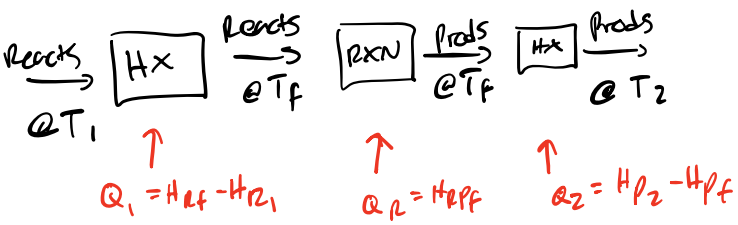
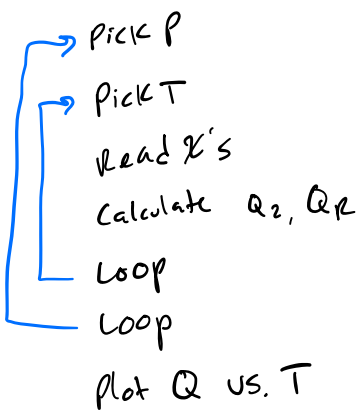
HW12 due Monday 12/16 latest

Recap



To determine T_2:

- Assume $T_1 = T_f$
- Net heat $Q = Q_R + Q_2$
- Pick chemical model
- Use plots like fig. 2.14 (χ's vs. T; P as param.)



values of T where $Q = 0$ called adiabatic flame temp
(all heat goes into raising T of products)

In fig. 2.15, shape / values of curves depend on chemical model.

Revisit $H_2 - O_2$ rxn to compare complete vs. incomplete comb.

$Q = Q_z + Q_R = 0$ (adiabatic)

$H_{P_z} - H_{P_f} = - H_{RPf}$ (1)

i) $H_2 + \frac{1}{2} O_2 \rightarrow H_2O$ (ideal, complete combustion)

$H_{RPf} = -241.83 \frac{MJ}{KMol}$ (@ $T_f = 298K$) $+0 + 0$

H_2 O_2

$Q_z = H_{P_z} - H_{P_f}$

$H_P(T) = \int_{0K}^{T} \bar{C_p}(T)\, dT$

Plotted in fig. 2.5 (solve for H_{P_z} & find H_{P_z} on chart)

enforcement of eq. (1): enter fig. 2.5 w/ $\bar{h} = 241.8$ MJ/KMol @ P = 100atm

exit w/ T = 5000K

Note that @ 5000K H_2O dissociates a lot!

→ our choice of model not accurate

Instead pick model:

$aH_2 + bO_2 \rightarrow cH_2O + dO + eH + fO_2 + gH_2 + hOH$

→ pick P, T, etc.

Generate fig. 2.15 & Find $T_{adiabatic}$ on Q = 0 line

→ $T_{adb} \cong 3800K$

& read corresponding x's from fig. 2.14

Summary

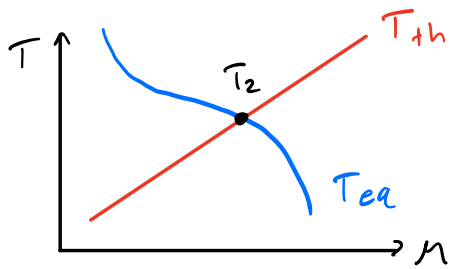
- select chemical model
- combine thermodynamics & chem. EQ. into single plot (like fig. 2.15)
- Determine T_{adb} from $Q=0$ in fig. 2.15
- Determine composition from 2.14

In Hull p. 4

unknowns { M, v, ξ, T

- pick M
- Determine v & ξ from mass balance
- Determine T_{th} from thermo (e-bal)
- " T_{eq} from chem. EQ via K_p (analyt. expr. for $K_p(T)$)
- loop

plot T vs. M



Intersection is T_2

→ balancing heats of formation & thermo, i.e. chemistry & thermo

the higher M, the more complete combustion, thus higher T (less waste used to decompose products)

For a well-designed combustion chamber, the time for mixing & the reaction altogether << residence time

→ chem. EQ. is established

usually T high enough for some dissociation to occur

§ 5 Evaluation of Isp (u_e)

$T_{O_2} = T_{adiab} = T_2 = T_0$

& in 1-D Gas dynamics

Previously
In nozzle:
γ = const, $p\downarrow$, $T\downarrow$ → this changes chem EQ!!

- recombination of products
- γ changes

could calculate new γ & properties at different segments of nozzle – however gas is moving fast now, so chemical equilibrium doesn't complete

→ Non-equilibrium flow