger.

ii) Outlet temperature of water and chemical.

c) Define NTU. What does it represent? Is as heat exchanger with a very large NTU (say, 10) necessarily a good one to buy? **[4]**

OR

Q10) a) Draw labeled temperature profiles (with suitable temperature values) of the following types of heat exchangers: **[4]**

i) Parallel flow heat exchanger

ii) Counter flow heat exchanger

iii) Condenser,

iv) Evaporator.

b) Explain phenomenon of nucleate boiling. List the factors that affect nucleate boiling. **[6]**

c) Derive the expression for LMTD for parallel flow heat exchanger. **[8]**

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