NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY
BACHELOR OF ENGINEERING (HONS) DEGREE
Part Two Examination August 2009

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. In a poorly constructed house with single–pane windows construction, proposed that winter heat losses be reduced by covering the windows with a polystyrene insulation ($k_{ins} = 0.027W/mK$) during the evening hours. To estimate the energy savings, consider application of *25 mm* thick insulation panels to *6 mm* thick windows ($k_w = 1.4\ W/mK$).

The contact resistance between the glass and the insulation may be approximated as ($R''_{t.c} = 0.002m^2K/W$), while the convection coefficient at the outer surface of the window is nominally (h_0 = 20 W/m^{2}K). With the insulation, the convection coefficient at the inner surface is $h_i = 2\ W/m^2K$; without the insulation, it is $h_i = 5\ W/m^2K$.

a) What is the percentage reduction in heat loss associated with use of the insulation?
b) If the total surface area of the windows in the home is $A_s = 12m^2$, what are the heat losses associated with insulated and un-insulated windows for interior and exterior air temperatures of $T_{\infty,i}$ = 20°C and $T_{\infty,o}$ = -12°C?
c) If the home is heated by a gas furnace operating at an efficiency of $\eta_f = 0.8$ and a natural gas is priced at $0.01 per MJ, what is the daily savings associated with covering the windows for 12 hours? **(20 marks)**

2. **(a)** Air at a free stream temperature of 20 C is in parallel flow over flat plate of 5m length and temperature 90 C. However, obstacles placed in the flow intensify mixing with increasing distance x from the leading edge, and the spatial variation of temperatures measured in the boundary layer is correlated by an expression of the form T(ºC)=20+70exp(-600xy), where x and y are in meters. Determine and plot the manner in which the local convection coefficient varies with x. Evaluate the average convection coefficient for the plate. **(16 marks)**

(b) What are the physical mechanisms associated with heat transfer by conduction, convection and radiation. **(4 marks)**

3. Consider a rectangular fin that is used to cool a motorcycle engine. The fin is 0.15m long and at a temperature of 250ºC , while the motorcycle is moving at 80 km/h in air at 27ºC . The air is in parallel flow over both surfaces of the fin and turbulent flow conditions may be assumed to exist throughout. What is the rate of heat removal per unit width on the fin? **(20 marks)**

4. Ethylene glycol flows at 0.01 kg/s through a 3mm diameter, thin-walled tube. The tube is coiled and submerged in a well-stirred water bath maintained at 25ºC. If the fluid enters the tube at 85ºC, what heat rate and tube length are required for the fluid to leave at 35ºC? Neglect heat transfer enhancement associated with the cooling. **(20 marks)**

5.

(a) What are the two possible arrangements for a concentric tube heat exchanger? For each arrangement what restrictions are associated with the fluid outlet temperature? **(4 marks)**

(b)A counterflow, concentric tube heat exchanger used for engine cooling has been in service for an extended period of time. The heat transfer surface area of the exchanger is $5m^2$, and *design value* of the overall convection coefficient is $38\ W/m^2K$. During the test run, engine oil flowing at *0.1 kg/s* is cooled from *110°C* to *66 °C* by water supplied at a temperature of *25° C* and a flow rate of *0.2 kg/s*. determine whether fouling has occurred during the service period, if so calculate the fouling factor, $R''_f(m^2K/W)$ **(16 marks)**