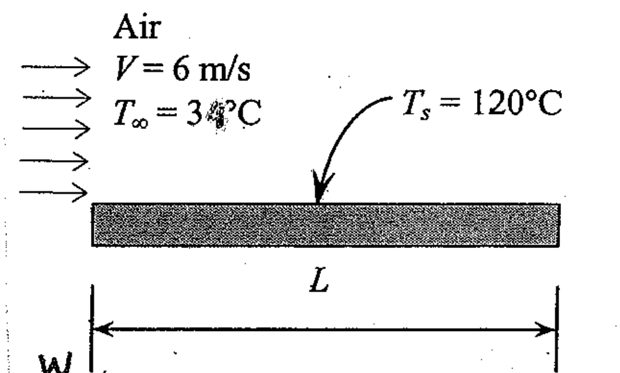
1. The top surface of a hot block 8 m long and 2.5 m wide with a surface temperature $T_s = 120°C$ is to be cooled by forced air at 6 m/sec and 34°C. Assume an atmospheric pressure of 1 atm, a critical Reynold's number of 5×10^5, and steady convective heat transfer, and determine a) the convective heat transfer coefficient h, and b) the heat transfer from the block in kw.



$$T_{avg} = \frac{120 + 34}{2} = 77°C$$

$$= 350°K$$

From A-19, p 876

$\rho = 1.009\ kg/m^3$ $\quad k = .0297\ W/m°C$

$\nu = 2.06 \times 10^{-5}\ m^2/sec$ $\quad P_r = 0.706$

$$Re_L = \frac{VL}{\nu} = \frac{6(8)}{2.06 \times 10^{-5}} = 2.33 \times 10^6$$

Turbulent at x = L

$$N_u = (.037\,Re_L^{.8} - 871)\,P_r^{\frac{1}{3}} = 3314 = \frac{hL}{k}$$

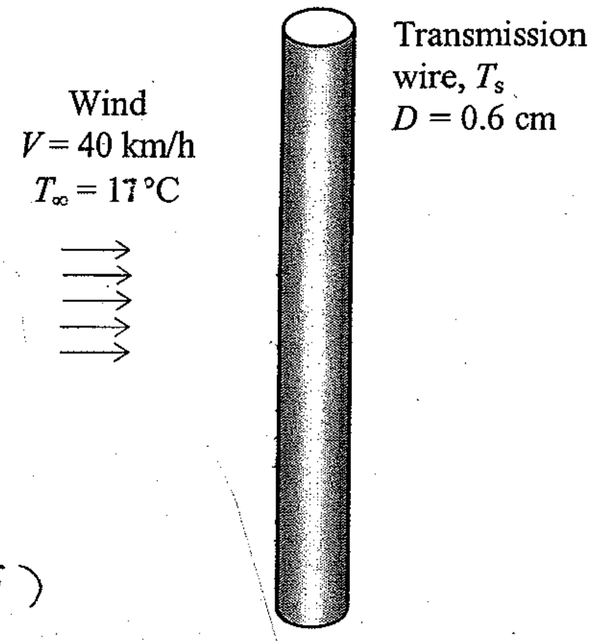
$$h = \frac{.0297}{8}(3314) = 12.3\ W/m^2\,°K$$

$$A_s = 2.5 \times 8 = 20\ m^2$$

$$\dot{Q} = hA_s(T_s - T_\infty) = (12.3)(20)(120 - 34) = 21,163\ W$$

$$= 21.16\ Kw$$

2. Wind at 17°C is blowing directly across a 0.6 cm diameter wire of a transmission line at 40 km/hr. The rate of heat generated in the electrical line is 5.0 W/m. Neglect radiation effects and determine a) the convective heat transfer coefficient h, and b) the steady state surface temperature of the wire T_s. Use a temperature of 17°C to determine the properties of air.



At 17°C = 290°K

From A-19, 874

$\rho = 1.224 \ kg/m^3$

$k = .0253 \ W/m\,°C$

$\nu = 1.48 \times 10^{-5} \ m^2/sec$

$P_r = .714$

$$Re_D = \frac{VD}{\nu} = \frac{40(1000)(.006)}{3600(1.48 \times 10^{-5})}$$

$$= 4504$$

From Eq 10-38 $\quad N_u = 0.193\, Re^{.618}\, P_r^{\frac{1}{3}} = 31.25$

$$h = \frac{.0253}{.006}(31.25) = 131.7 \ \frac{W}{m^2\,°C}$$

$A = .006(\pi) \ m^{-1}$

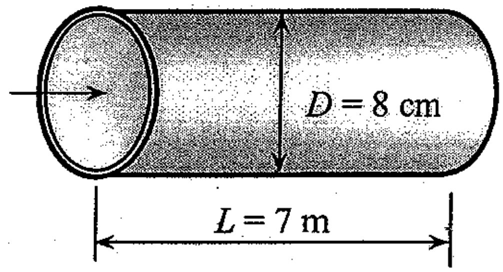
$$\dot{W} = 5 \frac{W}{m} = (131.7)(.006)\pi(T_s - 17)$$

$T_s = 19.01°C$

3. Water at a temperature of 25°C and an average velocity of 2 m/sec enters and flows through an 8 cm diameter pipe that is 7 m long. The water leaves the pipe at 69°C. The inner surfaces of the pipe are smooth, and the flow is steady. Use the Colburn equation to determine a) the convective heat transfer coefficient, and b) the heat rate that is received by the water over the 7 meter length. Use the average bulk temperature for the properties of the water.

