CBCS SCHEME

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15AU62

Sixth Semester B.E. Degree Examination, July/August 2022
Heat and Mass Transfer

Time: 3 hrs. Max. Marks: 80

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. Use of Heat and Mass transfer data handbook is permitted.

Module-1

1 a. Explain the concept of boundary conditions and also the basic Governing laws of heat transfer. **(08 Marks)**

b. The door of an industrial furnace is 2m × 4m in surface area and is to be insulated to reduce the heat loss to not more than 1200 W/m^2. The interior and exterior walls of the door are 10mm and 7mm thick steel sheets K = 25 W/mK between these 2 sheets a suitable thickness of insulating material is to be placed. The effective gas temperature inside the furnace is 1200°C and U = 20 W/m^2 K this between the gas and door. H = 5 W/m^2C is between outside the door. The surrounding air is 20°C. Select suitable insulating material among fire Clay brick (k = 1.09 W/mK) and Silica fibre (K = 0.115 W/mK) and its size. **(08 Marks)**

OR

2 a. Derive an expression of general 3-D Heat conduction equation in Cartesian co-ordinate. **(08 Marks)**

b. A steel tube K = 45 W/mK of outside diameter 7.6cm and thickness 1.3 cm is covered with an insulating material K= 0.2 W/mK of thickness 2 cm. A hot gas at 330°C with h = 200 W/m^2K is flowing inside the tube. The outer surface of the insulation is exposed to ambient air at 30°C with h = 50 W/m^2K. Calculate rate of heat flow from 5m long tube and temperature drop due to thermal resistance of hot gas steel tube, insulation layer and outside air. **(08 Marks)**

Module-2

3 a. With a neat sketch, name the types of fins with assumptions and discuss few practical applications of fins. **(08 Marks)**

b. A pipe 4 cm in outer diameter is maintained at uniform temperature at T_1 and is covered with an insulation (k = 0.2 W/mK) in order to reduce the heat loss. The heat is dissipated from outer surface of the insulation into an ambient at T_∞, with heat transfer coefficient of 8 W/m^2K. Determine the thickness of insulation at which the heat dissipation rate could be the maximum. Calculate the ratio of heat loss from the outer surface of insulated pipe and that of from the base pipe for (i) thickness of insulation is equal to critical thickness of insulation (ii) thickness of insulation is 2 cm thicker than critical thickness. **(08 Marks)**

OR

4 a. State the assumptions made in lumped system analysis and derive the expression for temperature distribution, instantaneous heat transfer and total heat transfer for body when subjected to heating or cooling. **(08 Marks)**

b. A bearing piece in the form of half of a hollow cylinder of 60 mm internal diameter, 90mm outer diameter and 100mm long is to be cooled to – 100°C from 30°C using cryogenic gas at – 150°C with a convection heat transfer co-efficient of 70 W/m^2K. Determine the time required. Take thermophysical properties of bearing material as C_p = 444 J/kgK, ρ = 8900 kg/m^3, K = 17.2 W/mK. **(08 Marks)**

Module-3

5 a. With a neat sketch, write short notes on
(i) Velocity boundary layer
(ii) Thermal boundary layer **(08 Marks)**

b. The water in a tank at 30°C is heated by passing steam through a vertical tube 50cm long and 5cm outer diameter. If the pipe surface is maintained at 80°C, determine the time required to heat 100 liters of water to 50°C. **(08 Marks)**

OR

6 a. With the help of Buckingham Pi theorem, obtain the expression for the dimensionless number related to forced convection. **(08 Marks)**

b. 50 kg of water per minute is heated from 30°C to 50°C by passing through a pipe of 2 cm diameter. The pipe is heated by condensing the steam on its surface at 100°C. Find length of the tube. **(08 Marks)**

Module-4

7 a. Determine the expression for LMTD of counter flow Heat Exchanger and state the assumptions. **(08 Marks)**

b. 5.795 kg/s of oil flows through the shell side of a 2 shell 4 tube pass oil cooler. The oil enters at 101°C and leaves at 38°C. Water flows in the tubes entering at 32°C and leaving at 49°C. In addition $C_{P_{oil}}$ = 2282 J/kgK and U = 416 W/m^{2}t. Find how much area the heat exchanger must have. **(08 Marks)**

OR

8 a. Derive an expression of boundary layer thickness using Nusselt theory for laminar film condensation on a vertical plate and also state the assumptions. **(08 Marks)**

b. The bottom of copper pan, 300mm in diameter is maintained at 120°C by an electric heater. Calculate the power required to boil water in this pan. What is the evaporation rate? Estimate the critical heat flux. **(08 Marks)**

Module-5

9 a. Derive an expression for radiation heat exchanger between 2 infinite parallel planes (Gray bodies). **(08 Marks)**

b. Two large planes with emissivity of 0.3 and 0.8 exchange heat. Find the percentage in reduction in heat transfer when polished aluminium shield emissivity of 0.04 is placed between them. **(08 Marks)**

OR

10 a. Write short notes on :
i) Stefan – Boltzmann law
ii) Kirchoff's law
iii) Planck's law
iv) Wein's Displacement law. **(08 Marks)**

b. 2 large parallel plates with emissivity 0.5 and 0.8 all maintained at 800 K and 600 K respectively. A radiation shield having an emissivity of 0.05 on both side is placed between the 2 planes. Calculate the heat transfer per unit area without shield, temperature of shield and heat transfer per unit area with shield. **(08 Marks)**

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