Hw 4.2 Ch.12: 5, 14, 26, 33

12.5) Given: $T_i = 25^\circ C$ $V_n = 1.5 m/s$

$D_i = 1.34 cm$ $D_o = 1.58 cm$ $K = 110 w/m.c$

$h_o = 12,000 (w/m^2 c)$

Find: $V_o = ?$

solution: $V_o = \frac{1}{(D_o/D_i)(1/h_i) + (D_o/2K)\cdot \ln(D_o/D_i) + 1/h_o}$

$V_o = \frac{1}{(.0158m/.0134m)(1/5070\ w/m^2c) + (.0134m/2 \cdot 110 w/mc)\ln\frac{.0158m}{.0134m} + \frac{1}{(12,000\ w/m^2 c)}}$

$V_o = \frac{1}{(1.18)(.0001972) + (.0006609)(.165) + .0000833}$

$Re = \frac{V_n D}{\nu} = \frac{(1.5 m/s)(.0134m)}{(1.046 \times 10^{-6} m^2/s)}$ → table B.1 and $Pr = 7.02$

$Re = 19980$

$Nu = .023 Re^{.8} Pr^{.3}$

$Nu = .023(19980)^{.8}(7.02)^{.3}$

$Nu = 113.8$

$h_i = Nu \cdot \frac{K}{D_i} = 113.8 \frac{.597 (w/m.K)}{.0134m}$

$h_i = 5070 w/m^2 c)$

$V_o = \frac{1}{.000233 + .0000394 + .0000833}$

$V_o = 3064 \ w/m^2 c$

(12.19) Given: $T_i = 85°C$ $v = .15\ m/s$ $K_{copper} = 386\ w/m\cdot°$

$D = 2.5cm$ ID $T_\infty = 15°C$

Find: $U_o = ?$

$Q = ?$

Solution: water at $T_i = 80°C$

$\nu = .364 \times 10^{-6} m^2/s$

$k = .668\ w/(m\cdot°C)$ $Pr = 2.22$

$$Re = \frac{vD}{\nu} = \frac{(.15 m/s)(.015 m)}{.364 \times 10^{-6} m^2/s}$$

$$Re = 41,760$$

$$N_u = .023 Re^{.8} Pr^{.3} = .023 (41,760)^{.8} (2.22)^{.3}$$

$$N_u = 145.3$$

$$h_i = N_u \frac{k}{D_i} = 145.3 \frac{.668 (w/m\cdot°C)}{.015 m} = 6470.7\ w/(m^2\cdot°C)$$

$h_o = 5\ w/(m^2\cdot°C)$ from table 12 p.25

$$U = \frac{1}{1/h_i + 1/h_o} = \frac{1}{\frac{1}{6470.7} + \frac{1}{5}}$$

$$U = 4.99\ w/(m^2\cdot°C)$$

$$Q = \pi D L U (T_i - T_\infty)$$

$$= \pi (.023 m)(4.99\ w/m^2\cdot°C)(80°C - 15°C)$$

$$Q = 25.5\ w/m$$

12.26) Given: $T_{c,in} = 25°C$ $\dot{m}_c = 1\ kg/s$

$T_{h,in} = 200°C$ $\dot{m}_h = 2\ kg/s$

$A = 30\ m^2$ $U_m = 120\ W/m^2°C$ $C_{p,h} = 1100\ J/(kg·°C)$

Find: $Q = ?$ $T_{h,out} = ?$

$T_{c,out} = ?$

Solution:

$$C_h = \dot{m}_h C_{p_h} = (2\ kg/s)(1100\ J/(kg·°C)) = 2200\ W/°C$$

$$C_c = \dot{m}_c C_{p_c} = (1\ kg/s)(1100\ J/(kg·°C)) = 1100\ W/°C$$

$$\frac{C_{min}}{C_{max}} = \frac{1100}{2200} = .5$$

$$NTU = \frac{A U_m}{C_{min}} = \frac{(30\ m^2)(120\ W/m^2°C)}{1100\ W/°C} = 3.27$$

$\varepsilon = .81$ from fig 12.15

$$Q = \varepsilon C_{min}(T_{h,in} - T_{c,in})$$

$$Q = (.81)(1100)(200 - 25)$$

$Q = 155925\ W$ or $155.9\ kW$

$$Q = \dot{m}_h C_{p_h}(T_{h,in} - T_{h,out})$$

$$155925 = (2\ kg/s)(1100\ J/(kg·°C))(200°C - T_{h,out})$$

$$\frac{155925}{2200} = \frac{2200(200 - T_{h,out})}{2200}$$

$$70.875 = 200 - T_{h,out}$$

$-200 \quad -200$

$T_{h,out} = 129.1°C$

$$Q = \dot{m}_c C_{p_c}(T_{c,out} - T_{c,in})$$

$$155925 = (1\ kg/s)(1100\ J/(kg·°C))(T_{c,out} - 25°C)$$

$$\frac{155925}{1100} = \frac{1100(T_{c,out} - 25°C)}{1100}$$

$141.75 = T_{c,out} - 25°C$

$+25°C \quad +25°C$

$T_{c,out} = 166.75°C$

12.53) Given: $T_{c,in} = 15°C$ $\dot{m}_c = 2\ kg/s$ $C_p\ [2600\ J/kg \cdot C]$

$T_{h,in} = 85°C$ $\dot{m}_h = 1\ kg/s$ $U_m = 500\ W/m^2 \cdot C$

$A = 10m^2$

Find: $Q = ?$, $T_{h,out} = ?$, $T_{c,out} = ?$

Solution;

$$C_h = \dot{m}_h C_p = (1\ kg/s)(2600\ J/kg \cdot C) = 2600\ W/C$$

$$C_c = \dot{m}_c C_p = (2\ kg/s)(2600\ J/kg \cdot C) = 5200\ W/C$$

$$\frac{C_{min}}{C_{max}} = \frac{2600}{5200} = .5$$

$$NTU = \frac{AU_m}{C_{min}} = \frac{(10m^2)(500\ W/m^2 C)}{2600\ W/C} = 1.92$$

$\varepsilon = .7$ from Eq 12.16

$$\varepsilon = \frac{Q}{C_{min}(T_{h,in} - T_{c,in})}$$

$$.7 = \frac{Q}{(2600)(85°C - 15°C)}$$

$$.7 = \frac{Q}{182000}$$

$$Q = 127{,}400\ W$$

- ethylene

$$Q = \dot{m}_h C_{ph}(T_{h,in} - T_{h,out})$$

$$127{,}400\ W = (1\ kg/s)(2600\ J/kg \cdot C)(85°C - T_{h,out})$$

$$49 = 85°C - T_{h,out}$$

$$T_{h,out} = 36°C$$

- water

$$Q = \dot{m}_c C_p (T_{c,out} - T_{c,in})$$

$$127{,}400\ W = (2\ kg/s)(2600\ J/kg C)(T_{c,out} - 15°C)$$

$$24.5 = T_{c,out} - 15°C$$

$$T_{c,out} = 39.5°C$$