NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY
BACHELOR OF ENGINEERING (HONS) DEGREE
Part Two Examination May 2008

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.

1.

(a) A 240 mm steam main, 210 mm long is covered with 50 mm of high temperature insulation(k= 0.092 W/m°C) and 40 mm of low temperature insulation (k=0.062 W/m°C) . The inner and outer surface temperatures as measured are 390°C and 40°C respectively.

Calculate;

a) The total heat loss per hour.
b) The heat loss per m^2 of pipe surface.
c) The total heat loss per m^2 of outer surface.
d) The temperature between two layers of insulation. **(16 marks)**

(b) Describe and explain the relationship between the thermal conductivities of liquids, solids and gases. **(4marks)**

2. **(a)** One-dimentional, steady-state conduction with uniform internal energy generation occurs in a plane wall with a thickness of 50 mm and a constant thermal conductivity of 5 *W/m K*. For these conditions, the temperature distribution has the form, $T(x) = a+bx+cx^2$. The surface at x=0 has a temperature of $T(0)=T_0$=120°*C* and experiences convection with fluid for which $T\infty$=20°C and h=500 W/m^2K. The surface at $x=L$ is well insulated.

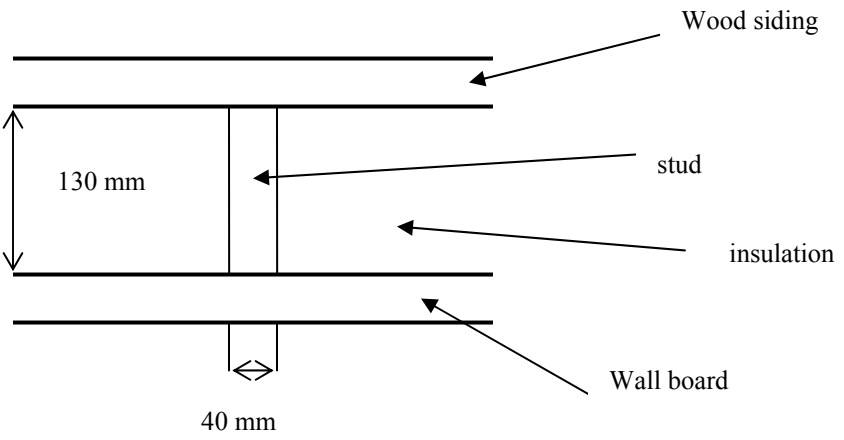
a) Applying an overall energy balance to the wall calculate the internal energy generation rate, $\dot{q}$
b) Determine the coefficients *a*, *b*, and *c* by applying the boundary conditions to the prescribed temperature distribution.

(16 marks)

(b) What is a contact resistance? How it is defined? What are its units? How is the contact resistance affected by the roughness of adjoining surfaces?

(4 marks)

3.(a) Consider a composite wall that includes an 8 mm thick hardwood siding, 40 mm by 130 mm hardwood studs on 0.65 m centers with glass fiber insulation (paper – faced, 28 kg/m^3) and a 12 mm layer of gypsum wall board.
What is the thermal resistance associated with a wall that is 2.5 m high by 6.5 m wide (having 10 studs, each 2.5 m high)?
Take: Hardwood siding k=0.094 W/m K, Hardwood k=0.16 W/m K, Gypsum k=0.17 W/m K, Insulation (glass fiber paper faced, 28 kg/m^3) k= 0.038 W/m K.



(17 marks)

(b) What are the forms of Newton's law of cooling for a heat flux and a heat rate?
(3 marks)

4. The Weather Channel reports that it is a hot, muggy day with an air temperature of 90°F, a 10 mph breeze out of the south-west, and bright sunshine with a solar insulation of 400 W/m^2. Consider a wall of a metal building over which the prevailing wind blows. The length of the wall in the wind direction is 10 m, and the emissivity is 0.93. Assume that all the solar irradiation is absorbed, that irradiation from the sky is negligible, and that flow is fully turbulent over the wall. Estimate the average wall temperature.
Take: $\nu = 16.27 \times 10^6$ m^2/s, k = 0.02658 W/m K, $Pr = 0.707$ **(20 marks)**

5. (a) Exhaust gas from the furnace is used to preheat the combustion air supplied to the furnace burners. The gas, which has the flow rate of 15 kg/s and an inlet temperature of 1100 K, passed through a bundle of tubes , while the air , which has a flow rate of 10 kg/s and an inlet temperature of 300 K, is in cross flow over the tubes. The tubes are unfinned, and the overall heat transfer coefficient is 100 W/m^2 K. Determine, using the LMTD and effectiveness-NTU methods, the total tube surface area required to achieve an air outlet temperature of 850 K. The exhaust gas and the air may each be assumed to have a specific heat of 1075 J/kg K.
Take F = 0.73, NTU ≈ 2.3 **(16 marks)**
(b) Why are baffles used in shell-and-tube heat exchanger? **(4 marks)**