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Quiz 7

$T_{m,i} = 350 \text{ K}$

$T_{m,o} = 345 \text{ K}$

$\dot{m} = 160 \frac{\text{kg}}{\text{s}}$

$T_{\text{wall}} = 290 \text{ K}$

$T_m = \frac{T_i + T_o}{2} = 347.5$

Properties at 347.5 K

$\mu = 4. \times 10^{-2} \frac{\text{Ns}}{\text{m}^2}$

$k = 138 \times 10^{-3} \frac{\text{W}}{\text{m} \cdot \text{K}}$

$Pr \approx 600$

$C_p = 2090 \frac{\text{J}}{\text{kg} \cdot \text{K}}$

$Re = \frac{4\dot{m}}{\pi D \mu} = \frac{4(160 \frac{\text{kg}}{\text{s}})}{\pi (0.5 \text{ m}) (0.04 \frac{\text{Ns}}{\text{m}^2})} = 10,186$

$(8.61) \quad Nu_D = 0.027 Re_D^{1/5} Pr^{1/3} \left(\frac{\mu}{\mu_s}\right)^{0.14}$

$Nu_D = 283$

$\mu_s = 99.9 \times 10^{-2} \frac{\text{Ns}}{\text{m}^2}$

$h = \frac{Nu_D k}{D} = 64.4 \frac{\text{W}}{\text{m}^2 \cdot \text{K}}$

$\dot{Q}_{TO} = \dot{m} C_p (T_{m,o} - T_{m,i}) \rightarrow = (160 \frac{\text{kg}}{\text{s}}) (2090 \frac{\text{J}}{\text{kg} \cdot \text{K}}) (350 - 345) \text{ K} = 1.67 \times 10^6 \text{ W}$

$\dot{Q}_{HT} = h A \Delta T_{\text{Lm}}$

$\Delta T_{\text{Lm}} = 57.46 \text{ K}$

$1.67 \times 10^6 \text{ W} = (64.4 \frac{\text{W}}{\text{m}^2 \cdot \text{K}}) A (57.46) \text{ K} \rightarrow A = 451.3 \text{ m}^2$

$L = \frac{A}{\pi D} = \frac{451.3}{\pi \cdot 0.5} = 287.3 \text{ m}$

$$C_h = \dot{m}_h C_p = (160 \frac{\text{kg}}{\text{s}}) (2090 \frac{\text{J}}{\text{kg} \cdot \text{K}}) = 334,000 \frac{\text{W}}{^\circ\text{C}}$$

$$C_c = \infty$$

$$C_r = \frac{C_{\min}}{C_{\max}} = 0$$

$$q_{\max} = C_{\min} (T_{h,i} - T_{c,i}) \rightarrow (334,000 \frac{\text{W}}{^\circ\text{C}}) (350 - 290) \text{K} = 2.004 \times 10^7 \text{ W}$$

$$E = \frac{q}{q_{\max}}$$

$$q = \dot{m} C_p (T_{h,i} - T_{h,e}) = 1.67 \times 10^6 \text{ W}$$

$$E = \frac{1.67 \times 10^6}{2.004 \times 10^7} = 0.0835$$

$$(11.35) \quad NTU = -\ln(1-E) \rightarrow -\ln(1-0.0835) \rightarrow NTU = 0.087$$

$$NTU = \frac{UA}{C_{\min}} \rightarrow \frac{hA}{C_{\min}} = 0.087 \rightarrow A = \frac{(0.087) C_{\min}}{h}$$

$$R_{\text{tot}} = \left(\frac{1}{h_h} + \frac{1}{h_c} \right) \frac{1}{A}$$

high

$$A = \frac{(0.087) (334,000 \frac{\text{W}}{^\circ\text{C}})}{64.4 \frac{\text{W}}{\text{m}^2 \cdot ^\circ\text{C}}} = 450 \text{ m}^2$$

$$L = \frac{A}{\pi D} = \frac{450 \text{ m}^2}{\pi (5 \text{ m})} = \boxed{286.5 \text{ m}}$$