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10ME63

Sixth Semester B.E. Degree Examination, June/July 2017
Heat & Mass Transfer

Time: 3 hrs. Max. Marks:100

Note: 1. ***Answer FIVE full questions, selecting at least TWO questions from each part.***
2. ***Use of Heat transfer data hand book is permitted.***

PART – A

1 a. Explain the three types of boundary conditions used in conduction heat transfer. **(06 Marks)**

b. Derive general three dimensional conduction equation in Cartesian co-ordinate. **(08 Marks)**

c. A furnace wall is made up of three layers of thickness 250 mm, 100 mm and 150 mm with thermal conductivities of 1.65 K and 9.2 W/m°C respectively. The inside is exposed to gases at 1250°C with a convection co-efficient of 25 W/m²°C and the inside surface is at 1100°C, the outside surface is exposed to air at 25°C with convection co-efficient of 12 W/m²°C. Determine

(i) The unknown thermal conductivity K

(ii) The overall heat transfer co-efficient. **(06 Marks)**

2 a. Define critical thickness of insulation and explain its significance. **(04 Marks)**

b. Obtain an expression for temperature distribution and heat flow through a rectangular fin, when the end of the fin is insulated. **(08 Marks)**

c. A steel rod (K = 30 W/mK) 1 cms diameter and 5 cms long with insulation end is to be used as a spine. It is exposed to the surrounding temperature of 65°C and heat transfer co-efficient of 50 W/m²K. The temperature of the base is 98°C. Determine (i) Fin efficiency (ii) Temperature at the end of spine (iii) Heat dissipation from spine. **(08 Marks)**

3 a. Explain the physical significance of Biot number and Fourier number. **(04 Marks)**

b. Derive an expression for temperature distribution in a lumped system. **(08 Marks)**

c. A steel ball 5 cms diameter and initially at 900°C is placed in still air at 30°C. Find

(i) Temperature of the ball after 30 seconds.

(ii) The rate of cooling in (°C/min) after 30 seconds.

Assume h = 20 W/m²°C

K(steel) = 40 W/m°C

ρ(steel) = 7800 kg/m³

C_p(steel) = 460 J/kg°C **(08 Marks)**

4 a. Explain briefly with sketches:

(i) Boundary layer thickness (ii) Thermal boundary layer thickness **(08 Marks)**

b. Explain the significance of Grashoff number. **(02 Marks)**

c. The water in a tank at 20°C is heated by passing the steam through a pipe of 50 cms long and 5 cms dia. If the pipe surface temperature is maintained at 80°C (i) find the heat loss from the pipe per hour if the pipe is kept horizontal (ii) If the pipe is kept vertical, then also find out the heat loss from the pipe per hour. **(10 Marks)**

PART – B

5 a. Obtain an empirical expression in terms of dimensionless numbers for heat transfer co-efficient in the case of forced convection heat transfer. **(08 Marks)**

b. Explain the significance of Nusselt number. **(02 Marks)**

c. A tube 5 m long is maintained at 100°C by steam jacketing. A fluid flows through the tube at the rate of 175 kg/hr at 30°C. The dia of the tube is 2 cms. Find out the average heat transfer co-efficient.

Take the following properties of the fluid :

$\rho = 850\ kg/m^3$

$C_P = 2000\ J/kg°C$

$\gamma = 5.1\times10^{-6}\ m^2/S$

$K = 0.2\ W/m°C$ **(10 Marks)**

6 a. Obtain an expression for the effectiveness of parallel flow heat exchanger by NTu method. **(10 Marks)**

b. The velocity of water flowing through a tube of 2.2 cms dia is 2 m/s. Steam condensity at 150°C on the outside surface of the tube heats the water from 15°C to 60°C over the length of the tube. Find the heat transfer co-efficient and the length of the tube neglecting the tube and steam side film resistance. Take the following properties of water at mean temperature $\rho = 990\ kg/m^3$; $K = 0.5418\ W/m°C$; $C_P = 4.2\ kJ/kg°C$; $\mu = 700\times10^{-6}\ kg/m.S$ **(10 Marks)**

7 a. State and explain the Fick's law of diffusion. **(04 Marks)**

b. Distinguish between the nucleate boiling and film boiling. **(06 Marks)**

c. Steam at 0.065 bar condenses on a vertical plate of 0.6 m square. If the surface temperature of the plate is maintained at 15°C, estimate the rate of condensation, $T_S = 37.7°C$,

h_{fg} (at 0.065 bar) $= 2412\times10^3\ J/kg$

The properties of water at mean temperature 26.4°C are listed below.

$\rho = 1000\ kg/m^3$;

$K = 0.913\ W/mK$;

$\mu = 864\times10^{-6}\ kg/m.S$ **(10 Marks)**

8 a. State and prove the Kirchoff's law of radiation. **(06 Marks)**

b. Explain the following terms:

(i) Black body and gray body.

(ii) Radiosity and irradiation **(04 Marks)**

c. The concentric spheres 20 cms and 30 cms in diameter are used to store liquid O_2 (-153°C) in a room at 300 K. The space between the spheres is evacuated. The surfaces of the spheres are highly polished as $\epsilon = 0.04$. Find the rate of evaporation of liquid air per hour. **(10 Marks)**

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