Question 1: What is the measured Temperature of the inshielded TC?

Given Parameters:

$\varepsilon_t := 0.9$ $\quad T_{air} := 5\,°C = 278.15K$ $\quad R_t := 0.5mm$

$\sigma := 5.67 \cdot 10^{-8} \frac{W}{m^2 \cdot K^4}$ $\quad T_{wall} := -10\,°C = -283.15K$

$h_f := 10 \cdot \frac{W}{m^2 K}$

Initial Calculations:

$A_t := 4 \cdot \pi \cdot R_t$

$\therefore\ A_t = 6.283 \times 10^{-3}\,m$

Heat transfer Calcs:

Guess

$T_t := 2\,°C$

Given

$h_f \cdot A_t \cdot (T_{air} - T_t) = \sigma \cdot \varepsilon_t \cdot A_t \cdot (T_t^{\,4} - T_{wall}^{\,4})$

Solution

$T_t := \text{Find}(T_t) = 279.714K$

$err_t := T_t - T_{air} = 1.564K$

Question 2: With shielding?

Additional Parameters:

$R_s := 1mm$ $\quad \varepsilon_s := 0.9$

Initial Calcs:

$A_s := 4 \cdot \pi \cdot R_s^{\,2}$

$$A_s = 1.257 \times 10^{-5}\,m^2$$

Guess

$T_{t2} := 6\,°C = 279.15\,K$

$T_s := T_{t2} = 279.15\,K$

Given

$$\frac{\sigma \cdot A_t \cdot \varepsilon_t \cdot \left(T_{t2}^{\,4} - T_s^{\,4}\right)}{\frac{1}{\varepsilon_t} + \frac{1-\varepsilon_s}{\varepsilon_s}\left(\frac{R_t}{R_s}\right)^2} = h_f \cdot A_t \left(T_{air} - T_{t2}\right)$$

$$\frac{\sigma \cdot A_t \varepsilon_t \cdot \left(T_{t2}^{\,4} - T_s^{\,4}\right)}{\frac{1}{\varepsilon_t} + \frac{1-\varepsilon_s}{\varepsilon_s}\left(\frac{R_t}{R_s}\right)^2} + 2 \cdot h_f \cdot A_s \cdot \left(T_{air} - T_s\right) = \sigma \cdot \varepsilon_s \cdot A_s \left(T_s^{\,4} - T_{wall}^{\,4}\right)$$

Solution

$$\begin{pmatrix} T_{t2} \\ T_s \end{pmatrix} := \text{Find}\left(T_{t2}, T_s\right) =$$

Question 3: With differentshielding?

Additional Parameters:

$\varepsilon_{s2} := 0.1$

Guess

$T_{t2} := 6\,°C = 279.15\,K$

$T_s := T_{t2} = 279.15\,K$

Given

$$\frac{\sigma \cdot A_t \cdot \varepsilon_t \cdot \left({T_{t2}}^4 - {T_s}^4 \right)}{\frac{1}{\varepsilon_t} + \frac{1 - \varepsilon_s}{\varepsilon_s} \left(\frac{R_t}{R_s} \right)^2} = h_f \cdot A_t \left(T_{air} - T_{t2} \right)$$

$$\frac{\sigma \cdot A_t \varepsilon_t \cdot \left({T_{t2}}^4 - {T_s}^4 \right)}{\frac{1}{\varepsilon_t} + \frac{1 - \varepsilon_s}{\varepsilon_s} \left(\frac{R_t}{R_s} \right)^2} + 2 \cdot h_f \cdot A_s \cdot \left(T_{air} - T_s \right) = \sigma \cdot \varepsilon_{s2} \cdot A_s \left({T_s}^4 - {T_{wall}}^4 \right)$$

Solution

$$\begin{pmatrix} T_{t2} \\ T_s \end{pmatrix} := \text{Find}\left(T_{t2}, T_s \right) =$$