CBCS SCHEME

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15AU62

Sixth Semester B.E. Degree Examination, July/August 2021
Heat and Mass Transfer

Time: 3 hrs. Max. Marks: 80

Note: 1. ***Answer any FIVE full questions.***
2. Use of Heat transfer data hand book, steam tables are permitted.

1 a. Explain Boundary condition of 1st, 2nd and 3rd kind. **(06 Marks)**

b. A composite wall made of 3 layer of thickness 25cm, 10cm and 15cm of material A, B, C respectively. The thermal conductivities of A and B are 1.7W/mK and 9.5w/m°K respectively. The outside surface is exposed to air at 20°C with convection. Coefficient of 15W/m^{2}K and inside is exposed to gases at 1200°C with a convection coefficient of 28W/m^{2}K and the inside surface is at 1080°C. Determine the unknown thermal conductivity of layer made up material 'C' and interface temperature. **(10 Marks)**

2 a. Derive the general three dimensional heat conduction equations in Cartesian co-ordinate system. **(08 Marks)**

b. Steam at 350°C flowing in a pipe (K = 80W/m°K) of 5cm inner diameter and 5.6cm outer diameter is covered with 3cm thick insulation of K = 0.05W/m°K. Heat is lost to the surroundings at 5°C by natural convection and radiation. The combined h being 20W/m^{2}K. Taking the heat transfer coefficient inside the pipe as 60W/m^{2}K. Determine the rote of heat loss from the steam pipe per unit length. **(08 Marks)**

3 a. Derive the expression for critical thickness of insulation for cylinder. **(06 Marks)**

b. Define Fin efficiency and effectiveness. **(04 Marks)**

c. An electrical wire of 1mm diameter is covered with a 2mm thick layer of plastic insulation (K = 0.5W/m°K). Air surrounding the wire is at 25°C and h = 10W/m^{2}K. The wire temperature is 100°C and it is not affected by the presence of insulation. Estimate the rate of heat dissipation from the wire per unit length with and without the insulation. Find the radius of insulation when the rate of heat dissipation is maximum. What is the maximum value of this heat dissipation? **(06 Marks)**

4 a. Obtain an expression for temperature variation and instantaneous heat transfer for lumped heat analysis. **(08 Marks)**

b. A 60mm thick large steel plate (K = 42.6W/m°C, α = 0.043m^2/hr) initially at 440°C is suddenly exposed on both the sides to an environment with convective heat transfer coefficient 235W/m^2°C and temperature 50°C. Determine centre line temperature and temperature inside the plate 15mm from the midplane after 4.3mins. **(08 Marks)**

5 a. Using dimensional analysis derive an expression relating Nusselt number, Prandtl and Grashoff numbers for Natural convection. **(08 Marks)**

b. The maximum allowable surface temperature of an electrically heated vertical plate 15cm high and 10cm wide is 140°C. Estimate the maximum rate of heat dissipation from both sides of the plate in an atmosphere at 20°C. The radiation heat transfer co-efficient is 8.72 W/m^{2}K. For air at 80°C, take $\gamma = 21.06\times10^{-6}$ m^2/s, $P_r = 0.692$ and K = 0.03W/mK. **(08 Marks)**

6 a. Explain the physical significance of the following dimensionless numbers :
   i) Raynold's number
   ii) Prandtl number
   iii) Nusselt number
   iv) Stanton number. **(08 Marks)**

b. A liquid metal flows at the rate of 4kg/s through a constant heat flux 6cm inner diameter tube in a nuclear reactor. The fluid at 200°C to be heated with the tube wall 40°C above the fluid temperature. Determine the length of the tube required for 25°C rise in bulk fluid temperature. Using the following properties $S = 7.7 \times 10^3$ kg/m^3, $\gamma = 8\times10^{-8}$ m^2/s, $C_p = 130$ J/kg°C $K = 12$W/mK and $P_r = 0.011$. **(08 Marks)**

7 a. Derive expression for LMTD for parallel flow heat exchanger and state the assumptions made. **(08 Marks)**

b. A counter flow heat exchanger of heat transfer area 12.5m^2 is to cool oil (C_{ph} = 2000 J/kg°C) with water (C_{pc} = 4170 J/kg°C. The oil enters at T_{hi} = 100°C and m_h = 2kg/s while the water enters at T_{ci} = 20°C and m_c = 0.48kg/s. The overall heat transfer coefficient is 400W/m^{2o}C. Calculate exit temperature of cold water and oil and total heat transfer rate. **(08 Marks)**

8 a. Explain different regimes of pool boiling with neat sketch. **(08 Marks)**

b. Saturated steam at 110°C condenses on the outsides of a Bank of 64 horizontal tubes 25mm outer diameter 1m long arranged in a 8×8 square array. Calculate the rate of condensation if the tube surface is maintained at 100°C. The properties of saturated water at 105°C are $S = 954.7$Kg/m^3, $K = 0.684$W/m^{2}K, $\mu = 271 \times 10^{-6}$kg/ms and $h_{fg=}$ 2243.7kJ/Kg. Had the condenser been vertical what would have been the rate of condensation. **(08 Marks)**

9 a. Explain:
   i) Plank's law
   ii) Kirchoff's law
   iii) Stefan – Boltzmann law. **(09 Marks)**

b. An enclosure measures 1.5m×1.7m with a height of 2m. The walls and ceiling are maintained at 250°C and the floor at 130°C. The walls and ceiling have an emissivity of 0.82 and the floor 0.7. Determine the net radiation to the floor. **(07 Marks)**

10 a. Prove that emissive power of the block body in hemispherical enclosures in π-terms of intensity of radiation. **(08 Marks)**

b. Calculate net radiant heat exchange for 1m square area for two large parallel plates at temperature 427°C and 27°C respectively. The emissivity of hot plate is 0.9 and cold plates is 0.6 if a polished aluminium sheet is placed between them. Then find the percentage reduction in heat transfer taking emissivity of shield 0.04. **(08 Marks)**

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