NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY
BACHELOR OF ENGINEERING (HONS) DEGREE
Part Two Examination May 2012

TCE 2206 Heat Transfer Processes

Duration of Examination 3 Hours

Instructions to Candidates:
1. Answer ALL FIVE questions.
2. Each question carries equal marks.
3. Show all your steps clearly in your calculation.
4. Start the answers for each question on a new page.

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1. a) What is contact resistance? How is it defined? [4]

b) A commercial grade cubical freezer, 3m on the side, has a composite wall consisting of an exterior sheet of 6.35-mm-thick plain carbon steel, an intermediate layer of 100-mm-thick cork insulation, and an inner sheet of 6.35-mm-thick aluminum alloy (2024). Adhesive interfaces between the insulation and the metallic strips are each characterized by a thermal contact resistance of $R''_{t,c} = 2.5 \times 10^{-4} m^2 \cdot K / W$. What is steady-state cooling load that must be maintained by the refrigerator under conditions for which the outer and inner surface temperatures are $22^\circ C$ and $-6^\circ C$ respectively? **[12]**

Draw the thermal circuit. **[4]**

2. The surface of a 1.5-m long flat plate is maintained at 40°C, and water at a temperature of 4°C and velocity of 0.6m/s flows over the surface.

a) Using the film temperature for evaluation of the properties, calculate the heat transfer rate per unit width of the plate, $q'(W/m)$ **[6]**

b) Calculate the error in $q'(W/m)$,that would be incurred in part **(a)** if the thermophysical properties of the water were evaluated at the free stream temperature and the same empirical correlations were used. **[7]**

c) In part **(a)**, if a wire were placed near the leading edge of the plate to induce turbulence over its entire length, what would be the heat transfer rate? **[7]**

3. Hot water at 50°Cis routedfrom one building in which it is generated to an adjoining building in which it is used for space heating. Transfer between the buildings occurs in a steel pipe (k= 60W/mK) of 100-mm outside diameter and 8-mm wall thickness. During the winter, representative environmental conditions involve air at -5°C and velocity of 3 m/s in cross flow over the pipe.

a) If the cost of producing the hot water is $0.05per kW h, what is the representative daily cost of heat loss from an uninsulated pipe to the air per meter of pipe length? The convection resistance associated with water flow in the pipe may be neglected. **[12]**

b) Determine the savings associated with application of 10-mm-thick coating of urethane insulation (k=0.026W/m K) to the outer surface of the pipe. **[8]**

4. Water enters a tube at 27°C with a flow rate of 450 kg/h. The heat transfer from the tube wall to the fluid is given as $q_s'(W/m) = ax$, where coefficient $a=20$W/m^{2}and x (m) is the axial distance from the tube entrance.

a) Beginning with a properly defined differential control volume in the tube, derive an expression for the temperature distribution $T_m(x)$ of the water.**[10]**

b) What is the outlet temperature of the water for a heated section 30 m long?**[10]**

5. Water at a rate of 45 500 kg/h is heated from 80 to 150° Cin a heat exchanger having two shell passes and eight tube passes with a total surface area of 925m^2. Hot exhaust gases having approximately the same thermophysical properties as air enter at 350°C and exit at 175°C. Determine the overall heat transfer coefficient.**[20]**

Problems: 3.24, 7.14, 7.55, 8.11, 11.10