Entropy

Clausius Inequality

$$\oint \left(\frac{\delta Q}{T}\right)_b \leq 0$$

b Boundary

Integral across all parts of the boundary

δQ = Heat Transfer along the boundary

T = Temperature at the boundary

$$\oint \left(\frac{\delta Q}{T}\right)_b = -\sigma_{cycle}$$

strength of the inequality

$\sigma_{cycle} = 0$ => No irreversibilities present

$\sigma_{cycle} > 0$ => Irreversibilities present

$\sigma_{cycle} < 0$ => Not possible

Entropy for an Internally Reversible Process

$$\sigma_{cycle} = 0$$

$$dS = \left(\frac{\delta Q}{T}\right)_{\substack{int\\rev}}$$

S = Entropy (J/K , Btu/°R)

s = specific entropy (J/kg·K , Btu/lb·°R)

$$s = s_f + x(s_g - s_f)$$

$$\boxed{\begin{gathered} S_2 - S_1 = \int_1^2 \left(\frac{\delta Q}{T}\right)_{\substack{int\\rev}} \\ Q_{\substack{int\\rev}} = \int_1^2 T\,dS \end{gathered}}$$

If isothermal

$$\boxed{Q_{\substack{int\\rev}} = T(S_2 - S_1)}$$

T-dS Equations

- Relate entropy to internal energy and specific heats

Air as an Ideal Gas

$$\boxed{s_2 - s_1 = s_2^o - s_1^o - R \ln\left(\frac{P_2}{P_1}\right)}$$

$s^o \Rightarrow$ Table A

$s^o \neq s$

Entropy Balance for a Closed System

$$S_2 - S_1 = \int_1^2 \left(\frac{\delta Q}{T}\right)_b + \sigma$$

Entropy Production

$$S_2 - S_1 = \int_1^2 \left(\frac{\delta Q}{T}\right)_{\substack{int \\ rev}}$$