Day-6

→ **Steady flow energy equation**—

$$W_{in} + Q_{in} + H_{in} + K.E_{in} + PE_{in}$$

$$= W_{out} + Q_{out} + H_{out} + K.E_{out} + PE_{out}$$

For practical combustion devices,

$$\underset{H_R}{Q_{in} + H_{in}} = Q_{out} + \underset{H_P}{H_{out}}$$

$Q_{in} \sim 0$ (generally)

If $Q_{out} = 0$ ⇒ Products are at highest temperature

$\Rightarrow H_R = H_P$

→ **general reaction** :

$$\sum n_i' c_i \longrightarrow \sum n_i'' c_i$$

$c_i \longrightarrow$ Any species
$n_i' \longrightarrow$ no. of moles of reactants
$n_i'' \longrightarrow$ " " " " products

Eg: $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$
(Not necessarily a stoichiometric reaction may

happen)

We want $H_R(T_R) = H_P(T_P)$

$$LHS = \sum n_i' \left[\bar{h}_f^\circ + (\bar{h}^\circ - \bar{h}^\circ_{f,298})\right]$$
$$RHS = \sum n_i'' \left[\bar{h}_f^\circ + (\bar{h}^\circ - \bar{h}^\circ_{f,298})\right]$$
$$= \sum n_i'' \left[\underbrace{\bar{h}_f^\circ}_{298\,K} + \bar{C}_p (T_{ad.} - 298)\right]$$

→ $CH_4 + 2(O_2 + 3.76 N_2) \longrightarrow CO_2 + 2H_2O + 2\times 3.76 N_2$

$$H_R(298) = 1\times(-74831)$$
$$= -74831 \text{ kJ}$$

Assuming $T_{ad} = 2100$ K

Take C_p at $\cancel{298}$ $\frac{300+2100}{2} = 1200$ K

$$H_P(T) = 1\times(-393546) + 1\times 56.205(T-298)$$
$$+ 2\times(-241845) + 2\times 43.874(T-298)$$
$$+ 7.52\times 33.707(T-298)$$
$$= -877236 + (T-298)\times 397.43$$

$H_R = H_P$

$$\Rightarrow -74831 = -877236 + 397.43(T-298)$$

$$\Rightarrow T = 298 + \frac{877236 - 74831}{397.43}$$
$$= 2316.98 \text{ K}$$