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10AU65

Sixth Semester B.E. Degree Examination, June/July 2018
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. State the assumptions and derive the most general three dimensional heat conduction equation in Cartesian co-ordinates. **(08 Marks)**

b. A furnace wall is made up of inside Silica bricks (K = 1.6 W/mK), outside magnetia brick (K = 4.8 W/mK), 10 cm thick each. The inside and outside surfaces are exposed to fluid temperatures of 820°C and 120°C respectively. Find the heat flow through the wall per m^2 per hour. Assume a contact resistance of 0.002 m^2/w. Draw the temperature profile through the composite wall. The inside and outside heat transfer co-efficients are 35 W/m^2K and 12 W/m^2K respectively. **(12 Marks)**

2 a. Derive expressions for temperature distribution and heat transfer rate for a fin of circular cross section with insulated tip. **(10 Marks)**

b. In a conductivity measurement experiment, two identical long rods are used one rod is made of Aluminium (K = 200 W/mK), the other rod is the specimen. One end of both rods are fixed to a wall at 100°C and they are suspended in air at 25°C. The steady temperature at same distance along the rods were measured and found to be 75°C on aluminium rod and 60°C on the specimen rod. Find K of the specimen. **(10 Marks)**

3 a. State the assumptions made in lumped parameter analysis and derive an expression for instantaneous temperature and heat transfer rate for a body subjected to heating or cooling in terms of Biot and Fourier numbers. **(10 Marks)**

b. An Iron sphere (K = 60 W/mK, C_P = 460 J/kgK, ρ = 7850 kg/m^3 and $\alpha = 1.6\times10^{-5}$ m^2/s) of 5 cm diameter is initially at a uniform temperature $T_i = 225°C$. Suddenly the surface of the sphere is exposed to an ambient at $T_\infty = 25°C$ with a heat transfer co-efficient $h = 500$ $W/m^{2°}K$. Find (i) The centre temperature at time t = 2 min after start of cooling (ii) The temperature at a depth of 1 cm from the surface at time t = 2 min after start of cooling (iii) The energy removed from the sphere during this time period. **(10 Marks)**

4 a. Distinguish between : (i) Hydrodynamic and thermal boundary layers (ii) Laminar and turbulent flow. **(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 30 cm long and 60°C. Calculate
(i) Velocity and thermal boundary layer thicknesses at 20 cms from the leading edge.
(ii) Average heat transfer co-efficient.
(iii) Total drag force on the plate per unit width. **(12 Marks)**

PART – B

5 a. Using dimensional analysis, derive a correlation in terms of Nusselt number, Grashoff number and Prandtl number for free convection heat transfer. **(10 Marks)**

b. Calculate heat transfer from a 60 W incandescent bulb at 125°C to ambient air at 25°C. Assume the bulb as a sphere of 50 mm diameter. Also find the percentage of power lost by free convection. Use $Nu = 0.6\,(Gr.Pr)^{1/4}$. **(10 Marks)**

6 a. Derive an expression for LMTD for a counter flow heat exchanger. **(10 Marks)**

b. In a counter flow double pipe heat exchanger, water is heated from 25°C to 65°C by an oil with a specific heat of 1.45 kJ/kgK and mass flow rate of 0.9 kg/sec. The oil is cooled from 230°C to 160°C. If the overall heat transfer coefficient is 420 $W/m^{2}{}^{\circ}C$. Calculate

(i) The rate of heat transfer.
(ii) The mass flow rate of water.
(iii) The surface area of the heat exchanger. **(10 Marks)**

7 a. With the help of boiling curve for water, explain different regimes of boiling. **(10 Marks)**

b. Estimate the peak-flux for water boiling at normal atmospheric pressure. The relevant thermo-physical properties are: **(10 Marks)**

$\rho_{f(liquid)} = 958.45\ kg/m^3$; $\rho_{g(vapour)} = 0.61\ kg/m^3$;

$h_{fg} = 2.25 \times 10^6\ J/kg$ and $\sigma = 0.0585\ N/m$.

8 a. State and explain the following : (i) Stefan – Boltzman law. (ii) Kirchoff's law (iii) Planck's law (iv) Wein's displacement law. **(08 Marks)**

b. Two large parallel plates are at 1000°K and 800°K. Determine the heat exchange per unit area, when (i) the surfaces are black (ii) the hot surface has an emissivity of 0.9 and the cold surface has emissivity of 0.6 (iii) A large plate of emissivity 0.1 is inserted between them. Also find the percentage reduction in heat transfer because of introduction of the large plate. **(12 Marks)**

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