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10AU65

Sixth Semester B.E. Degree Examination, Feb./Mar. 2022
Heat and Mass Transfer

Time: 3 hrs. Max. Marks:100

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

PART – A

1 a. Derive the general equation for the 3-dimensional unsteady state heat conduction with uniform rate of heat generation in an isotropic solid. Hence, deduce Laplace's equation. **(10 Marks)**

b. Consider an aluminium hollow sphere of inside radius $r_i = 2$cm, outside radius $r_0 = 6$cm and $K = 200$ W/m°C. The inside surface is kept at an uniform temperature of $T_i = 100$°C and outside surface dissipate heat by convection with $h = 80$W/m^2°C into ambient air at a temperature of $T_a = 20$°C.
Determine :
i) Outside surface temperature of the sphere in steady state
ii) Rate of heat transfer
iii) Temperatures within the aluminium sphere at a radius r = 3cm. **(10 Marks)**

2 a. Derive an expression for critical thickness of insulation in case of an electric cable. Explain the significance of critical thickness. **(10 Marks)**

b. A steel rod (K = 30W/mC), 10mm in diameter and 50mm long, with an insulated end is to be used as a spine. It is exposed to surrounding with a temperature of 65°C and a heat transfer coefficient of 50W/m^{2}C. The temperature of the base is 98°C. Determine :
i) Find efficiency
ii) Temperature at the end of spine
iii) Heat dissipation. **(10 Marks)**

3 a. What are Heisler charts? Explain their significance in solving transient conduction problems. **(04 Marks)**

b. A 50cm × 50cm copper slab, 6mm thick, at a uniform temperature of 350°C, suddenly has its surface temperature lowered to 30°C. Find the time at which the slab temperature becomes 100°C. Given : $\rho = 9000$kg/m^3, $C_p = 0.38$kJ/kg K, K = 370 W/mK, h = 100W/m^{2}K. Also find out rate of cooling after 60 seconds. **(10 Marks)**

c. A thick concrete slab ($\alpha = 7 \times 10^{-7}$m^2/s, K = 1.37W/mC) is initially at a uniform temperature of 350°C. Suddenly, its surface is subjected to convective cooling with a heat transfer coefficient h = 100W/m^{2}C into an ambient at 30°C. Calculate the temperature 8cm from the surface, 1 hour after start of cooling. **(06 Marks)**

4 a. Use the principle of dimensional analysis to establish a relationship between Nusselt number, Grashoff number and Prandtl number. **(10 Marks)**

b. A hot, square plate, 50cm × 50cm, at 100°C is exposed to atmospheric air at 20°C. Find the heat loss from both the surface of the plate :
i) If the plate is kept vertical
ii) If the plate is kept horizontal. **(10 Marks)**

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 – B

5 a. Explain the physical significance of
i) Reynolds number
ii) Prandtl number
iii) Nusselt number
iv) Stanton number. **(08 Marks)**

b. Air at 1 bar and 20°C flow through a 6mm ID, 1m long smooth pipe, whose surface is maintained at constant heat flux, with velocity of 3m/s. Determine the heat transfer coefficient if the exit bulk temperature of air is 80°C. Also determine the exit wall temperature and the value of h at the exit. **(12 Marks)**

6 a. Show that for a parallel flow heat exchanger the effectiveness 'ε' is given by
$$\varepsilon = \frac{1 - \exp(-NTU(1 + C))}{1 + C}.$$ **(10 Marks)**

b. An oil cooler for a large diesel engine is to cool engine oil form 60°C to 45°C using sea water whose inlet temperature 20°C with a temperature rise of 15°C. The designed heat load is 140KW and the mean overall heat transfer coefficient, based on the outer surface area of tube is $70 W/m^2 °C$. Calculate the heat transfer surface area for counter flow and parallel flow arrangement. Which is more effective? **(10 Marks)**

7 a. Clearly explain the regions of pool boiling with a neat sketch. **(10 Marks)**

b. A vertical plate 350mm high and 420mm wide at 40°C is exposed to saturated steam at 1 atm. Calculate :
i) The thickness of the film at the bottom of the plate
ii) Maximum velocity of film
iii) Total heat flux to the plate. **(10 Marks)**

8 a. Explain :
i) Stefan Boltzmann's Law
ii) Kirchoff's Law
iii) Plank's Law
iv) Wein displacement Law
v) Radiation shield. **(10 Marks)**

b. Two very large parallel plates are maintained at uniform temperature $T_1 = 800K$ and $T_2 = 500K$ and have emissivities $\varepsilon_1 = 0.2$ and $\varepsilon_2 = 0.7$ respectively. Determine the net rate of radiation heat transfer between the two surfaces per unit surface area of the plates. **(06 Marks)**

c. What does the view factor represent? When is the view factor from a surface to itself not zero? **(04 Marks)**

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