B.Tech III Year I Semester (R13) Supplementary Examinations June 2017

HEAT TRANSFER

(Mechanical Engineering)

Use of heat transfer data book and steam tables is permitted in the examination hall

Time: 3 hours Max. Marks: 70

PART – A

(Compulsory Question)

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1 Answer the following: (10 X 02 = 20 Marks)

(a) Mention different types of boundary conditions applied to heat conduction problems.
(b) Explain the concept of driving potential applied to heat transfer problems.
(c) What is lumped capacity?
(d) Explain why Heisler chart cannot be used for the case of Biot number approaching zero.
(e) What do you understand by thermal boundary layer?
(f) Define Grashof number and explain its significance in free convection heat transfer.
(g) What is the equation which is used to transfer heat from solid surface to liquid in the case of boiling?
(h) Give two examples of direct contact heat exchanger.
(i) Define intensity of radiation of a surface.
(j) Define radiation shape factor.

PART – B

(Answer all five units, 5 X 10 = 50 Marks)

UNIT – I

2 (a) Derive general heat conduction equation for isotropic material in cylindrical co-ordinates.
(b) What do you mean by boundary and initial condition?

OR

3 (a) Derive expression for critical thickness of insulation for cylinder
(b) A refrigerant at -40^{0}C flows in a copper pipe (k = 400 W/mK) of I.D. 10 mm and O.D. 14 mm. A 40 mm thick shell of thermocol (k = 0.03 W/mK) is put on the pipe to reduce losses. Estimate the heat leakage to the refrigerant per meter length of pipe, if the ambient air temperature is 40^{0}C. Assume the internal and external heat transfer coefficients to be 500 and 5 W/mK respectively. Calculate also the amount of refrigerant evaporated per hour taking its latest at -40^{0}C as 1390 kJ/kg.

UNIT – II

4 (a) Give the values of characteristic dimensions (LC) used in lumped analysis for following cases:
(i) Sphere. (ii) Cylinder. (iii) Plate.
(b) A boiler furnace has the effective dimensions 4 m x 3 m x 3 m high. The walls are constructed from an inner firebrick wall 25 cm thick (k = 0.4 W/mK), a layer of ceramic blanket insulation (k = 0.2 W/mK), 8 cm thick and a steel protective layer (k = 54 W/mK) 2 mm thick. The inside temperature of the fire back layer was measured as 600^{0}C. Determine the rate of heat loss through the vertical walls of the furnace. Also calculate the temperature drop across the steel layer.

OR

5 (a) A high pressure steam pipe of I.D. 21 cm and thickness 2 cm (k = 54 W/mK) carries steam at a temperature of 450^{0}C. The pipe is covered with a layer of insulation 12 cm thick (k = 0.04 W/mK). Considering the resistance of steam to heat flow to be infinitesimally small, calculate the heat loss per meter length of pipe when the outer surface temperature of insulation is 55^{0}C.
(b) Derive the temperature distribution with negligible surface resistance.

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UNIT – III

6 (a) A plate at 90^0C is located parallel to an air stream flowing at a speed of 75 m/s. The temperature of air is 0^0C. The plate is 60 cm wide and 45 cm long. Assuming a transition Reynolds number of 4 x 10^5, calculate the average heat transfer and friction coefficients for the laminar and turbulent region of the plate.

(b) What is Reynolds analogy? Describe the relation between fluid friction and heat transfer.

OR

7 (a) Compare the variations of velocity, temperature and local heat transfer coefficient along a vertical plate for the plate under natural convection and forced convection.

(b) A vertical plate is at 96^0C in an atmosphere of air at 20^0C. Estimate the local heat transfer coefficient at a distance of 20 cm from the lower edge and the average value over 20 cm length.

UNIT – IV

8 (a) Discuss the flow regimes of forced convection boiling inside a tube.

(b) A long electric wire of 1mm diameter carrying electric current dissipates 4000 W/m and attains a surface temperature of 125^0C when submerged in water at atmospheric pressure. Calculate the boiling heat transfer coefficient.

OR

9 (a) What is the method used for the determination of mean temperature differences across the heat exchanger (T_m)?

(b) A counter flow concentric tube heat exchanger is used to cool engine oil (C = 2130 J/kgK) from 160^0C to 60^0C with water, available at 25^0C as the cooling medium. The flow rate of cooling water through the inner tube of 0.5 diameter is 2 kg/s while the flow rate of oil through the outer annulus O.D = 0.7m is also 2 kg/s. If the value of the overall heat transfer coefficient is 250 W/m^2K, how long must the heat exchanger be to meet its cooling requirement?

UNIT – V

10 (a) Using Planck's law, derive the expression for Stefan Boltzmann law.

(b) Two large parallel planes are at 1000 K and 500 K respectively ε_1 = 0.3 and ε_2 = 0.7. The planes are separated by a gray gaseous medium having ε_m = 0.2.

(i) What is the heat transfer rate between the two planes?

(ii) What is the temperature of the gas?

OR

11 (a) Two square plates, each of 5 m^2 area, are separated by a gap of 6 mm, one plate whose surface emissivity is 0.7, is at a temperature of 900 K. The other plate has surface emissivity of 0.95 and a temperature of 300 K. Assuming the plates to be much larger than the gap, calculate the net radiation exchange between the plates.

(b) State and prove reciprocal theorem apply to thermal radiation.

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