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12MTP21

Second Semester M.Tech. Degree Examination, June/July 2013
Advanced Heat Transfer

Time: 3 hrs. Max. Marks: 100

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

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

1 a. In a cylindrical fuel rod of nuclear reactor the internal heat generation is given by:
$q = q_0\left[1-\left(\frac{r}{r_0}\right)^2\right]$ where q and q_0 are the heat generation rates at any radius r and at the center respectively and r_0 outside radius of the rod. Derive a relation for the temperature drop from the centre line to the outside surface of the rod. Determine this temperature drop for 2.5 cm OD rod (K = 20 W/mK), if heat is removed from the outside surface at the rate of 2.5 MW/m^2. **(10 Marks)**

b. A cylinder 1 m long and 5 cm in diameter is placed in an atmosphere at 45°C. It is provided with 10 longitudinal straight fins of material having K = 120 W/mK. The height of 0.76 mm thick fins is 1.27 cm from the cylinder surface. The heat transfer coefficient between cylinder and atmospheric air is 17 W/m^{2}K. Calculate the rate of heat transfer and the temperature at the end of fins if surface temperature of cylinder is 150°C. **(10 Marks)**

2 a. The temperature distribution across a large concrete slab 500 mm thick heated from one side as measured by thermocouples approximates to the following relation:
$t = 120 - 100x + 24x^2 + 40x^3 - 30x^4$
where t is in °C and x is in meters. Considering an area of 4 m^2. Calculate : i) The heat entering and leaving the slab in unit time. ii) The heat energy stored in unit time. iii) Rate of temperature change at both sides of the slab iv) Point where the rate of heating or cooling is maximum. Properties of concrete are : K = 1.20 W/m°C, $\alpha = 1.77 \times 10^{-3}$ m^2/h. **(10 Marks)**

b. Develop the finite-difference equation for the solution of transient heat conduction in a slab of thickness L, initially with temperature distribution F(x) when for t > 0 the boundary surface at x = 0 and x = L are subjected to convection. **(10 Marks)**

3 a. What is conduction shape factor? What is its importance? **(04 Marks)**

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

c. Two large parallel plates with emissivities 0.5 each, are maintained at different temperatures and are exchanging heat only by radiations. Two equally large radiation shields with surface emissivity 0.05 are introduced in parallel to the plates. Find the percentage reduction in net radiative heat transfer. **(10 Marks)**

4 a. Derive the Reynolds-Colburn analogy for flow over a flat plate: $St_x P_r^{2/3} = \frac{C_{fx}}{2}$. **(10 Marks)**

b. Atmospheric air at 130°C flows with a velocity of 4 m/s along a flat plate 1 m long maintained at a uniform temperature 30°C. The average heat transfer coefficient is determined to be 7.75 W/m^2°C. Using the Reynolds – Colburn analogy, estimate the drag force exerted on the plate per 1-m width. **(10 Marks)**

5 a. Air entering at 2 bar pressure and bulk temperature of 200°C is heated as it flows through a tube with a diameter of 25.4 mm at a velocity of 10 m/s. Calculate the heat transfer per unit length of the tube if constant heat flux condition is maintained at the wall and wall temperature is 20°C above the air temperature all along the length of the tube. How much would the bulk temperature increase over a 3 meter length of the tube? Take the properties of air as: $\rho = 1.493\ kg/m^3$, $K = 0.0386\ W/m°C$, $\mu = 2.57\times10^{-5}\ NS/m^2$, $CP = 1025\ J/kg°C$. **(10 Marks)**

b. Water is heated in the annular section of a double pipe heat exchanger by electrical heating of the inner pipe. Outer pipe is insulated. Mean bulk temperature of water is 60°C. For the annulus $D_i = 2.5$ cm and $D_0 = 5$ cm. Determine the convection coefficient and pressure drop/ meter length for flow rate of 0.5 kg/s. **(10 Marks)**

6 a. Air flow through a long rectangular (30 cm height × 60 cm width) air conditioning duct maintains the outer duct surface temperature at 15°C. If the duct is uninsulated and exposed to air at 25°C. Calculate the heat gained by the duct per meter length, assuming it to be horizontal. **(10 Marks)**

b. A vertical pipe of 10 cm outer diameter, at a surface temperature of 100°C is in a room where the air is at 20°C. The pipe is 3 m long. What is the rate of heat loss per meter length of the pipe? **(10 Marks)**

7 a. Derive an expression for LMTD for counter flow heat exchanger. State the assumptions made. **(10 Marks)**

b. Saturated steam at 120°C is condensing on the outer tube surface of a single pass heat exchanger. The heat transfer coefficient is $U_0 = 1800\ W/m^2K$. Determine the surface area of the heat exchangers capable of heating 1000 kg/h of water from 20°C to 90°C. Also compute the rate of condensation of steam. Take $h_{fg} = 2200$ KJ/kg. **(10 Marks)**

8 a. Distinguish between:

i) Nucleate boiling and film boiling.

ii) Drop wise condensation and film wise condensation. **(10 Marks)**

b. The outer surface of a cylindrical drum 350 mm diameter is exposed to saturated steam at 2.0 bar for condensation. If the surface temperature of the drum is maintained at 80°C. Calculate the following:

i) The length of the drum.

ii) The thickness of the condensate layer to condense 70 kg/h of steam. **(10 Marks)**

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