Typical Steady State Control Volume Problem Chart 2
(Not complete material coverage)

Inflow point ①
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, e.g., 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)

- 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:
- \( w = \dot{W}/\dot{m} \)
- \( q = \dot{Q}/\dot{m} \)
- \( \dot{m} = \dot{V}/v = AV/v \)
- \( A = \frac{\pi}{4} D^2 \)

Device or Control Volume

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

C2: Mass:
- \( \sum \dot{m}_i = \sum \dot{m}_e \)
- Energy:
  - \( \dot{Q} + \sum \dot{m}_i \left( h_i + \frac{1}{2} V_i^2 + g z_i \right) = \sum \dot{m}_e \left( h_e + \frac{1}{2} V_e^2 + g z_e \right) + \dot{W} \)

C3: \( \dot{W} = 0? \) Or \( w = \Delta KE? + \Delta PE? = 0 \quad \mid - v (p_e - p_i) \mid \quad \frac{n (p_e v_e - p_i v_i)}{1-n} \quad - pv \ln \left( \frac{p_e}{p_i} \right) ? \)
- \( q = [0 \quad \text{and} \quad s_2 = s_1] \quad \mid T (s_2 - s_1) \quad \text{other?} \quad \sum \dot{m}_e s_e - \sum \dot{m}_i s_i = \sum \frac{Q}{\dot{T}} + \dot{S}_{\text{gen}} \)

For ideal gasses:
- \( h_2 - h_1 = \int_1^2 C_p dT \approx C_{p,\text{ave}} (T_2 - T_1) \)
- \( s_2 - s_1 = s^0 (T_2) - s^0 (T_1) - R \ln \left( \frac{p_2}{p_1} \right) \approx C_{p,\text{ave}} \ln \left( \frac{T_2}{T_1} \right) - R \ln \left( \frac{p_2}{p_1} \right) = \ldots \)

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

For compressed liquids, by approximation, best at constant pressure:
- \( h_2 - h_1 \approx C_{(p),\text{ave}} (T_2 - T_1) \quad s_2 - s_1 \approx C_{(p),\text{ave}} \ln \left( \frac{T_2}{T_1} \right) \)

Exit point ②
Same procedures as entrance point ①