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10AU65

Sixth Semester B.E. Degree Examination, Dec.2018/Jan.2019

Heat & Mass Transfer

Time: 3 hrs. Max. Marks:100

Note: 1. ***Answer FIVE full questions, selecting at least TWO questions from each part.***
2. ***Heat transfer data book and steam table are permitted.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

PART – A

1 a. Derive an expression for temperature distribution and heat flow rate through a hollow sphere. **(06 Marks)**

b. A hot steam pipe having an inside surface temperature of 250˚C has an inside diameter of 8 cm and a wall thickness of 5.5 mm. It is covered with a 9 cm layer of insulation having $K = 0.5$ W/m˚C, followed by a 4-cm layer of insulation having K = 0.25 W/m˚C. The outside temperature of the insulation is 20˚C. Calculate the heat loss per meter of length. Assume $K = 47$ W/m˚C for the pipe. **(06 Marks)**

c. A square plate heater ($20cm \times 20cm$) is inserted between two slabs. Slab A is 2 cm thick (K = 50 W/m˚C) and Slab B is 1 cm thick (K = 0.2 W/m˚C). The outside heat transfer co-efficient on A and B are 200 $W/m^{2\circ}C$ and 50 $W/m^{2\circ}C$ respectively. The temperature of surrounding air is 20˚C. If rating of heater is 2 kW. Find (i) Maximum temperature in the system. (ii) Outer temperature of two slabs. (iii) Draw an equivalent electrical circuit. **(08 Marks)**

2 a. Derive an expression for temperature distribution and heat flow rate for a fin connected between two heat sources. **(10 Marks)**

b. A copper road of diameter D = 5 mm is heated by the passage of an electric current. The surface of the rod is maintained at a temperature of 175˚C while it is dissipating heat by convection into an ambient at $T_\infty = 25^\circ C$. With heat transfer co-efficient $h_\infty = 150$ W/m^2˚C. If the rod is to be covered with a 1 mm thick coating (K = 0.6 W/m˚C). Will the heat loss from the rod increases or decreases? Comment on your result. **(03 Marks)**

c. It is required to heat the oil to 300˚C for frying purpose. A long ladle used in frying pan. The section of the ladle is 5 mm $\times$ 18 mm. The surrounding air is at 30˚C. The thermal conductivity of the material is 205 W/mK. If the temperature at a distance of 380 mm from the oil should not exceed 40°C, determine convective heat transfer coefficient. **(07 Marks)**

3 a. With a neat sketch derive an expression for temperature distribution and heat transfer rate for conduction in solids with negligible internal temperature gradient. **(10 Marks)**

b. An egg can be approximated as a sphere 5 cm in diameter, with thermophysical properties K = 0.6 W/mK, $\alpha = 0.14 \times 10^{-6}$ m^2/s. The egg is taken from a refrigerator at 2˚C and is dropped into boiling water, where the convective heat transfer co-efficient is estimated as 1200 W/m^{2}K. Calculate time required to reach the centre temperature of the egg to 75˚C. **(05 Marks)**

c. A mild steel sphere of 15 mm in diameter initially at 625˚C is exposed to a current of air at 25˚C with convection co-efficient of 120 W/m^{2}K. Calculate
   (i) Time required to cool the sphere to 100˚C
   (ii) Initial rate of cooling in ˚C/min
   (iii) Instantaneous heat transfer rate at the end of one miniute after the start of cooling.

Assume for mild steel K = 43 W/mK, $\rho = 7850$ kg/m^3, C = 474 J/kgK, $\alpha = 0.045$ m^2/s **(05 Marks)**

4 a. A 1 KW central heating radiator 1.5 m long and 0.6 m high with a surface temperature of 80˚C, dissipating heat by radiation and convection into room at 20˚C, with K = 0.026 W/mK. Calculate Nusselt number assuming black body radiations. **(04 Marks)**

b. Vertical door of a hot oven is 0.5 m high and is maintained at 200˚C. It is exposed to atmospheric air at 20˚C. Find (i) Local heat transfer half way up the door. (ii) Average heat transfer co-efficient for entire door (iii) Thickness of free convection boundary layer at the top of the door. **(08 Marks)**

c. Calculate the cooling capacity by natural convection in air of a heat sink, having four rectangular thin fins of size 20 mm height and 25 mm width. The fins may be assumed to have a constant surface temperature of 60˚C in ambient air at 20˚C. Take fin efficiency as 60%. **(08 Marks)**

PART – B

5 a. Air at 27˚C is flowing across a tube with a velocity of 25 m/s. The tube could be either a square of 5 cm side or a circular cylinder of 5 cm dia. Compare the rate of heat transfer in each case, if the tube is at 127˚C. **(08 Marks)**

b. Engine oil at 60˚C flows at 0.5 kg/s in a duct with constant surface temperature of 20˚C. Assuming fully developed flow calculate (i) heat flux at entry (ii) Pressure drop per meter length for 3 cm diameter tube and for a 3×1 rectangular duct of equal wall area. **(12 Marks)**

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

b. A shell and tube type heat exchanger is designed for heating water from 25˚C to 50˚C with the help of steam condensing at atmospheric pressure. The water flows through tubes (2.5 cm I.D, 2.9 cm O.D and 2 m long) and the steam condenses on the outside. Calculate the number of tubes required if the water flow rate is 500 kg/min and the individual co-efficients of heat transfer on the steam and water side are 8000 and 3000 W/m^2K. Neglect all the resistance. **(10 Marks)**

7 a. With the help of boiling curve, explain various regims of boiling. **(08 Marks)**

b. A steam condenser consist of 16 tubes arranged in 4×4 array. Water flows through the tube at 65˚C while steam condenses at 75˚C over the tube surface. Find the rate of condensation if, (i) tubes are horizontal (ii) tubes are vertical. **(12 Marks)**

8 a. State and explain : (i) Plank's law (ii) Kirchoff's law (iii) Wiens displacement law (iv) Lambert's cosine law. **(08 Marks)**

b. Explain briefly concept of black body with an example. **(02 Marks)**

c. Two parallel plates each of 4 m^2 area, are large compared to a gap of 5 mm separating them. One plate has a temperature of 800 K and emissivity of 0.6, while the other has a temperature of 300 K and a surface emissivity of 0.9. Find the net energy exchange by radiation between them. If a polished metal sheet of surface emissivity 0.1 on both sides is now located centrally between the two plates, what will be its steady state temperature? How the net heat transfer would be altered? **(10 Marks)**

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