$$T_b = \frac{25+69}{2} = 47^\circ$$

$$= 320^\circ K$$



From Table A-18, 873

$\rho = 989\ kg/m^3 \quad c_p = 4176\ J/kg^\circ C$

$k = .637\ W/m^\circ C \quad \nu = .59\times10^{-6}\ m^2/sec \quad P_r = 3.79$

$$Re_D = \frac{VD}{\nu} = \frac{2(.08)}{.59\times10^{-6}} = 271{,}186 \quad \text{Turbulent Flow}$$

$$A = \frac{\pi(.08)^2}{4} = .005\ m$$

$$L_t = 10D = 10(.08) = .8\ m$$

$$\dot{Q} = \dot{m}c_p(T_e - T_i) = \rho\left(\frac{\pi D^2}{4}\right)V_{avg}\,c_p(T_e - T_i)$$

$$= \frac{989}{4}(\pi)(.08)^2(2)(4176)(69-25)$$

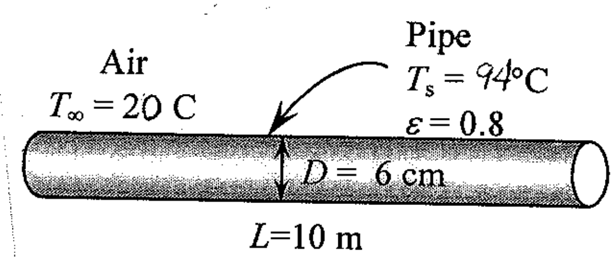
$$= 1.827\times10^6\ W = 1827\ kW$$

From Eq 10-75, 546 or Eq 10-76 (for $n = 0.4$)

$$N_u = .023\,Re_D^{.8}P_r^{n} = 796.53\ (n=\tfrac{1}{3}) \quad 870\ (n=.4)$$

$$h = \frac{.637}{.08}(796.53) = 6342\ W/m^2{}^\circ C \quad 6932\ (n=.4)$$

4. A horizontal 6 cm diameter pipe, 10 m long with a constant surface temperature of $T_s = 94°C$ passes through a large room that has an air temperature of 20°C. In addition to convection, the pipe surface has radiation exchange with the environment where $\varepsilon = 0.8$. Determine the rate of heat loss from the pipe by a combination of natural convection and radiation.



$$T_{avg} = \frac{94 + 20}{2} = 57°C$$

$$= 330 °K$$

From A-19, $\rho = 1.076 \; kg/m^3$

$k = .0283 \; W/m°C$

$\nu = 1.86 \times 10^{-5} \; m^2/sec$

$P_r = 0.708$

$g = 9.81 \; m/sec^2$

$\beta = \frac{1}{330°K} = .003 \; °K^{-1}$

$D = .06 \; m$

$$R_a = \frac{g\beta (T_s - T_\infty) D^3 P_r}{\nu^2} = .972 \times 10^6$$

Eq 11.15

$$N_u = \left\{ 0.6 + \frac{.387 \, R_a^{1/6}}{\left[1 + \left(\frac{.559}{P_r} \right)^{9/16} \right]^{8/27}} \right\}^2 = 14.42$$

$$h = \frac{.0283}{.06}(14.42) = 6.8 \; \frac{W}{m°C}$$

$$A_s = 10(.06)\pi$$

$$= 1.885 \; m^2$$

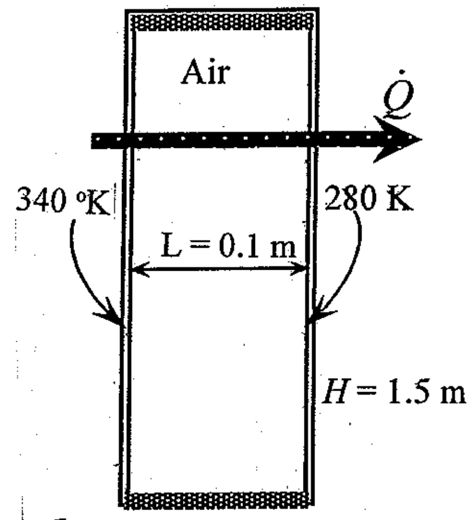
$$\dot{Q}_{conv} = 6.8(1.885)(94-20) = 949 \; W$$

$$\dot{Q}_{rad} = \varepsilon A \sigma (T_s^4 - T_\infty^4) = 0.8(1.885)(5.67 \times 10^{-8})(367^4 - 293^4)$$

$$= 920.96 \; W$$

$$\dot{Q}_{total} = \dot{Q}_{conv} + \dot{Q}_{rad} = 1870 \; W$$

5. The glass panes in a double-pane window (1.5 m high and 3 m wide) are maintained at 340°K and 280°K, respectively as shown. The enclosure is 0.1 m wide and is filled with air at 1 atmosphere. Neglect the thickness and effects of the glass panes and for steady state heat transfer, determine the convective heat transfer coefficient for transfer between the two panes.



$$T_{avg} = \frac{340 + 280}{2} = 310^\circ K$$

$$\rho = 1.143 \ Kg/m^3 \qquad k = .0268 \ \frac{W}{m\,^\circ C}$$

$$\nu = 1.67 \times 10^{-5} \ m^2/sec \qquad P_r = .711$$

$$R_a = \frac{g\beta (T_1 - T_2)\,\delta^3}{\nu^2} P_r = 4.84 \times 10^6$$

$$\frac{H}{L} = \frac{1.5}{0.1} = 15 \qquad A = (1.5)(3) = 4.5 m^2$$

$$N_u = 0.073 (4.84 \times 10^6)^{\frac{1}{3}} \left(\frac{H}{L}\right)^{-\frac{1}{9}} = 9.14$$

$$h = \frac{.0268}{.1} (9.14) = 2.45 \ W/m\,^\circ C$$