Faculty of Engineering & Technology

Fifth Semester B.E. (Mech.)/Power Engg. / Fourth Semester B.E.P.T. (Mech.) Examination

HEAT TRANSFER

Sections—A & B

Time—Three Hours] [Maximum Marks—80

INSTRUCTIONS TO CANDIDATES

(1) All questions carry marks as indicated.

(2) Answer **THREE** questions from Section A and **THREE** questions from Section B.

(3) Assume suitable data wherever necessary.

(4) Illustrate your answers wherever necessary with the help of neat sketches.

(5) Use of Steam tables, Mollier's chart, Heat transfer data book is permitted.

(6) Only non-programmable calculator are permitted.

SECTION—A

1. (a) Explain various modes of heat transfer alongwith the equation governing them. 6

(b) Derive the general heat conduction equation in Cartesian co-ordinates. 8

2. (a) Explain the concept of thermal contact resistance. 4

(b) The following data refers to wall of an industrial furnace :

Temperature of gases in the furnace = 1700°C

Temperature of air outside the furnace = 35°C

Combined radiative and convective heat transfer coefficient of the furnace gases = 50 w/m^2K

Heat transfer coefficient of surrounding air = 10 w/m^2K

The inner wall of the furnace is made of refractory bricks [K = 0.28 (1 + 0.000833T)$w/m°C$], 250 mm thick and it is followed by diatomaceous brick layer [K = 0.113 (1 + 0.000206T)$w/m°C$]

Calculate the thickness of diatomaceous brick layer, so that heat loss to the surroundings should not exceed 900 w/m^2. 9

3. (a) Derive the general heat conduction equation for sphere with internal heat generation. 5

(b) Two long rods of the same diameter, one made of brass (K = 85 w/m–K) and other made of copper (K = 375 w/m–K) have one of their ends inserted into a furnace. Both the rods are exposed to same environment. At a distance of 105 mm away from the furnace, the temperature of brass rod is 120°C. At what distance from the furnace, the same temperature would be reached in the copper rod ? 8

4. (a) Explain Biot and Fourier's no. along with its physical significance. 4

(b) Define fin effectiveness and fin efficiency. 3

(c) An egg with mean diameter of 40 mm and initially at 20°C is placed in a boiling water pan for 4 minutes and found to be boil to consumer's taste. For how long should a similar egg for same consumer be boiled when taken from refrigerator at 5°C. Take the following properties for egg :

$K = 10$ w/m°C, $\rho = 1200$ kg/m^3, $C = 2$ kJ/kg, $h = 100$ w/m^2°C

Use lumped heat capacity analysis. 6

5. (a) Explain the concept of hydrodynamic and thermal boundary layer. 4

(b) Write the physical significance of Reynold's number, Grashoff number and Prandtl number. 3

(c) Air at 20°C is flowing over a flat plate at the rate of 3 m/s. If the plate is 1 m wide and 30 cm long in direction of flow and is maintained at 80°C, calculate the heat loss from the part of the plate which is 10 cm in length when measured from trailing end in the direction of flow. 6

SECTION—B

6. (a) Sketch temperature and velocity profiles in free convection on a vertical wall. 4

(b) Draw the neat sketch of pool boiling curve and show in it the regimes of pool boiling and explain. 4

(c) Explain types of condensation and compare them. Also discuss the effect of non condensable gases on the rate of condensation. 5

7. (a) Derive LMTD for parallel flow heat exchanger. 8

(b) Hot water at 3.5 kg/s and 100°C enters a concentric tube counter flow heat exchanger having total area of 23 m^2. Cold water at 20°C enters at 0.5 kg/s and overall heat transfer coefficient is 1000 w/m^{2}K. Calculate NTU and effectiveness of heat exchanger. What will be the effectiveness if outlet temperature of hot water is 40°C ? 5

8. A counter flow heat exchanger, through which passes 12.5 kg/s of air to be cooled from 540°C to 146°C, contains 4200 tubes, each having a diameter of 30 mm. The inlet and outlet temperatures of cooling water are 25°C and 75°C respectively. If water side resistance to heat flow is

negligible, calculate the tube length required for this purpose.

For turbulent flow inside tubes :

$$Nu = 0.023\ Re^{0.8} Pr^{0.4}$$

Properties of air at the average temperature are as follows :

$\rho = 1.009\ kg/m^3$, $C_p = 1.0082\ kJ/kg^oC$,

$\mu = 2.075 \times 10^{-5}\ kg/ms\ (Ns/m^2)$ and

$K = 3.003 \times 10^{-2}\ w/m^oC$ 14

9. (a) Write and explain any two laws of radiation. 4

   (b) Define shape factor and explain various laws of shape factor. 5

   (c) Define the terms Radiosity, irradiation, emissive power and intensity of radiation. 4

10. (a) Assuming the Sun to be a black body emitting radiation with maximum intensity at $\lambda = 0.49\ \mu m$, calculate the following :

   (i) The surface temperature of the sun and

   (ii) The heat flux at surface of the sun. 5

   (b) Consider two large parallel plates, one at 1000 K with emissivity 0.8 and other is at 300 K having emissivity 0.6. A radiation shield is placed between them. The shield has emissivity as 0.1 on the side facing hot plate and 0.3 on the side facing cold plate. Calculate percentage reduction in radiation heat transfer as a result of radiation shield. 8