Chapter 5: First Law of Thermodynamics: Closed Systems

Work: Work is a force acting through a distance, $\dot{W}$
Power is work per unit time,

Boundary Work $W_b = \int F\,ds = \int P\,A\,ds = \int P\,dV$

Electrical Work $W_e = V\,N$ (kJ) $\quad W_e = V\,I$ (kW)

Work of a Spring $W_{spring} = \frac{1}{2} k_s (x_2^2 - x_1^2)$ (kJ)

First Law of Thermodynamics:

$Q - W = \Delta E$ $\quad \Delta E = \Delta U$ for closed systems

Specific Heats: $C_v = \left(\frac{\partial u}{\partial T}\right)_v$ $\quad C_p = \left(\frac{\partial h}{\partial T}\right)_P$

Internal Energy, Enthalpy and Specific Heats of an <u>Ideal Gas</u>:

$\Delta u = c_v\,\Delta T$ $\quad \Delta h = c_p\,\Delta T$ $\quad P\,v = R\,T$

$dh = du + RdT$ $\quad C_p - C_v = R$ $\quad k = C_p/C_v$

Internal Energy, Enthalpy and Specific Heats of <u>Solids and Liquids</u>:

$C_p = C_v = C$ $\quad \Delta u = C\,\Delta T$ $\quad \Delta h = \Delta u + v\,\Delta P$

Thermodynamics Processes for Closed Systems:

- Constant Volume Process: $(V = C)$

$$W_b = \int P\,dV = 0$$

- Constant Pressure Process: $(P = C)$

$$W_b = \int P\,dV = P(V_2 - V_1)$$

- Constant Temperature Process of an Ideal Gas: $(T = C)$

$$W_b = \int P\,dV = \int \frac{mRT}{V}\,dV = mRT \ln\frac{V_2}{V_1} = P_1V_1 \ln\frac{V_2}{V_1}$$

$$= P_1V_1 \ln\frac{P_1}{P_2}$$

- Polytropic Process: $(P V^n = C)$

$$W_b = \int P\,dV = \frac{P_2V_2 - P_1V_1}{1-n} \qquad n \neq 1$$

- Isentropic Process: $(P V^k = C)$ $\qquad k = \frac{c_p}{c_v}$

  $1.0 < k \leq 1.67$

For Monotamic Molecules (He, Ar, Kr, Ne, Xe) $\quad k = 1.67$
For Diatomic Molecules (N_2, O_2, CO_2, CO, Air) $\quad k = 1.40$
For More Complicated Molecules (CH_4, NH_3, etc.) $\quad k = 1.33$
For gases at high temperatures $\quad 1.15 \leq k \leq 1.30$