Paper Code & Roll No. to be filled in your Answer Book

Roll No. | | | | | | | | | | |

Odd Semester Examination-2016

B.Tech. (Semester-V)

HEAT & MASS TRANSFER

[Time : 3 Hours] **[Maximum Marks :100]**

Note : Attempt **all** questions. All questions carry **equal** marks. Assume missing data suitably.

1. Attempt **any two** parts : [10×2=20]

(a) Derive general heat conduction equation in Cartesian coordinates.

(b) Explain the significance of critical thickness of insulation. A 10 mm cable is to be laid in atmosphere of 20°C with outside heat transfer coefficient 8.5 W/m²°C. The surface temperature of cable is likely to be 65°C due to heat generation within. Will the rubber insulation, k=0.155 W/m°C, be effective? If yes how much?

(c) A furnace wall is made of composite wall of total thickness 550 mm. The inside layer is made of refractory material (k = 2.3 W/mK) and outside layer is made of an insulating material (k = 0.2 W/mK). The mean temperature of the glass inside the furnace is 900°C and interface temperature is 520°C. The heat transfer coefficient between the gases and inner surface can be taken as 230W/m^2 °C and between the outside surface and atmosphere as 46 W/m^2 °C. Taking air temperature = 30°C Calculate (i) required thickness of each layer (ii) rate of heat loss per m^2 area.

2. Attempt **any four** parts : [5×4=20]

(a) What do you understand by a black body? How does it differ from a gray body?

(b) Two large parallel plates with emissivity 0.5 each, are maintained at different temperatures and are exchanging heat only by radiation. Two equally large radiation shields with surface emissivity 0.05 are introduced in parallel to the plates. Find the percentage reduction in net radiative heat transfer.

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

(d) Explain Kirchhoff's law and Wein's displacement law.

(e) What is the difference between diffusion and radiation heat transfer.

(f) Explain absorptivity, reflectivity and transmissivity of radiation.

3. Attempt **any two** parts: [10× 2 = 20]

(a) Derive an expression for temperature distribution and heat transfer rate for a rectangular fin when tip of fin is insulated.

(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/m²°C. The temperature at the base of fin is 95°C. Determine (i) fin efficiency

(ii) temperature at the edge of the spine (iii) heat transfer rate.

(c) Explain lumped capacitance model.A 50 cm × 50 cm copper slab 6.25 mm thick has a uniform temperature of 300°C. Its temperature is suddenly lowered to 36°C. Calculate the time required for the plate to reach the temperature of 108°C. Take 'ρ'=9000 kg/m³, 'C' = 0.38 kJ/kg°C, k=370W/m°C and h = 90 W/m²°C.

4. Attempt **any two** parts : [10×2=20]

(a) Explain the phenomenon of the development of thermal boundary layer. Also obtain the expression for Reynolds analogy.

(b) Air entering at 2 bar pressure and bulk temperature of 200°C is heated as it flows through a tube with a diameter of 25.4 mm at a velocity of 10 m/s. Calculate the heat transfer per unit length of the tube if constant heat flux condition is maintained at the wall and wall temperature is 20°C above the air temperature all along the length of the tube. How much would the bulk temperature increase over 3 m length of the tube?

Take properties of air as: $\rho = 1.493$ kg/m^3, $\mu = 2.57 \times 10^{-5}$ Ns/m^2, $k = 0.0386$ W/m°C, $C_p = 1025$J/kg°C. The following relation may be used :

$$Nu = 0.023(Re)^{0.8}(Pr)^{0.4}$$

(c) A horizontal high pressure steam pipe of 10 cm outside diameter passes through a large room whose walls and air are at 23°C. The pipe outside surface temperature is 165°C and its emissivity is 0.85. Estimate the heat loss from the pipe per unit length. Use the following correlation for the calculation of film coefficient

$$\overline{Nu} = \left[0.6 + \frac{0.387(Ra)^{1/6}}{\left\{ 1 + \left(\frac{0.559}{Pr} \right)^{9/16} \right\}^{8/27}} \right]^2$$

where 'Ra' is Rayleigh Number. Take properties of air: $\upsilon = 22.8 \times 10^{-6}$ m^2/s, $k = 0.0313$ W/mK, $\alpha = 32.8 \times 10^{-6}$ m^2/s, $Pr = 0.697$, $\beta = 2.725 \times 10^{-3} K^{-1}$

5. Attempt **any four** parts. [5×4=20]

(a) Explain Flick's law of diffusion.

(b) Obtain an expression for logarithmic mean temperature difference (LMTD) for counter flow heat exchanger.

(c) Explain briefly the various regimes of saturated pool boiling.

(d) What are the main differences between the mechanism of filmwise and dropwise condensation.

(e) The flow rates of hot and cold water streams running through a parallel flow heat exchanger are 0.2 kg/s and 0.5 kg/s respectively. The inlet temperatures on the hot and cold sides are 75°C and 20°C respectively. The exit temperature of hot water is 45°C. If the individual heat transfer coefficients on both sides are 650 W/m^2°C, calculate the area of the heat exchanger.

(f) Discuss the main factors which affect nucleate boiling.

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