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Sixth Semester B.E. Degree Examination, June/July 2016
Heat and Mass Transfer

Time: 3 hrs. Max. Marks:100

Note: 1. *Answer FIVE full questions, selecting at least TWO questions from each part.*
2. *Use of heat transfer data hand book and steam tables are permitted.*

PART – A

1 a. What do you mean by boundary condition of Ist, 2nd and 3rd kind? **(06 Marks)**

b. Derive the general three dimensional heat conduction equation in cartesian co-ordinates and state the assumptions made. **(08 Marks)**

c. A pipe with outside diameter 20 mm is covered with two insulating materials. The thickness of each insulating layer is 10 mm. The conductivity of Ist insulating layer is 6 times that of the 2nd insulating layer. Initially insulating layer is placed in the order of 1st and 2nd layer. Then it is placed in the order of 2nd layer and 1st layer. Calculate percentage change in heat transfer and increase or decrease. Assume a length of 1 m. In both the arrangement, there is no change in temperature. **(06 Marks)**

2 a. What is physical significance of critical thickness of insulation? Derive an expression for critical thickness of insulation for a cylinder. **(06 Marks)**

b. Derive an expression for the temperature distribution for a pinfin, when the tip of the fin is insulated. **(08 Marks)**

c. Find the amount of heat transferred through an iron fin of thickness of 5 mm, height 50 mm and width 100 cm. Also determine the temperature difference at the tip of the fin assuming atmospheric temperature of 28°C and base temperature of fin = 108°C. Assume the following K = 50 W/mK, h = 10 W/m^{2}K. **(06 Marks)**

3 a. Write a note on Biot number and Fourier number. **(04 Marks)**

b. Obtain an expression for instantaneous heat transfer and total heat transfer for lumped heat analysis treatment of heat conduction problem. **(08 Marks)**

c. A hot mild steel sphere (K = 43 W/mK) having 10 mm diameter is planned to be cooled by an air flow at 25°. The convection heat transfer coefficient is 115 W/m^{2}K. Calculate the following (i) time required to cool the sphere from 600°C to 100°C (ii) Instantaneous heat transfer rate 1.5 min after the start of cooling (iii) total energy transferred from the sphere during the first 1.5 min. **(08 Marks)**

4 a. Explain the following: (i) Velocity boundary layer (ii) Thermal boundary layer. **(06 Marks)**

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

c. Air at 20°C flows over thin plate with a velocity of 3 m/sec. The plate is 2 m long and 1 m wide. Estimate the boundary layer thickness at the trailing edge of the plate and the total drag force experienced by the plate. **(06 Marks)**

PART – B

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

b. Air at 20°C flows past a 800 mm long plate at velocity of 45 m/sec. If the surface of the plate is maintained at 300°C. Determine (i) The heat transferred from the entire plate length to air taking into consideration both laminar and turbulent portion of the boundary layer.
(ii) The percentage error if the boundary layer is assumed to be of turbulent nature from the very leading edge of the plate. Assume unit width of the plate and critical Reynolds number to be 5×10^5. **(12 Marks)**

6 a. Derive an expression for LMTD for counter flow heat exchanger and state the assumptions made. **(10 Marks)**

b. A counter flow, concentric tube heat exchanger used to cool the lubricating oil for a large industrial gas turbine engine. The flow rate of cooling water through the inner tube. (d_i = 20 mm) is 0.18 kg/sec. While the flow rate of engine oil through the outer annulus (d_0 = 40 mm) is 0.12 kg/sec. The inlet and outlet temperature of oil are 95°C and 65°C respectively. The water enters at 30°C to the exchanger. Neglecting tube wall thermal resistance, fouling factors and heat loss to the surroundings, calculate the length of the tube. **(10 Marks)**

7 a. Clearly explain the regions of pool boiling with neat sketch. **(06 Marks)**

b. State and explain Ficks law of diffusion. **(06 Marks)**

c. Air free saturated steam at 85°C and pressure of 57.8 KPa condenses on the outer surface of 225 horizontal tubes of 1.27 cm outside diameter arranged in 15×15 array. Tube surfaces are maintained at a uniform temperature of 75°C. Calculate the total condensation rate/m length of the tube bundle. **(08 Marks)**

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

b. Calculate the net radient heat exchange per m^2 area for two large parallel plates at temperatures of 427°C and 27°C respectively. Take emissivity of the hot plate and cold plates are 0.9 and 0.16 respectively. If the polished aluminium shield is placed between them, find the percentage reduction in the heat transfer. Take emissivity of shield as 0.4. **(10 Marks)**

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