0.8. The heater is located in a large room whose walls are at 27 °C. How much will the radiant heat transfer from the heater be reduced if it is surrounded by a 300 mm diameter radiation shield of aluminium having emissivity of 0.2 ? What is the temperature of the shield ?

(c) Show that radiant heat exchange between two gray bodies is expressed by the relation :

$$(q_{net})_{12} = \frac{A_1\sigma(T_1^4 - T_2^4)}{\frac{1}{F_{12}} + \frac{1-\varepsilon_1}{\varepsilon_1} + \left(\frac{1-\varepsilon_2}{\varepsilon_2}\right)\frac{A_1}{A_2}}$$

5. Attempt any **TWO** out of following : **(10×2=20)**

(a) The heat exchanger is to be designed to condense an organic vapour at a rate of 500 kg/min which is available at its saturation temperature 355 K. Cooling water at 286 K is available at a flow rate of 60 kg/s. The overall heat transfer coefficient is 475 W/m² °C. Latent heat of condensation of the organic vapour is 600 kJ/kg. Calculate : (i) The number of tubes required, if 25 mm outer diameter, 2 mm thick and 4.87 m long tubes are available (ii) The number of tube passes, if the cooling water velocity (tube side) should not exceed 2 m/s.

(b) Distinguish between mechanism of filmwise condensation and dropwise condensation. And state the assumptions of Nusselt theory of condensation.

(c) Derive the following expression for steady state diffusion through a stagnant gas film :

$$(m_w)_{total} = D\frac{AM_w}{G.T}.\frac{p}{(x_2 - x_1)}\ln\left(\frac{p_{a2}}{p_{a1}}\right).$$





(Following Paper ID and Roll No. to be filled in your Answer Book)

**PAPER ID : 2104** **Roll No.**

**B.Tech.**

(SEM. V) ODD SEMESTER THEORY EXAMINATION 2012-13

# HEAT AND MASS TRANSFER

*Time : 3 Hours* *Total Marks : 100*

**Note :** *(1) Attempt all questions.*

*(2) All questions are of equal marks.*

*(3) All symbols have usual meaning.*

*(4) Use the relations provided in the question paper.*

*(5) Assume any relevant data, if missing.*

1. Attempt any **TWO** out of following : **(10×2=20)**

(a) Derive expressions under one dimensional steady state heat conduction for temperature distribution for the sphere.

(b) Find the steady state heat flux through the composite slab and the interface temperature of the composite slab having thickness 50 mm and 100 mm in the direction of heat flow. The thermal conductivities of the two materials vary with temperature as given : $k_{50\ mm} = 0.051\ (1 + 0.0065\ t)$ and $k_{100\ mm} = 0.042\ (1 + 0.0076\ t)$ W/m °C, where temperatures are in °C. The outer temperature of both slabs of the composite slab is 610 and 305 °C respectively.

(c) Explain any **TWO** of the following :

(i) What do you mean by thermal capacity and thermal diffusivity ?

(ii) State and explain the different types of boundary conditions applied to heat conduction problem.

(iii) Discuss the effect of temperature on thermal conductivity.

2. Attempt any **TWO** out of following : **(10×2=20)**

(a) A turbine blade of stainless steel (k = 29 W/m °C) is 60 mm long, 500 mm² cross-sectional area and 120 mm perimeter. The temperature of the root of blade is 480 °C and it is exposed to product of combustion passing through the turbine at 820 °C. If the film coefficient between the blade and the combustion gases is 320 W/m² °C, determine : (i) The temperature at the middle of the blade (ii) The rate of heat flow from the blade. Write the comments for rate of heat flow from the blade.

(b) A thermocouple junction of spherical form is to be used to measure the temperature of a gas stream. The junction is initially at 20 °C and is placed in gas stream which is at 200 °C. Make calculation for (i) Junction diameter needed for the thermocouple to have thermal time constant of one second (ii) time required for the thermocouple to reach 197 °C temperature. The thermo-physical properties are given as : k (thermocouple junction) = 20 W/m °C, ρ = 8000 kg/m³, c = 0.4 kJ/kg K, h = 350 W/m² °C.

(c) What are the Heisler charts ? How these charts are used to obtain temperature distribution when both conduction and convection resistances are almost of equal importance ?

3. Attempt any **TWO** out of following : **(10×2=20)**

(a) Derive energy equation for thermal boundary layer over a flat plate. And discuss the different characteristic parameters used in free convection heat transfer.

(b) Air at atmospheric pressure and 20 °C flows past a flat plate with velocity of 4 m/s. The plate is 30 cm wide, is heated uniformly throughout its entire length and is maintained at a surface temperature of 60 °C. Make calculations for the following parameters at 40 cm distance from the leading edge : (i) thickness of hydrodynamic and thermal boundary layers (ii) local and average friction coefficient (iii) local and average heat transfer coefficient (iv) total drag force on the plate. The relevant thermo-physical properties of air at mean film temperature are : $\upsilon = 17 \times 10^{-6}$ m²/s; k = 0.0272 W/m. K; ρ = 1.18 kg/m³; c = 1.007 kJ/kg K.

(c) A two stroke motor cycle petrol engine cylinder consists of 12 fins. Each fin is of 20 cm outer diameter and 10 cm inside diameter. The fins may be idealized as single horizontal flat plate of the same area. The average fins surface temperature is 480 °C and the atmospheric air temperature is 20 °C. Calculate the heat transfer rate from the fins when (i) the motor cycle is stationary, (ii) the motor cycle is running at speed of 70 km/h. The physical properties of air at mean film temperature : $\upsilon = 4.06 \times 10^{-5}$ m²/s; $k_{air} = 0.04266$ W/m. K; Pr = 0.667.

For vertical plate and large cylinder : $Nu = 0.59\ (Ra)^{1/4}$ for $10^9 \le Ra$; $Nu = 0.13\ (Ra)^{1/3}$ for $Ra \ge 10^9$.

$Nu = 0.036\ (Re)^{0.8}\ (Pr)^n$ (where n = 0.4 for heating, n = 0.33 for cooling) for fully turbulent flow in tube $(1 \times 10^4 \le Re \le 12 \times 10^4)$.

4. Attempt any **TWO** out of following : **(10×2=20)**

(a) State the prove the Kirchoff's law of radiation. What do you mean by shape factor in case of radiation exchange between two surfaces ?

(b) A long cylindrical heater 25 mm in diameter is maintained at 660 °C and has surface resistivity of