[03 – 4116]

IV/IV B.E. DEGREE EXAMINATION.

First Semester

Mechanical Engineering

HEAT AND MASS TRANSFER

(Common with Marine & Naval Architecture Engineering)

(Effective from the admitted batch of 2006–2007)

Time : Three hours Maximum : 70 marks

Question No. 1 is compulsory.

Answer any FOUR questions from the remaining.

All questions carry equal marks.

Heat transfer data book is permitted.

Assume suitable missing data wherever necessary.

Answer to question No. 1 must be at one place.

1. (a) What is meant by critical thickness of insulation?

   (b) Define time constant of thermo couple.

   (c) Draw the temperature distribution in a pipe when wall temperature is maintained constant.

   (d) What is meant by free convection?

   (e) Write two properties of shape factor.

7. (a) Derive CMTD of parallel flow heat exchanger.

(b) Steam is being condensed on a series of tubes through which cold water is flowing. Each tube is 25 mm in diameter and over all heat transfer coefficient based on outside area is 200 $W/m^r - k$. Water in each tube flows at a rate of 200 kg/hr and entering temperature of 15°C and leaving temperature of 80°C. If the steam is condensing at 100°C, find the steam condensed on each tube per hour and the length of the tube. Use NTU method.

8. (a) Explain different regimes of boiling.

(b) Saturated steam at t sat = 90°C (p = 70.14 kpa) condenses on the outer surface of a 1.5m long, 2.5 m OD vertical tube maintained at a uniform temperature $T_\infty = 70°C$, Assuming film condensation, calculate (i) the local heat transfer coefficient at the bottom of the tube and (ii) the average heat transfer coefficient over the entire length of the tube.

(f) State the importance of number of transfer units.

(g) Define the term mass transfer coefficient.

2. (a) Derive Fourier heat conduction equation in cylindrical coordinates.

(b) A cast iron central heating pipe has an inner diameter of 100 mm and wall thickness of 5 mm. The pipe feeds a radiator with water at a temperature of 90°C and inner wall temperature of the pipe may be assumed equal to the water temperature. Calculate the outer surface temperature of the pipe and heat transfer rate per meter length of pipe in a room at 20°C. Take k (pipe material) = 52 W/m-K and $h_0 = 20\,W/m^2 - °C$

3. (a) Discuss the fin analysis for measuring temperature error of thermometer.

(b) A thermo plastic material must be brought to atleast 90°C for easy moulding but its temperature must not exceed 120°C at any point in the material. A sheet of this material, 20 mm thick is put in an over maintained at 120°C. Find the time required to raise the temperature of the plate 90°C at the centre, if the initial temperature of the plate was 30°C. Take = h(in the over)= 25 W/m^r-k, K (thermoplastic material)= 5w/m-k α (thermoplastic material) = $4\times10^{-7}\,m^r/s$. Find the surface temperature, when the centre has reached the temperature of 90°C.

4. (a) Derive the equations for momentum thickness and energy thickness of boundary layer on a flat plate.

(b) Using the relation for heat transfer in turbulent flow through pipe given by Reynold as : $st = \frac{h}{\rho C_p U_m} = f/8$, determine the temperature rise of a fluid flowing through a pipe 15 cm diameter and 2 m long from which the heat is being transferred to the fluid if the temperature of the pipe wall is constant. Take $f = 0.02$ and temperature difference between the wall and find at the entry is 30°C.

5. (a) Derive the equation for Nusselt number as a function of Reynolds number and Prandtl number.

(b) A square duct of 30 cm × 30 cm carriers conditioned air at a temperature such that the outside surface temperature of the duct is maintained at 15°C and exposed to room air at 25°C. Calculate the heat gained by the duct per metre length assumes the duct runs horizontal.

6. (a) State and prove Wier's displacement law.

(b) Two large parallel planes with emissivities 0.4 (T= 500 k) and 0.8 (T=700 k) exchange heat. Find the net heat radiated by them and percentage reduction in heat transfer when polished aluminium radiation shield $(\in) = 0.04$ is placed between them.