



Quiz 6

CHG 2314

February 25, 2019

Solution

A thermocouple, which is initially at 25°C, is placed in a hot gas stream at 200°C, and after 1 s it records the temperature of 175°C. Assuming applicability of the lumped thermal capacitance method,

a) What is the time constant of this thermocouple? (5 points)

Assuming negligible radiation, this is a basic LTCC case in which temperature response is given by:

$$\frac{T - T_{\infty}}{T_i - T_{\infty}} = \exp\left(-\frac{t}{\tau_c}\right) \quad \text{where } \tau_c = \frac{\rho V c}{h A} \quad \text{Note: we do not know } \rho, V, c, h \text{ \& } A$$

where $T_i = 25^\circ\text{C}$ $T_{\infty} = 200^\circ\text{C}$ $T(t=1\text{s}) = 175^\circ\text{C}$

Rearranging above equation: $\tau_c = -\frac{t}{\ln\left(\frac{T - T_{\infty}}{T_i - T_{\infty}}\right)} = -\frac{1}{\ln\left(\frac{175 - 200}{25 - 200}\right)} = 0.514\text{s}$

b) What should be the temperature of this thermocouple after 2 s in the hot gas stream? (5 points).

Knowing τ_c we can calculate T at any t . Rearranging above equation

$$T = (T_i - T_{\infty}) \exp\left(-\frac{t}{\tau_c}\right) + T_{\infty}$$

sub-in numerical values $T = (25 - 200) \exp\left(-\frac{2}{0.514}\right) + 200 = 196.4^\circ\text{C}$

Note: we can get the same answer using $T_i = 175^\circ$ and $t = 1$

$$T = (175 - 200) \exp\left(-\frac{1}{0.514}\right) + 200 = 196.4^\circ\text{C}$$