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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Sixth semester B.Tech examinations (S), September 2020

Course Code: ME302

Course Name: Heat and Mass Transfer

Use of heat and mass transfer data book permitted

Max. Marks: 100 Duration: 3 Hours

PART A

Answer any three full questions, each carries 10 marks. Marks

1 a) Derive the expression for critical thickness of a cylinder. What is the importance of critical thickness of insulation? (4)

b) A hollow sphere of inner radius 30 mm and outside radius 50 mm is electrically heated at its inner surface at a constant rate of 10^5 W/m^2. The outer surface is exposed to a fluid at 30 °C with h = 170 W/m^{2}K. Thermal conductivity of the material is 20 W/m K. Calculate the inner and outer surface temperatures. (6)

2 a) Air at velocity of 3m/s and at 20°C flows over a flat plate along the length. The length, width and thickness of the plate are 100cm, 50cm, 2cm respectively. The top surface of the plate is maintained at 100°C. Calculate the heat lost by the plate and temperature at bottom surface of the plate for steady state conditions. Thermal conductivity of plate material is 23 W/mK (5)

b) A vertical plate 15cm high and 10cm wide is maintained at 140°C. Calculate the maximum heat dissipation rate from both sides of the plate in ambient air at 20°C by free convection (5)

3 a) Derive the general heat conduction equation in Cartesian coordinates, state the assumptions. (8)

b) Good electrical conductors usually have the property of high thermal conductivity. Why? (2)

4 a) Using Buckingham pi theorem derive the expression for flow through a tube under forced convection . Make suitable assumptions (7)

b) Explain the importance of hydrodynamic and thermal boundary layers in heat transfer. (3)

PART B

Answer any three full questions, each carries 10 marks.

5 a) An aluminium sphere weighing 6kg and initially at temperature of 350°C is suddenly immersed in a fluid at 30°C with h = 60 W/m^2 C. Estimate the time required to cool the sphere to 100°C. (7)

b) Define fin efficiency and effectiveness (3)

6 a) Explain the features of pool boiling process with the curve (5)

b) Derive an expression for heat flow from a fin with tip insulated (derivation may start from solution of general fin differential equation, $\theta=C_1e^{mx}+C_2e^{-mx}$, with clear statement of boundary conditions) (5)

7 a) Classify heat exchangers based on flow direction .Explain why a counter flow is superior arrangement. When do we use specifically use parallel flow heat exchangers? (3)

b) Derive the expression for LMTD of a parallel flow heat exchanger (7)

8 The following are the details of a parallel flow heat exchanger - Heat capacity of cold flow entering at 40°C = 20000 W/K, Heat capacity of hot flow entering at 150°C = 10000 W/K, A=30 m^2 , U=500 W/m^{2}K. Determine heat transfer rate and exit temperatures (10)

PART C

Answer any four full questions, each carries 10 marks.

9 a) State and prove Kirchhoff's law of radiation (3)

b) Two black discs of diameter 50 cm each are placed parallel to each other concentrically at a distance of 1m. Disc temperatures are 727°C and 227°C . Calculate the heat transfer between discs if no other surface is present in between. (7)

10 a) What are radiation shields? Mention some of their applications (2)

b) Two concentric cylinders have inner and outer radius with 5cm and 10cm and length 20cm. Calculate the view factors (8)

11 Determine the heat lost by radiation per meter length of 80mm diameter pipe at 300°C, if (i)Located in a large room with red brick walls at temperature of 27°C (ii)Enclosed in a 160 mm diameter red brick conduit at a temperature of 27°C. Emisssivities of pipe material and brick 0.79 and 0.93 respectively (10)

12 a) State ficks law of mass diffusion, explaining all the terms (3)

b) Air at atm temperature 25°C, 18% RH flows through a pipe of 25mm inside dia (7) with a velocity of 4.5m/s. The inside is constantly wetted with water so as to maintain a water film on the inside the surface. Determine evaporation rate per m^2 of surface area. Kinematic viscocity =15.6 x 10^{-6} m^2/s , Sc = 0.6, Diffusion coefficient = 0.26 x 10^{-4} m^2/s, density under saturated conditions at 25°C = 0.231 kg/m^3 .

13 Derive the expression for mass transfer for the case of isothermal evaporation from the bottom of a small tube through surrounding stagnant gas. (10)

14 a) Discuss the analogy between heat transfer and mass transfer (5)

b) Estimate the diffusion rate of water from bottom of a test tube 1.5cm in diameter and 15cm long into dry atmospheric air at 25°C. D = 25.6 x $10^{-6}$$m^2/s$ (5)

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