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Find $T_{c,o}$, Length per tube.

Example 11.5

# of tubes = 30,000 $\quad d = 0.025\,m$

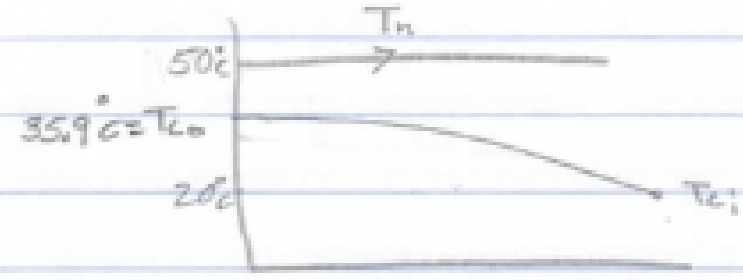
$h_o = 11{,}000 \frac{W}{m^2 C}$

$q = 2 \times 10^9\,W$

$\dot{m}_c = 3 \times 10^4 \frac{kg}{s}$

$T_{c,i} = 20^\circ C$

$T_{h,i} = 50^\circ C$



$T_{c\,average} = 27^\circ C = 300K$

$C_r = 0$

$C_h = \infty$

$h_{fg\,@323} \approx 2384 \frac{kJ}{kg}$

$C_c = (3 \times 10^4 \frac{kg}{s})(4{,}200 \frac{J}{kg\,C}) = 1.26 \times 10^8 \frac{kJ}{^\circ C}$

$q = \dot{m}_c C_c (T_{c,o} - T_{c,i}) \rightarrow 2 \times 10^9 W = (3 \times 10^4 \frac{kg}{s})(4{,}200 \frac{J}{kg\,C})(T_{c,o} - 25^\circ C)$

$T_{c,o} = 35.9^\circ C$

$UA = \frac{1}{R_{total}} \rightarrow R_{tot} = \frac{1}{h_c A_c} + \frac{1}{h_h A_h} = (\frac{1}{h_c} + \frac{1}{h_h}) \frac{1}{\pi D L}$

$\rightarrow \underline{?}\ \frac{m^2 C}{W} \frac{1}{L}$

— Chapter 8 to get h_c

$Re_D = \frac{4\dot{m}}{\pi D \mu} = 59{,}567$

(eqn 8.60) $Nu_D \cong .023\, Re_D^{4/5} Pr^{.4} \rightarrow Nu_D = 307$

$h_c = \frac{Nu\,k}{D} \rightarrow \frac{(307)(.613 \frac{W}{mC})}{.025m} = 7527 \frac{W}{m^2 C}$

$U = (\frac{1}{h_c} + \frac{1}{h_h}) = (\frac{1}{7527}) + (\frac{1}{11{,}000}) \rightarrow 4469 \frac{W}{m^2 C}$

$UA = 4469\,\pi(.025)L \rightarrow UA = 351 \frac{W}{m^2 C} L$

or

$UA = .00286 \frac{m^2 C}{W} \frac{1}{L}$

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

$q_{max} = C_{min}(T_{h,i} - T_{ki}) = 12.6 \times 10^8 \frac{W}{C}(50^\circ C - 20^\circ C) = 3.78 \times 10^9\,W$

$\varepsilon = \frac{2 \times 10^9}{3.78 \times 10^9} = 0.529$