Plane wall - multi layers

\[ T_1 \quad T_2, T_2 \]

\[ \frac{L_B}{k_B A_B}, T_2 \]

Overall heat transfer coefficient (Conductive)

\[
\frac{U A}{\pi} = \frac{U A \pi (T_1 - T_2)}{\pi} = \frac{T_1 - T_2}{R_1 + \frac{1}{R_A} + \frac{1}{R_{eq}} + \frac{1}{R_2}}
\]

\[ R_{eq} = \frac{1}{\frac{1}{R_B} + \frac{1}{R_C}} = \frac{R_B R_C}{R_B + R_C} \]

For parallel, easier to combine the conductances, rather than resistances
\[ A_c + A_B = A_A \]

\[ \frac{1}{h_{AB}} + \frac{L_A}{A_B} k_A \frac{L_B}{A_B} k_B + \frac{1}{R_2 A_B} \]

\[ Q_1 = \sum R_{in} \]

\[ Q_{eq_2} = \frac{1}{n_A c} + \frac{L_A}{A_c} k_A + \frac{L_B}{A_c} k_B + \frac{1}{R_2 A_c} \]

\[ Q_1 = \frac{(T_1 - T_2)}{\sum R_{in}} = \frac{T_1 - T_2}{Q_{eq_1}} \]

\[ Q_2 = (T_1 - T_2) U_2 A_c \]

\[ Q_{all} = Q_1 + Q_2 = (T_1 - T_2) (U_1 A_B + U_2 A_c) \]

**Acid Exchangers.**

**Simple Tube-in-tube Exchanger.**

\[ \text{Diagram of equipment} \]
Parallel flow - both fluids flow in same direction

Counter flow - fluid s flow in opposite directions

For parallel flow, there is a limiting temperature for Texit: $T_{ci} < Texit < Thi$

For counter flow, possible for one fluid to reach the inlet temperature of the other fluid.

$Q_{net} = -Q_{cold}$

$m_a \cdot C_{pa} \cdot (Th_i - Th_o) = m_c \cdot C_{pc} \cdot (T_{co} - T_{ci})$

$C_{ly} \cdot (Th_i - Th_o) = C_{lc} \cdot (T_{co} - T_{ci})$

The fluid that can attain the inlet temp of the other is the minimum fluid with $\min(C_{ly}, C_{lc})$.
Heat transfer in exchangers:

Temperature profiles are logarithmic

\[ q = UA \Delta T_{lm} = UA \times LMTD \]

Log Mean Temperature Difference

\[ \Delta T_{lm} = \frac{\Delta T_{\text{one end}} - \Delta T_{\text{other end}}}{\ln\left(\frac{\Delta T_{\text{one end}}}{\Delta T_{\text{other end}}}\right)} \]

\[ LMTD = \frac{(T_{hi} - T_{co}) - (T_{no} - T_{ci})}{\ln\left(\frac{T_{hi} - T_{co}}{T_{no} - T_{ci}}\right)} \]

For not counterflow or parallel flow, use:

\[ q = F_c \times UA \times \Delta T_{lm} \]

\[ \Delta T_{lm} \] depends on exchanger