ME-318 Engineering Heat Transfer

Chapter 3 (Part 1)

What you should learn:

- How to construct a thermal analog to an electrical network and quantify the thermal *resistance* of a medium
- To recognize and solve one-dimensional, steady state heat conduction problems in planar and radial systems
- How to quantify conductive and convective network resistances in planar and radial systems

Important Concepts & Equations

- Conductive Thermal Resistance: $R = \dfrac{L}{kA}$
- Convective Thermal Resistance: $R = \dfrac{1}{hA}$
- Series Effective Resistance: $R_{eff} = R_1 + R_2 + ... + R_N$
- Parallel Effective Resistance: $\dfrac{1}{R_{eff}} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + ... + \dfrac{1}{R_N}$
- Cylindrical Systems:
    - Heat Equation: $\dfrac{1}{r}\dfrac{d}{dr}\left(kr\dfrac{dT}{dr}\right) = 0$
    - Temperature Distribution: $T(r) = T_0 + \dfrac{(T_i - T_0)}{\ln\left(\dfrac{r_i}{r_0}\right)}\ln\left(\dfrac{r}{r_0}\right)$

Adapted from V. Prantil

- Heat Flow Rate: $$q = \frac{2\pi k L (T_i - T_0)}{\ln\left(\frac{r_0}{r_i}\right)}$$

- Conductive Resistance: $$R_{cyl} = \frac{\ln\left(\frac{r_0}{r_i}\right)}{2\pi k L}$$

- Spherical Systems:

  - Heat Equation: $$\frac{1}{r^2}\frac{d}{dr}\left(kr^2\frac{dT}{dr}\right) = 0$$

  - Temperature Distribution: $$T(r) = T_0 + \frac{(T_i - T_0)}{\left(\frac{1}{r_0} - \frac{1}{r_i}\right)}\left(\frac{1}{r_0} - \frac{1}{r}\right)$$

  - Heat Flow Rate: $$q = \frac{4\pi k (T_i - T_0)}{\left(\frac{1}{r_i} - \frac{1}{r_0}\right)}$$

  - Conductive Resistance: $$R_{cyl} = \frac{\left(\frac{1}{r_i} - \frac{1}{r_0}\right)}{4\pi k}$$

- Contact thermal resistance $$R''_{t,c} = \frac{T_A - T_B}{q''_x}$$