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10AU65

Sixth Semester B.E. Degree Examination, June/July 2015
Heat and Mass Transfer

Time: 3 hrs. Max. Marks:100

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

PART – A

1 a. State the modes of heat transfer with governing laws and equations. **(09 Marks)**

b. Discuss with an example heat transfer in combined mode. **(05 Marks)**

c. With sketches, write the mathematical representation of boundary condition 2nd kind and 3rd kind for 1-D heat conduction in rectangular coordinates. **(06 Marks)**

2 a. Derive an expression for the critical radius for the insulation of a cylinder. **(08 Marks)**

b. Fins, 12 in number with tips insulated, having thermal conductivity 75 W/m-K and 0.75 mm thickness protrude 25 mm from a cylindrical surface of 50mm diameter and 1 m length placed in an atmosphere of 40°C. If the cylinder surface is maintained at 150°C and the heat transfer coefficient is 23 W/m^2K, calculate:

i) The rate of heat transfer by fins.
ii) The percentage increase in heat transfer due to fins.
iii) The temperature at the centre of the fins and
iv) The fin efficiency
v) The fin effectiveness. **(12 Marks)**

3 a. What is lumped system analysis? When is it applicable? What is the physical significance of Biot number? **(06 Marks)**

b. A solid iron rod [K = 60 W/m-K, $\rho = 7280\ kg/m^3$, $c_p = 410$ J/kg K and $\alpha = 2 \times 10^{-5}\ m^2/s$] of 6cm diameter, initially at temperature 800°C is suddenly dropped into an oil bath at 50°C. The heat transfer coefficient between the fluid and the surface is 400 W/m^2K. Using the transient temperature chars, determine:

i) The centerline temperature 10 min after immersion in the fluid.
ii) The temperature at a depth of 2cm from the surface 10 min after immersion in the fluid.
iii) The energy removed from the rod during this period. **(14 Marks)**

4 a. Define the following dimensionless members. Also give their physical significance.
i) Prandtl number ii) Nusselt number. **(08 Marks)**

b. A horizontal pipe 0.3m in diameter is maintained at a temperature of 245°C in a room where the ambient air is at 15°C. Calculate the free convection heat loss per meter length of the pipe. Take the properties of air at the bulk mean temperature of 130°C as [$K = 34.14 \times 10^{-3}$ W/m-K, $\gamma = 26.63 \times 10^{-6}\ m^2/s$ and $P_r = 0.685$]. **(12 Marks)**

PART – B

5 a. Distinguish between hydrodynamic and thermal boundary layers with sketches. **(08 Marks)**

b. Air at 20°C and at atmospheric pressure flows over a flat plate at a velocity of 3 m/s. The plate is 0.3m long and at 60°C. The properties of air at the bulk mean temperature of 40°C are [K = 0.02756 W/m-K, C_p = 1005 J/kg K, ρ = 1.128 kg/m^3, γ = 19.96 × 10^{-6} m^2/s and P_r = 0.699]. Calculate:

i) Velocity and thermal boundary layer thickness at 0.2m from the heading edge.

ii) Local and average friction coefficient.

iii) Average heat transfer coefficient.

iv) Rate of heat transfer by convection.

v) Total drag force on the plate per unit width. **(12 Marks)**

6 a. Briefly explain the classification of heat exchanger by flow management. **(08 Marks)**

b. A two-shell pass, four-tube pass heat exchanger has water on the shell side and brine on the tube side. Water is cooled from 18°C to 6°C with brine entering at -1°C and leaving at 3°C. The overall heat transfer coefficient is 600 W/m^2 K. Calculate the heat transfer are required for a design heat load of 24 kW. **(12 Marks)**

7 a. Sketch and explain boiling curve. **(08 Marks)**

b. Air free saturated steam at 85°C [P = 57.83 kPa] condenses on the outer surface of 25 horizontal tubes of 1.27 cm diameter in a 15-by-15 array. Tube surfaces are maintained at a uniform temperature of 75°C. Calculate the total condensation rate per 1m length of the tube bundle. The physical properties of water at T_f = 80°C are K = 0.688 W/m K, ρ_l = 974 kg/m^3, μ_l = 0.355 × 10^{-3} kg/m-s, h_{f_g} = 2309 kJ/kg. **(12 Marks)**

8 a. State: i) Wein's displacement law; ii) Kirchoff's law; iii) Planck's law, also state their significances. **(09 Marks)**

b. Consider two large parallel plates; one at 1000K with emissivity 0.8 and the other is at 300 K with emissivity 0.6. A radiation shield is placed between them. The shield has emissivity of 0.1 on the side facing hot plate and 0.3 on the side facing cold plate. Calculate the percentage reduction in radiation heat transfer as a result of radiation shield. **(11 Marks)**

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