Tentamination FTV 2

Friday August 25, 2006

09:00–12:00 / 5118.-152

Mention on the first page:
- Name
- Address
- Student number
- Day of birth
- Study
- Year of registration RuG

And on the following pages:
- Your Name

Question 1:

a) Derive from the expression for the penetration depth that instationary heat transfer at short times can be described by the expression:

$$Nu = 0,57 Fo^{-\frac{1}{2}}$$

b) For longer times the Nusselt number becomes constant. Derive for this situation an expressing for the average temperature of a body as function of time.

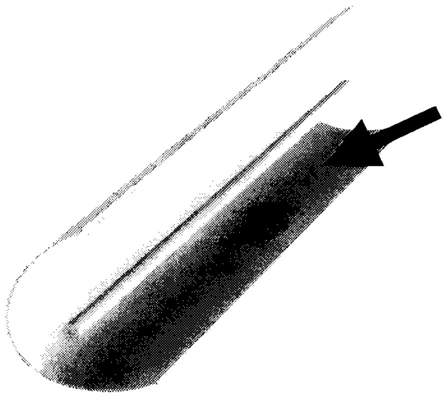
Question 2:

A tube with a diameter of 1,25 cm is placed at the focus of a solar collector. The solar energy received by the tube is $\Phi''_s = 24\ kW/m^2$. Water is heated while it flows through the tube with a velocity of 1 m/s. Ambient temperature and the water temperature at the inlet are both 25°C. The water leaves the solar collector with a temperature of 100 °C.

The energy losses of the tube are due to radiation to the surroundings (at 25 ^{0}C) and free convection of the ambient air.

a. Derive a differential equation for the axial temperature profile in the tube (including all effects).
b. Make an estimation of the relative importance of the heat losses due to radiation and free convection.
c. Determine the length of the tube (and collector) needed for water to reach an exit temperature of 100 °C.
d. How much extra length do you need to obtain steam of 100 °C.

The heat transfer coefficient due to free convection equals 25 W/m^2 K. Find all other relevant quantities yourself and state clearly the values you use.



Question 3:

At a recycle plant an oil is collected that has been polluted with a chlorinated carbohydrate. One wants to remove the pollutant from the oil by extraction with water. The solubility of the pollutant in water is 200 fold its solubility in oil (m=200). For the extraction the oil is dispersed as droplets in the water. The mass transfer inside and outside the droplets occurs only by diffusion.

a. Show that the resistance to mass transfer for long times lies mainly in the oil phase. (Hint: which Sherwood relations can be used outside and inside the droplet?)
b. Show that the same can be concluded for short times. Neglect the curvature of the surface of the droplet.
c. Calculate the time needed to decrease the concentration of the pollutant in the oil phase with a factor of 100. Assume therefore that the concentration in the water phase remains negligible.

Given:

Diffusion coefficient of the pollution in oil: $D_0=2\cdot10^{-10}$ m^2/s

Diffusion coefficient of the pollution in water: $D_w=6\cdot10^{-10}$ m^2/s

Diameter of the oil droplets: $d = 2\cdot10^{-4}$ m