Typical Steady State Control Volume Problem Chart 2

(Not complete material coverage)

Inflow point ⓘ

Normally 4 variables are needed to fully determine it (since there is also an unknown velocity.)

2 known intensive variables

(May get away with T only in some approximations, eg, when using saturated values as an approximation for compressed liquids.)

- Tables, eg B.1.1-B.1.4; pv or Tv diagrams; $v = v_f + x\,(v_g - v_f)$ and similar for u, h, and s.
- Ideal gas (applicable?) $pv = RT$ (4 forms) Tables A5-A8 for u, h, s.
- Make do with the formulae for *differences* in intensive variables listed below under "Device"?

Remaining intensive variables $p, T, v, (x,)u, h, s$.

Material flow: $w = \dot{W}/\dot{m}$ $\quad q = \dot{Q}/\dot{m}$ $\quad \dot{m} = \dot{V}/v = A\mathbf{V}/v$ $\quad A = \frac{\pi}{4}D^2$

Device or Control Volume

C1: Type of device? Given that $\dot{Q} = 0$? Reversible? $\quad \eta_{\text{turbine}} = w/w_s;\ \eta_{\text{compressor}} = w_s/w$

C2: Mass: $\quad \sum \dot{m}_i = \sum \dot{m}_e$

Energy: $\quad \dot{Q} + \sum \dot{m}_i \left(h_i + \frac{1}{2}\mathbf{V}_i^2? + gZ_i?\right) = \sum \dot{m}_e \left(h_e + \frac{1}{2}\mathbf{V}_e^2? + gZ_e?\right) + \dot{W}$

C3: $\dot{W} = 0$? Or $w + \Delta KE? + \Delta PE? = 0 \;\Big|\; -v\,(p_e - p_i) \;\Big|\; \dfrac{n\,(p_e v_e - p_i v_i)}{1-n} \;\Big|\; -pv \ln\left(\dfrac{p_e}{p_i}\right)$?

$q = [0 \text{ and } s_2 = s_1] \;\Big|\; T(s_2 - s_1) \;\Big|\;$ other? $\quad \sum \dot{m}_e s_e - \sum \dot{m}_i s_i = \sum \dfrac{\dot{Q}}{T} + \dot{S}_{\text{gen}}$

For ideal gasses:

$$h_2 - h_1 = \int_1^2 C_p \,\mathrm{d}T \approx C_{p_{\text{ave}}}(T_2 - T_1)$$

$$s_2 - s_1 = s_T^0(T_2) - s_T^0(T_1) - R\ln\left(\frac{p_2}{p_1}\right) \approx C_{p_{\text{ave}}} \ln\left(\frac{T_2}{T_1}\right) - R\ln\left(\frac{p_2}{p_1}\right) = \ldots$$

Polytropic: $\dfrac{p_2}{p_1} = \left(\dfrac{v_1}{v_2}\right)^n = \left(\dfrac{T_2}{T_1}\right)^{\frac{n}{n-1}}$ $\quad$ isothermal: $n = 1$; isentropic and k constant: $n = k$?

For compressed liquids, *by approximation*, best at constant pressure:

$$h_2 - h_1 \approx C_{(p)_{\text{ave}}}(T_2 - T_1) \qquad s_2 - s_1 \approx C_{(p)_{\text{ave}}} \ln\left(\frac{T_2}{T_1}\right)$$

Exit point ⓔ

Same procedures as entrance point ⓘ