AQ – 2834

First Semester M. E. (Mech. Engg.) (Thermal Engg.) Examination

ADVANCED HEAT TRANSFER

1 MTE 4

P. Pages : 3

Time : Three Hours] [Max. Marks : 80

Note : (1) Answer **three** questions from Section A and **three** questions from Section B.
(2) Due credit will be given to neatness and adequate dimensions.
(3) Assume suitable data wherever necessary.
(4) Illustrate your answer wherever necessary with the help of neat sketches.
(5) Use of slide rule, logarithmic tables, Steam tables, Mollier's Chart, Drawing instrument, Thermodynamic table for moist air, Psychrometric Charts and Refrigeration charts is permitted.
(6) Use of Heat and Mass Transfer Data Book is permitted.
(7) Use pen of Blue/Black ink/refill only for writing the answer book.

SECTION A

1. (a) State the general heat conduction differential equation in cylindrical coordinates. Using this equation, derive the expression for maximum temp. in a solid cylinder, considering one dimensional steady state heat conduction. 7

(b) A current of 350 amp passes through a stainless steel wire, 2.5 mm dia and 2 m long. The resistivity and thermal conductivity of the wire are 70×10^{-8} Ω m and 20 W/mK resp. If the wire is submerged in a fluid maintained at 50 ^{0}C and convective heat transfer coeff on wire surface is 3500 W/m^{2}K, calculate the steady state temp at the centre and at the surface of wire. 6

2. (a) Explain briefly graphical method for solving two dimensional steady state conduction problem. Also discuss the significance of the conduction shape factor in this method. 8

(b) The inside dimensions of a furnace are 3 m x 2.5 m x 2 m. The walls are 0.2 m thick and have thermal conductivity of 1.3 W / mK. If the temperatures at the inner and outer surfaces are 300 ^{0}C and 100 ^{0}C resp, calculate the rate of heat loss. 6

3. (a) What are Heisler charts ? Discuss their significance in solving transient conduction problems. 7

(b) A 6 cm thick large steel plate ($k = 42.6\,W/mK$, $\alpha = 0.043\,m^2/h$), initially at 440 ^0C is suddenly exposed on both sides to an environment with convective heat transfer coefficient $235\,W/m^2\,K$ and temp. 50^0C. Determine the centre line temp. and temp. .inside the plate 15 mm from the mid plane after 4.3 minutes. 6

4. (a) What is thermal boundary layer ? Discuss its formation for flow of a cold fluid over a hot horizontal surface. 7

(b) Air at 1 atm and 35^0C flows across a 5 cm dia cylinder at a velocity of 50 m / sec. The cylinder surface is maintained at 150^0C. Calculate the heat loss per unit length of the cylinder.
Use – $Nu = CR_e^m \cdot P_r^{1/3}$. 6

5. (a) How are the velocity and temp fields developed, in natural convection, in front of a vertical plate which is maintained at a temp. higher than the surrounding fluid ? Discuss and also sketch the corresponding boundary layers. 7

(b) A horizontal pipe 0.3048 m in dia is maintained at a temp of 250^0C in a room where the ambient air is at 15^0C. Calculate heat loss per meter of length. 6

SECTION B

6. (a) What is radiation shape factor ? State and prove the reciprocity theorem. 8

(b) Two parallel rectangular surfaces 1 m by 2 m are opposite to each other at a distance of 4 m. The surfaces are black and at 100^0C and 200^0C. Calculate the heat exchange by radiation between the two surfaces. 6

7. (a) Discuss the concept of electrical network analogy for radiant heat exchange between non – black bodies. 7

(b) 'Understanding and analysis of radiation from gases and vapours is different than that for solids'. Explain. 6

8. (a) Discuss the Nusselt theory of laminar flow film condensation on a vertical plate. 7

(b) Saturated steam at $110\,^0$C condenses on the outside of a bank of 64 horizontal tubes of 25 mm outer dia, 1 m long arranged in an 8 x 8 square array. Calculate the rate of condensation if the tube surface is maintained at $100\,^0$C. The properties of saturated water at $105\,^0$C are $\rho = 954.7\ kg/m^3$, $k = 0.684\ W/mK$, $\mu = 271 \times 10^{-6}\ kg/m-sec$ and $h_{fg} = 2243.7\ kJ/kg$. 6

9. (a) Water at 1 atm boils in a stainless steel kitchen pan with $\Delta T = 8\,^0$C. Estimate the heat flux which will be obtained. If the same pan operates as a pressure cooker at 1.7 atm, what percent increase in heat flux might be expected ? 6

(b) What is film cooling and transpiration cooling ? Discuss their applications. 7

10. What is a heat pipe ? How are the heat pipes classified ? Discuss the construciton, working and applications of heat pipes. 13