MEEN 461-501 Heat Transfer Fall 2016

Homework 8

Due at the beginning of the class on Tuesday, November 1, 2016

8.27 In the final stages of production, a pharmaceutical is sterilized by heating it from 25 to 75°C as it moves at 0.2 m/s through a straight thin-walled stainless steel tube of 12.7-mm diameter. A uniform heat flux is maintained by an electric resistance heater wrapped around the outer surface of the tube. If the tube is 10 m long, what is the required heat flux? If fluid enters the tube with a fully developed velocity profile and a uniform temperature profile, what is the surface temperature at the tube exit and at a distance of 0.5 m from the entrance? Fluid properties may be approximated as $\rho = 1000\ \text{kg/m}^3$, $c_p = 4000\ \text{J/kg}\cdot\text{K}$, $m = 2 \times 10^{-3}\ \text{kg/s}\cdot\text{m}$, $k = 0.8\ \text{W/m}\cdot\text{K}$, and $Pr = 10$.

8.35 Water flowing at 2 kg/s through a 40-mm-diameter tube is to be heated from 25 to 75°C by maintaining the tube surface temperature at 100°C.

(a) What is the required tube length for these conditions?

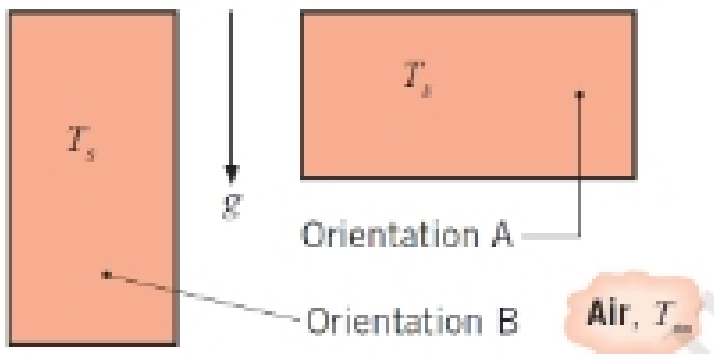
8.52 Air at 200 kPa enters a 2-m-long, thin-walled tube of 25-mm diameter at 150°C and 6 m/s. Steam at 20 bars condenses on the outer surface.

(a) Determine the outlet temperature and pressure drop of the air, as well as the rate of heat transfer to the air.

(b) Calculate the parameters of part (a) if the pressure of the air is doubled.

8.58 Oil at 150°C flows *slowly* through a long, thin-walled pipe of 30-mm inner diameter. The pipe is suspended in a room for which the air temperature is 20°C and the convection coefficient at the outer tube surface is 11 W/m^2·K. Estimate the heat loss per unit length of tube.

9.17 Consider a vertical plate of dimension 0.25 m × 0.50 m that is at $T_s = 100°C$ in a quiescent environment at $T_\infty = 20°C$. In the interest of minimizing heat transfer from the plate, which orientation, (A) or (B), is preferred? What is the convection heat transfer from the front surface of the plate when it is in the preferred orientation?



9.37 An electrical heater in the form of a horizontal disk of 400-mm diameter is used to heat the bottom of a tank filled with engine oil at a temperature of 5°C. Calculate the power required to maintain the heater surface temperature at 70°C.

9.60 A horizontal electrical cable of 25-mm diameter has a heat dissipation rate of 30 W/m. If the ambient air temperature is 27°C, estimate the surface temperature of the cable.