• The temperature dependence of flow stress at constant strain and strain rate can be given by:

\[ \sigma = C_2 \exp \left( \frac{Q}{RT} \right) \bigg|_{\varepsilon, \dot{\varepsilon}} \]  

2-1

where Q is the activation energy for plastic flow, C₂ is a constant, T is the testing temperature and R is the universal gas constant.

• A plot of \( \ln \sigma \) versus 1/T will give a straight line with a slope \( Q/R \).

• Activation energy, Q, can be determined by performing two tensile tests at two temperatures, \( T_1 \) and \( T_2 \) and at a constant strain rate. It can be shown that:

\[ Q = R \ln \left( \frac{\sigma_1}{\sigma_2} \right) \frac{T_1 T_2}{T_2 - T_1} \]  

2-2
Constitutive Equations

• Describe the relations between stress and strain in terms of the variables of strain rate and temperature

• Early concept: \( f(\sigma, \varepsilon, \varepsilon, T) = 0 \)
  
  – Analogous to equilibrium in thermodynamics system which states that:

  \[ f(P, V, T) = 0 \]

• There are several forms of constitutive relations, including the simple power law relation (Hollomon equation) and its variants.

2-3a

2-3b