Overall heat transfer coefficient

Let \( q = UA \Delta T_{\text{overall}} \)

overall heat transfer coefficient

\( A = \text{area for heat flow} \)

Consider plane wall

\[ \frac{1}{h_1 A} \frac{\Delta x_1}{K_1 A} + \frac{1}{h_2 A} \frac{\Delta x_2}{K_2 A} + \ldots + \frac{1}{h_n A} \frac{\Delta x_n}{K_n A} = \frac{1}{h_2 A} \]

So \( q = \frac{T_{\infty 1} - T_{\infty 2}}{R_{\text{conv}1} + R_1 + R_2 + \ldots + R_n + R_{\text{cond}2}} \equiv UA \Delta T_{\text{rev}} \)
So for this case

\[ UA = \sum R_{th} \]

Note "A" same for all terms and cancels out.

Consider cylinder wall.

\[ \frac{1}{T_a} = \frac{1}{T_0} \]

\[ T_a \text{ is wall temp} \]

\[ Q = \frac{T_a - T_0}{R_1 + R_2 + R_{conv}} = UA \Delta T_{overall} \]

Note that "A" must be specified to determine "U" but in any case

\[ UA = \frac{1}{\sum R_{th}} \]

Be careful with parallel paths. E.g. Framed wall construction.

- 2x4" framing
- Gypsum board
- Brick
- Fiberglass batt insulation
Note $A_i = A_{ins} + A_{gr}$.

Resistances in parallel combine like this:

$$\frac{1}{\text{Requiv}} = \frac{1}{\sum_i R_i}$$

For two in parallel:

$$\text{Requiv} = \frac{R_1 R_2}{R_1 + R_2} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1}$$

"Critical thickness of insulation" pertains to radial systems.

Look at heat flow.

To $T_o$,

$$\frac{1}{ln\frac{r_o}{r_i}} = \frac{1}{h_2\tau_{r_2} L}$$
\[ q = \frac{T_i - T_\infty}{R \text{ead} + \text{Reconv}} \]

Note: Read \( \uparrow \) as \( R_0 \uparrow \) (good)

But: Reconv \( \downarrow \) as \( R_0 \uparrow \) (maybe bad)

There is a value of \( R_0 \) for which \( q = \max \)

This is the "critical thickness of insulation" \( R_0 \)

\[ R_{\text{critical}} = \frac{R}{h} \] (not \( R_0 \))

This is the value of \( R_0 \) for which \( q \) is maximum