Problem Set # 8

Given: Mon., Nov. 05 **Recommended Completion Date:** Mon., Nov. 12
Do not submit for grading

Problem 1: Air at ambient temperature of 25°C and a velocity of 0.5 m/s flows over a 50 W incandescent bulb whose surface temperature is at 140°C. the bulb may be approximated as a sphere of 50 mm diameter. What is the rate of heat loss by convection to the air?

Ans.: 10.29 W

Problem 2: To enhance heat transfer from a square shape chip of width W = 4 mm on a side, a copper pin fin (k_{copper} = 380 W/m-°C) is brazed to the surface of the chip. The fin length is L = 12 mm and the diameter is D = 2mm. Atmospheric air at U_∞ = 10 m/s; T_∞ = 300 K is in cross flow over the fin. The surface of the chip and the base of the fin are maintained at a temperature of T_{Base} = 350 K.

a) What is the average convection heat transfer coefficient for the surface of the fin?
b) Neglecting radiation heat transfer, what is the fin heat transfer rate?
c) Assuming the same convection coefficient obtained in part (a) for the exposed portion of the chip surface, determine the total rate of heat transfer from the chip.

Ans.: (a) h = 223.3 W/m^2-°C; (b) 0.826 W; (c) $q_{\substack{total \\ chip}}$ = 0.97 W.

Problem 3: Water at an inlet temperature (bulk temperature) of 10°C is pumped at the rate of 5 kg/s through a horizontal metal pipe (k_{pipe} = 25 W/m-°C) of inside diameter D_i = 0.05 m, outside diameter D_o = 0.06 m, and a total length L = 10 m. The inside surface of the tube may be assumed smooth. Saturated steam at T_{sat} = 125°C condenses on the outside surface of the pipe: $h_{outside}$ = 25000 W/m^2-°C. the latent heat of condensation of the steam at 125°C is $h_{fg} = 2.2 \times 10^6$ J/kg. The properties of the water may be assumed constant at the following values:

ρ = 1000 kg/m^3; c_p = 4180 J/kg-°C; $\mu = 1.2\times 10^{-3}$ kg/m-s; k = 0.585 W/m-°C

a) Calculate the rate of condensation of the steam.
b) What is the total pressure drop in the pipe?

Ans.: *(a)* 0.20425 kg/s ; *(b)* 1.15×10^4 Pa

Problem 4: Consider fully developed fluid flow and heat transfer in a duct of non-circular cross section and unknown roughness.
Duct geometry: Perimeter of cross section = 0.08 m; Cross sectional area = 5×10^{-4} m^2. Total length of the duct = 2 m.
Flow and heat transfer: u_{av} = 8 m/s; T_w = 200°C; T_{b1} = 20°C; T_{b2} = 160°C
Fluid properties: ρ = 1 kg/m^3; c_p = 1000 J/kg-°C; $\mu = 2\times 10^{-5}$ kg/m-s; k = 0.025 W/m-°C

a) Find the average heat transfer coefficient; b) What is the total pressure drop in the pipe?

Ans.: (a) 37.6 W/m^2°C; (b) 82.94 Pa (N/m^2)

Selected Problems from the Textbook: Please do the following problems
6th Edition: **8.25, 8.84 or 7th Edition**: **8.29, 8.90**