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10AU65

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

Time: 3 hrs. Max. Marks:100

Note: 1. ***Answer FIVE full questions, selecting at least TWO questions from each part.***
2. Usage of HMT data hand book is permitted.
3. Missing data; if any, may be assumed suitably.

PART – A

1 a. Stating all the assumptions, derive 3-D heat conduction equation made in Cartesian co-ordinates. **(10 Marks)**

b. Steam at 350°C flowing in a pipe (K = 80 W/mk) 5 cm inner dia, 5.6 cm outer dia is covered with 3 cm thick insulation (K = 0.05 W/mK). Heat is lost to the surroundings at 5°C by natural convection (h_0 = 20 W/m^{2}K and h_i = 60 W/m^{2}K). Find
(i) Rate of heat loss from pipe per unit length.
(ii) Temperature drop across the pipe and insulation.
Draw net–work diagram. **(10 Marks)**

2 a. Derive an expression for the heat transfer from an extended rectangular surface of finite length with usual assumptions. **(10 Marks)**

b. A stainless steel fin (K = 20 W/mK) having a diameter of 20 mm and a length of 0.1 m is attached to a wall at 300°C. The ambient temperature is 50°C and the heat transfer coefficient is 10 W/m^{2}K. The fin tip is insulated. Determine (i) The rate of heat dissipation from the fin (ii) The temperature at the fin tip (iii) The rate of heat transfer from the wall area covered by the fin if the fin was not used and (iv) the heat transfer rate from same fin geometry if the stainless steel fin is replaced by a fictitious fin with infinite thermal conductivity. **(10 Marks)**

3 a. Explain Biot and Fourier numbers. Show that $\frac{T-T_\infty}{T_0-T_\infty} = e^{-B_i F_o}$ **(10 Marks)**

b. Steel ball bearings (K = 50W/mK, $\alpha = 1.3\times10^{-5}$ m^2/s) having a diameter of 40 mm are heated to a temperature of 650°C and then quenched in a tank of oil at 55°C. If the heat transfer coefficient between the ball bearings and oil is 300 W/m^{2}K, determine (i) duration of time the bearings must remain in oil to reach a temperature of 200°C (ii) The total amount of heat removed from each bearing during this time and (iii) The instantaneous heat transfer rate from the bearings when they are first immersed in oil and when they reach 200°C. **(10 Marks)**

4 a. Discuss the concepts of hydrodynamic and thermal boundary layers with neat sketches. **(06 Marks)**

b. Give physical significance of, (i) Grashoff number. (ii) Nusselt number (iii) Prandtl number. **(06 Marks)**

c. A fine wire having a diameter of 0.02 mm is maintained at a constant temperature of 54°C by an electric current. The wire is exposed to air at 1 atm and 0°C. Calculate the electric power necessary to maintain the wire temperature if the length is 50 cm. **(08 Marks)**

PART – B

5 a. Using dimensional analysis correlate the forced convection data: $Nu = C(Re^m)(P_r)^n$. **(10 Marks)**

b. Air at 35°C flows across a cylinder of 50 mm diameter at a velocity of 50 m/s. The cylinder surface is maintained at 145°C. Find the heat loss per unit length. Properties at mean temperature are $\rho = 1\,kg/m^3$, $\mu = 20\times10^{-6}$ kg/ms, K = 0.0312 W/m°C, C_P = 1.0 KJ/kg°C. **(10 Marks)**

6 a. For a co-axial parallel flow heat exchanger, establish $\epsilon = \frac{1-e^{-NTU(1+c)}}{1+c}$ with usual notation. **(10 Marks)**

b. Water is heated at a rate of 1.4 kg/s from 40°C to 70°C by an oil entering at 110°C and leaving at 60°C in a counter flow heat exchanger. If $U_0 = 350$ W/m² K. Calculate

(i) Mass flow rate of oil.
(ii) Surface area required and
(iii) Effectiveness of heat exchanger using NTU method.

C_P of water = 4.187 KJ/kgK; C_p of oil = 1.9 KJ/kgK. **(10 Marks)**

7 a. With a neat sketch, explain regimes of pool boiling. **(10 Marks)**

b. Saturated steam at 110°C condenses on the outside of a bank of 64 horizontal tubes 25 mm outer diameter. 1 m long arranged in a 8×8 square array. Calculate the rate of condensation if the tube surface is maintained at 100°C. The properties of saturated water at 105°C are $\rho = 954.7\,kg/m^3$, K = 0.684 W/m² K, $\mu = 271\times10^{-6}$ kg/ms, $h_{fg} = 2243.7$ kJ/kg. **(10 Marks)**

8 a. Explain
(i) Stefan-Boltzmann law
(ii) Kirchoff's law.
(iii) Planck's law.
(iv) Weins-displacement law.
(v) Radiation shield. **(10 Marks)**

b. Two very large parallel planes with emissivities 0.3 and 0.8 exchange radiative energy. Determine the percentage reduction in radiative energy transfer when a polished aluminium radiation shield ($\varepsilon = 0.04$) is placed between them. Draw network diagram. **(10 Marks)**

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