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10MTP21

Second Semester M.Tech. Degree Examination, June 2012
Advanced Heat Transfer

Time: 3 hrs. Max. Marks:100

Note: ***1. Answer any FIVE full questions.***
2. Use of heat transfer data hand book permitted.

1 a. What is critical thickness of insulation? **(02 Marks)**

b. The steam at 300°C is passing through a steel tube. A thermometer pocket of steel (K = 45 W/mk) of inside diameter 14mm and 1mm thick is used to measure the temperature calculate the length of thermometer pocket needed to measure the temperature with in 1.8% permissible error. The diameter of steam tube is 95mm. Take heat transfer coefficient as 93 W/m^2K and tube wall temperature as 100°C. **(06 Marks)**

c. During the ripening process of oranges, the energy released is estimated as 563 W/m^3. If the orange is assumed to be homogeneous sphere with K = 0.15 W/mK. Compute the temperature at the centre of the orange and the heat flow from the outer surface. Assume a diameter of 8cm and outer surface temperature of 2°C. Derive the equations used. **(12 Marks)**

2 a. Define fin effectiveness and fin efficiency. Show that Bi < 1 is the ideal condition for using fins. **(08 Marks)**

b. A mild steel sphere of 15mm in diameter initially at 625°C is exposed to a current of air at 25°C with convection coefficient of 120 W/m^2K.
Calculate :
i) Time required to cool the sphere to 100°C.
ii) Initial rate of cooling in °C/S.
iii) Instantaneous heat transfer rate at the end of one minute after the start of cooling.
iv) Total energy transferred during first one minute. **(12 Marks)**

3 a. What is conduction shape factor? What is its importance? **(06 Marks)**

b. Explain the graphical method of solving two dimensional heat conduction problems. **(06 Marks)**

c. Liquid, oxygen (boiling temperature = -183°C) is to be stored in a spherical liquid oxygen tank 0.3m in diameter enclosed concentrically in a spherical container of 0.4m diameter and space in between is evacuated. The tank surface has an emissivity of 0.2. The container surface is at 15°C and has an emissivity of 0.25. Determine the net radiant heat transfer rate and rate of evaporation of liquid oxygen if its latent heat is 220 kJ/kg. **(08 Marks)**

4 a. Derive an expression for momentum transfer equation for flow over flat plate. **(12 Marks)**

b. Atmospheric air at 400K flows with a velocity of 4 m/s along a flat plate 1m long, maintained at an uniform temperature of 300K. The average heat transfer coefficient is estimated to be 7.75 W/m^2K. Using Reynolds Colburn analogy calculate the drag force exerted on the plate per meter width. **(08 Marks)**

5 a. A refrigerated truck carrying food stuff is speeding on a highway at 95 km/hr in a desert area where the ambient air temperature is 50°C. The body of the truck may be considered as a rectangular box 10m long, 4m wide and 3m high. Consider the boundary layer on four walls to be turbulent and heat is transferred from the four surfaces (neglect the heat loss from front and back surface). If the wall surfaces of the truck are maintained at 10°C. Calculate: i) the heat loss from four surfaces; ii) Power required to overcome the resistance acting on surfaces. **(12 Marks)**

b. Air at 27°C is flowing across a tube with a velocity of 25 m/s. The tube could be either a square of 5cm side or a circular cylinder of 5cm in diameter. Compare the rate of heat transfer in each case if tube surface is at 127°C. Use $Nu = C\,Re^n\,pr^{1/3}$; c = 0.027 n = 0.805 for cylinder; c = 0.102 n = 0.675 for square plate. **(08 Marks)**

6 a. A block 10cm × 10cm × 10cm in size is suspended in still air at 10°C with one of its surface in horizontal position. All surfaces of the block are maintained at 150°C. Determine the total heat transfer rate from the block. **(12 Marks)**

b. An ornament space heater is in the form of a 60cm diameter sphere which is freely suspended in a large room. The surface of the sphere is maintained at 100°C and the room air is at 20°C. Calculate the convective heat transfer rate. **(08 Marks)**

7 a. Derive an expression for condensate film thickness and average heat transfer coefficient for laminar condensation on a vertical plate. **(10 Marks)**

b. One hundred tubes 12mm in diameter are arranged in a square array and are exposed to steam at atmospheric pressure. Calculate the mass of steam condensed per unit length of tube, if the tube wall temperature is at 98°C. Use the following properties at mean temperature.
$\rho = 960$ kg/m^3; $\mu = 282 \times 10^{-6}$ kg/ms; k = 0.61 W/mK; $h_{fg} = 2255$ kJ/kg. **(10 Marks)**

8 a. Show that the effectiveness for a counter flow heat exchanger is given by $\in = \dfrac{1 - e^{-N(1-c)}}{1 - ce^{-N(1-c)}}$. **(10 Marks)**

b. Water flowing at the rate of 0.22 kg/s and at a temperature of 50°C enters a 1.5cm × 1.8cm rectangular tube which is 1m long. The tube wall is at 90°C. Calculate the exit water temperature. Use the following properties of water at 70°C.
$\rho = 977.8$ kg/m^3; C = 4.187 kJ/kg K; K = 0.667 W/mK; $\gamma = 0.415 \times 10^{-6}$ m^2/s. **(10 Marks)**

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