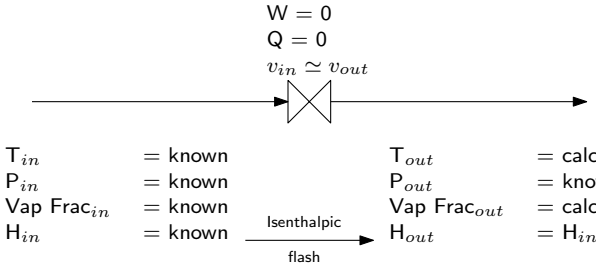
2.9 Example 3 - Valve/Orifice Temperature Change

- Derive the equations for the temperature change of an (a) ideal gas and (b) ideal liquid across a valve or orifice.



Energy balance: $H_{out} = H_{in}$

Property function:
$$dH = C_p dT + \left[V - T\left(\frac{\partial V}{\partial T}\right)_{Px_i}\right] dP$$
$= C_p dT$ ideal gas
$= C_p dT + V dP$ ideal liquid

Ideal gas: $T_{out} = T_{in}$

Ideal liquid: $C_p(T_{out} - T_{in}) = V(P_{in} - P_{out})$

Thus, for an ideal gas the temperature is unchanged. For an ideal liquid the temperature increases.

2.9 Example 4 - Water dew point

- Severe corrosion and occasional instabilities were experienced in a Deethanizer since the overhead temperature was reduced to 20°C to recover more propane. The overhead pressure was 2200 kPaa and dry gas flow was 6000 kg/h (10 mole weight). Water entering tower in liquid and gas streams was roughly 36 kg/h. Calculate the overhead water dew point to identify the problem.

Water mole fraction $y_w = \frac{\text{Water moles}}{\text{Gas plus Water moles}}$
$= \frac{36/18}{6000/10+36/18}$
$= 0.0033$

Water partial pres $P_w = y_w \times P_{total}$
$= 0.0033 \times 2200$
$= 7.3$ kPaa

Water vapor pres $\ln P_w = 16.453 - \frac{3923.3}{T+231.48}$ P in kPaa, T in °C, valid 0-150°C

Water dew pt $T = \frac{3923.3}{16.453 - \ln P_w} - 231.48$
$= 39.8$°C higher than ovhd temp !