NGINEERING & MANAGEMENT EXAMINATIONS, DECEMBER – 2007

HEAT TRANSFER

SEMESTER – 5

: 3 Hours] [Full Marks : 70

GROUP – A

(Multiple Choice Type Questions)

Choose the correct answer from the given alternatives : 10 × 1 = 10

i) Nusselt number for heat transfer from sphere to a stagnant film is

a) 2 b) 0.5

c) 1.0 d) none of these.

ii) Estimation of wall heat flux requires

a) film heat transfer coefficient b) thermal diffusivity

c) both (a) & (b) d) none of these.

iii) Prandtl number of liquid is higher than gas because

a) liquid has higher viscosity b) liquid has higher specific heat

c) both (a) & (b) d) none of these.

iv) The basis of the Stefan-Boltzmann law is

a) Kirchhoff's law b) Planck distribution law

c) Wien's displacement d) None of these.

v) The mean temperature difference between hot fluid and cold fluid in a shell-and-tube heat exchanger is more accurately calculated by

a) log mean b) arithmetic mean

c) geometric mean d) none of these.

vi) The critical insulation radius of a pipe carrying hot fluid is

a) k/h b) 2k/h

c) 0.5 k/h d) none of these.

vii) Which of the following does not depend on the thermophysical properties of working fluid ?

a) Radiative heat transfer coefficient

b) Lorez number

c) Frounde number

d) none of these.

viii) In a stagnant fluid, the most probable mechanism of heat transfer is

a) molecular transport b) bulk transport

c) both of them d) none of these.

ix) According to reciprocity theorem

a) $A_1F_{12} = A_2F_{21}$ b) $A_2F_{12} = A_1F_{21}$

c) $A_1F_{21} = A_2F_{12}$ d) all of these.

x) The natural convection will dominate over the forced convection, if

a) $\frac{Gr}{Re^2} >> 1$ b) $\frac{Gr}{Re^2} << 1$

c) $\frac{Gr}{Re^2} = 1$ d) $\frac{Gr}{Re} >> 1$.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. Derive the three-dimensional heat conduction equation in Cartesian coordinate. 5

3. Define and explain any *two* of the following : 5

a) Reynolds number

b) **Eckert number**

c) **Weber number.**

4. **A wall of a furnace is made up of inside layer of silica brick 120 mm thick covered with layer of magnesite brick 240 mm** thick. The temperatures at the inside surface of **silica brick wall and outside surface** of magnesite brick wall are 725°C and 110°C **respectively. The contact thermal resistance** between the two walls at the interface is **0.0035°C/W per unit wall area. If thermal** conductivity of silica and magnesite bricks are 1.7 W/m°C and 5.8 W/m°C. Calculate

Repeat 2.5

a) the rate of heat loss per unit area of walls

b) temperature drop at the interface. 5

long 25 mm diameter copper rod (k = 380 W/m°C) extends horizontally from a heated wall at 120°C. The temperature of the surrounding air is 25°C and the nnective heat transfer co-efficient is 9.0 W/m ^{2}°C. Determine heat loss. 5

efine lumped parameter modelling and distributed parameter modelling. How does ot number influence them ? 5

GROUP – C

(Long Answer Type Questions)

Answer any *three* questions. 3 × 15 = 45

The inner surface at $r = a$ and the outer surface at $r = b$ of a hollow sphere are maintained at uniform temperatures T_1 and T_2 respectively. The thermal conductivity k of the solid is constant. Develop an expression for the one-dimensional, steady state temperature distribution $T(r)$ in the sphere. Also obtain an expression for the thermal resistance of the hollow sphere. 7

A steel tube of 10 cm ID, 15 cm OD, k_1 = 20 W/m-K is covered with an insulation of thickness t = 3 cm, k_2 = 0.15 W/m-K. A hot gas at T_i = 400°C, h_i = 300 W/m ^{2}K flows inside the tube. The outer surface of the insulation is exposed to cooler air at T_o = 30°C with h_o = 50 W/m ^{2}K. Find

i) heat loss from the tube to the air for the tube length L = 10 m.

ii) temperature drops resulting from the thermal resistances of the hot gas flow, the steel tube, the insulation layer and the outside air. **8**

What is the physical mechanism of radiative heat transport ? Define shape factor and view factor. 6

In a rectangular furnace, fuel is burnt at the base. The boiler tubes are placed in array to cover the ceiling. The side walls are properly insulated. Derive an expression for side wall temperature and calculate net heat received by the boiler tubes. Data : Fuel bed (surface 1) temperature = 2000 K,

Bioiler tubes (surface 2) temperature = 500 K,

Side walls (surface 3) temperature = T_3,

A_1 = 0.5 m ^{2}; A_2 = 0.5 m ^{2}; A_3 = 5 m ^{2}. **9**

9. a) Show that the emissive power of a black body is π-times the intensity of emitted radiation. 4

b) By using one radiation shield between two surfaces and if all the three surfaces have the same emissivity, show that the net radiant heat transfer is reduced by 50%. 4

c) Two parallel, infinite gray surfaces are maintained at temperature of 127°C and 227°C respectively. If the temperature of the hot surface is increased to 327°C by what factor is the net radiation exchange per unit area increased ? Assume the emissivities of cooler and hotter surfaces to be 0.9 and 0.7 respectively. 7

10. a) Show that for parallel flow heat exchanger

$$\varepsilon = \frac{1 - \exp[-NTU(1+R)]}{1+R}, \quad R = \frac{C_{min}}{C_{max}}$$ with C_{min}, C_{max} having their usual meanings. 7

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b) Two fluids A and B exchange heat in a counter flow heat exchanger. Fluid A enters at 420°C and has a mass flow rate of 1 kg/s. Fluid B enters at 20°C and also has a mass flow rate of 1 kg/s. Effectiveness of the heat exchanger is 75%. Determine the heat transfer rate and exit temperature of fluid B. Given : Specific heat of Fluid A = 1 kJ/kg-K and Specific heat of Fluid B = 4 kJ/kg-K. 8

10.12

11. a) Two pin fins are identical except that the diameter of one is twice that of other. For which fin will (i) fin effectiveness (ii) fin efficiency be higher ? Explain. 5

b) Copper plate fins of rectangular cross-section, 1 mm thick, 10 mm long and thermal conductivity as 380 W/m-K are attached to a plane wall maintained at a temperature of 230°C. The fins dissipate heat by convection into an ambient at 30°C with a heat transfer coefficient of 40 W/m ^{2}-K. Fins are spaced at 8 mm. Assume negligible heat loss from the tip. Calculate

i) fin efficiency

ii) area weighted fin efficiency

iii) the total heat transfer per m ^{2} of plane wall surface

iv) the heat transfer rate from the plane wall if there were no fins attached. 10

END