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BT–5/D–21 **45195**

HEAT TRANSFER

Paper–MEC–301A

Time Allowed : 3 Hours] [Maximum Marks : 75

Note : Attempt **five** questions in all, selecting at least **one** question from each Unit. All questions carry equal marks. Assume any missing data suitably.

UNIT–I

1. Saturated steam at 110ºC flows inside a copper pipe (thermal conductivity 450 W/m K) having an internal diameter of 10 cm and an external diameter of 12 cm. The surface resistance on the steam side is 12000 W/m^2 K and that on the outside surface of pipe is 18 W/m^{2}K. Determine the heat loss from the pipe if it is located in space at 25ºC. How this heat loss would be affected if the pipe is logged with 5 cm thick insulation of thermal conductivity 0.22 W/m K? 15

2. Derive an equation giving the temperature at the centre of a circular rod conducting electric current in terms of the current density, the wall temperature and the material properties. What is the centre temperature of a stainless steel (k = 16 W/m K, $\rho = 0.67 \times 10^{-4}\,\Omega\,\text{cm}$) rod of 20 mm diameter with an outer temperature of 400ºC when conducting 1000 A? 15

UNIT–II

3. What is Boundary layer thickness? What do you mean by laminar and turbulent boundary layers? What is laminar Sublayer? 15

4. Air at 2 atm and 200ºC is heated as it flows at a velocity of 12 m/s through a tube with a diameter of 3 cm. A constant heat flux condition is maintained at the wall and the wall temperature is 20ºC above the air temperature all along the length of the tube. Calculate : 15

   (a) the heat transfer per unit length of tube

(b) the increase in bulk temperature of air over a 4 m length of the tube. Use Dittus-Boelter equation, $Nu_d = 0.023\ Re^{0.8}\ Pr^{0.4}$. Properties of air are Pr = 0.681, $\mu = 2.57 \times 10^{-5}$ kg/ms, k = 0.0386 W/m K and c_p = 1.025 kJ/kg K.

UNIT–III

5. Why is Planck's law the basic law of thermal radiation? Explain graphically how $E_{b\lambda}$ and T are related. 15

6. (i) State and explain the reciprocity theorem. 6

   (ii) Two very large parallel plates with emissivities 0.5 exchange heat. Determine the percentage reduction is heat transfer rate if a polished aluminium radiation shield $(\varepsilon = 0.04)$ is placed in between the plates. 9

UNIT–IV

7. What is the limitation of LMTD method? Derive the expression for effeciveness using NTU method for counter flow heat exchanger. 15

8. A 4 kg/s product stream from a distillation column is to be a 3 kg/s water stream in a counter flow heat exchanger. The hot and cold stream inlet temperatures are 400 K and 300 K respectively and the are fo the exchanger is 30 m^2. If the overall heat transfer coefficient is estimated to be 820 $W/m^2/K$, determine the product stream outlet temperature, if its specific heat is 2500 J/kg K and coolant outlet temperature. 15