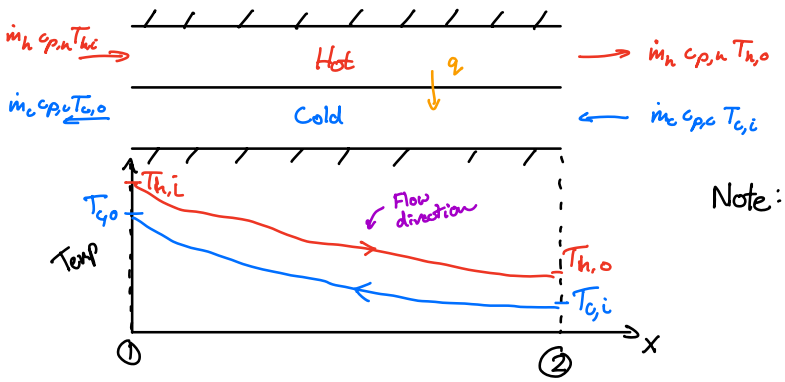
13A - 2ND CLASS

Counterflow HX



Note: $T_{c,o}$ can be greater than $T_{h,o}$

Analysis:

$$q = \dot{m}_h c_{p,h} (T_{h,i} - T_{h,o})$$

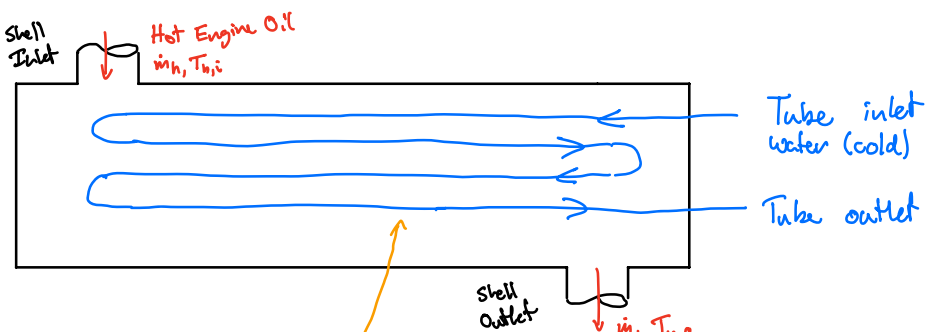
$$q = \dot{m}_c c_{p,c} (T_{c,o} - T_{c,i})$$

$$q = UA \Delta T_{lm} \qquad \Delta T_{lm} = \frac{\Delta T_2 - \Delta T_1}{\ln(\Delta T_2 / \Delta T_1)}$$

$$\Delta T_2 = T_{h,o} - T_{c,i}$$

$$\Delta T_1 = T_{h,i} - T_{c,o}$$

see Table 11.3 for $\varepsilon = f(NTU, C_r)$



N = number of brass tubes = 11 — there are 11 tubes along tube path

1 shell pass
4 tube pass

Engine Oil

$T_{h,i} = 160°C$

$T_{h,o} = 94°C$

Water

$\dot{m}_c = 10{,}000\ kg/hr$

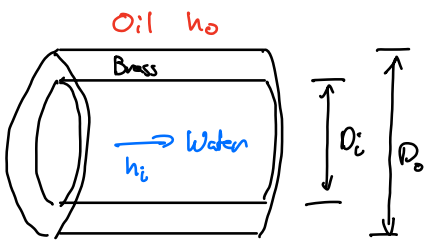
$T_{c,i} = 16°C$

$T_{c,o} = 84°C$

$N = 11$ ← Number of brass tubes

$D_i = 22.9\ mm$, $D_o = 25.4\ mm$ } Dimensions of brass tubes

$h_o = 400\ \frac{W}{m^2 K}$



1. Number of mass transfer units (NTU)?

$NTU = ?$

$NTU = \frac{UA}{C_{min}}$ ⟶ Table 11.4 ⟶ $NTU = -(1+C_r^2)^{-1/2} \ln\left(\frac{E-1}{E+1}\right)$ for 1 shell pass (2, 4, ..., tube passes)

$E = \frac{\frac{2}{\varepsilon} - (1+C_r)}{(1+C_r^2)^{1/2}}$

$C_r = \frac{C_{min}}{C_{max}}$ $\quad \varepsilon = \frac{q}{q_{conv}}$

heat capacity rate

$C \equiv \dot{m}\, c_p$

$C_c = \dot{m}_c\, c_{p,c}$ ⟶ Evaluate water at $\overline{T_c} = \frac{T_{c,i} + T_{c,o}}{2} = 50°C$

⇒ Table A-6 @ 323 °K, Interpolate:

specific volume → $v_f = 1.0122 \times 10^{-3}\ m^3/kg$ → $\rho_f = \frac{1}{v_f}$

$k_w = 0.643\ \frac{W}{m\text{-}K}$

$c_p = 4181.2\ \frac{J}{kg\text{-}K}$

$\mu = 5.476 \times 10^{-4}\ kg/m\text{-}s$

$Pr = 3.56$

So, $C_c = 11,614.4 \ W/K$

Recall,

$$q = C_c (T_{c,o} - T_{c,i}) = 7.898 \times 10^5 \ W$$

$$q = C_h (T_{h,i} - T_{h,o})$$

$$C_h = \frac{q}{T_{h,i} - T_{h,o}} \approx 11,966.4 \ W/K$$

$C_{min} = C_c$

$$C_r = \frac{C_{min}}{C_{max}} = 0.971$$

$$\varepsilon = \frac{q}{q_{max}} = \frac{q}{C_{min}(T_{h,i} - T_{c,i})}$$

$\varepsilon = 0.472$

$E = \cdots = 1.625$

$NTU = \cdots = 1.03$

2. Find the U based on area A_o