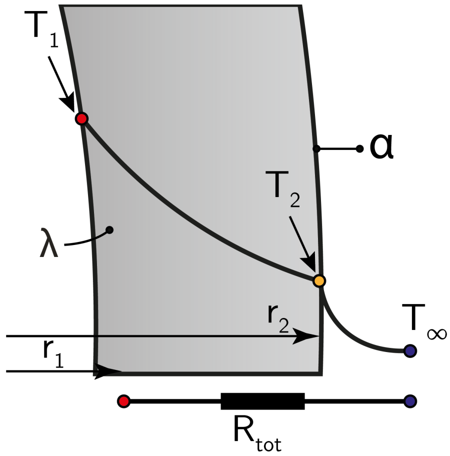
Conduction - Thermal Resistance 06

Define the heat transfer resistance R_{tot} for a tube of length L with the given radii r_1 and r_2:



The standard expression for conductive thermal resistance is:

$$R_{\text{cond}} = \frac{\Delta T_{\text{cond}}}{\dot{Q}_{\text{cond}}}$$

The temperature difference in the conductive layer can be expressed as:

$$\Delta T_{\text{cond}} = T_1 - T_2$$

Where the rate of heat transfer for a plane wall can be stated as follows:

$$\dot{Q}_{\text{cond}} = -\lambda A \frac{\partial T}{\partial r} = \lambda 2\pi \lambda L \frac{T_1 - T_2}{\ln\left(r_2/r_1\right)}$$

Substitution yields:

$$\rightarrow R_{\text{cond}} = \frac{\delta}{\lambda A}$$

The standard expression for convective thermal resistance is:

$$R_{\text{conv}} = \frac{\Delta T_{\text{conv}}}{\dot{Q}_{\text{conv}}}$$

The temperature difference can be expressed as:

$$\Delta T_{\text{conv}} = T_2 - T_\infty$$

Where the rate of heat transfer for a plane wall can be stated as follows:

$$\dot{Q}_{\text{conv}} = \alpha A \left(T_2 - T_\infty\right) = \alpha 2\pi r_2 L \left(T_2 - T_\infty\right)$$

Substitution yields:

$$\rightarrow R_{\text{conv}} = \frac{1}{2\pi r_2 L \alpha}$$

The expression for the total thermal resistance yields:

$$\rightarrow R_{\text{tot}} = \sum R = R_{\text{cond}} + R_{\text{conv}} = \frac{1}{2\pi L \lambda} \ln\left(r_2/r_1\right) + \frac{1}{2\pi r_2 L \alpha}$$