STUDENT SUCCESS CENTER
THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

THERMODYNAMICS: ENTROPY & ENTHALPY

Entropy & Enthalpy:

The Clausius theorem states that a system exchanging heat with external reservoirs and undergoing a cyclic process, is one that ultimately returns a system to its original state:

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

The Kelvin-Planck statement states it is impossible to devise a cyclically operating heat engine, the effect of which is to absorb energy in the form of heat from a single thermal reservoir and to deliver an equivalent amount of work. This implies that it is impossible to build a heat engine that has 100% thermal efficiency.

- Entropy balance:

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

$$\begin{matrix} Change\ in \\ entropy \end{matrix} = \begin{matrix} Entropy \\ transfer \end{matrix} + \begin{matrix} Entropy \\ production \end{matrix}$$

  If $\sigma = 0$, it is a reversible process since no entropy is generated (can be returned to original state). If $\sigma > 0$, it is irreversible. Further, σ can never be < 0, as this would imply its destruction.

- Entropy rate of change:

$$\frac{ds}{dt} = \sum \dot{m}s + \int_1^2 \left(\frac{\delta \dot{Q}}{T}\right)_b + \dot{\sigma}$$

- Ideal gas
  - Variable Specific Heat: $\Delta S = S_1^\circ - S_2^\circ - R \cdot ln\left(\frac{P_2}{P_1}\right)$
  - Constant Specific Heat: $\Delta S = C_V \ln\left(\frac{T_2}{T_1}\right) + R \cdot \ln\left(\frac{v_2}{v_1}\right) = C_P \ln\left(\frac{T_2}{T_1}\right) - R \cdot \ln\left(\frac{P_2}{P_1}\right)$

- Isentropic

$$\frac{P_2}{P_1} = \frac{P_{r2}}{P_{r1}} \qquad and \qquad \frac{v_2}{v_1} = \frac{v_{r2}}{v_{r1}}$$

  - Constant Specific Heats:

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} = \left(\frac{v_1}{v_2}\right)^{k-1} \qquad and \qquad \frac{P_2}{P_1} = \left(\frac{v_1}{v_2}\right)^k$$

    Where k is the ratio of specific heats, $k = \frac{c_P}{c_V}$

For more information, visit a tutor. All appointments are available in-person at the Student Success Center, located in the Library, or online. Adapted from Moran, M. J., Shapiro, H. N., Boettner, D. D., & Bailey, M. B. (2014). *Fundamentals of Engineering Thermodynamics.* Hoboken, NJ: Wiley.