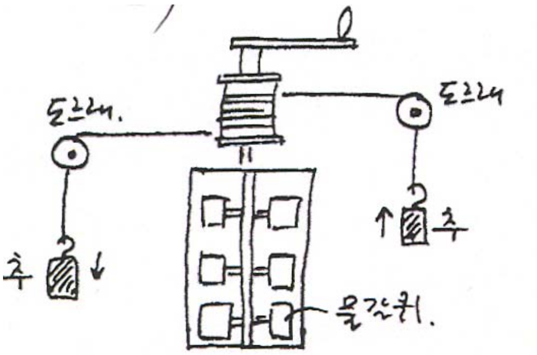
Solution Midterm

Prob 1.



일과 열사이의 정량적 관계 연구.

열이 역학적 에너지의 한 형태임을 밝힘
→ 일정한 높이에서 추를 떨어뜨리고
그 힘으로 물탱크 안의 갈퀴 팔을 돌려
물이 얼마 만큼의 열을 얻었는지 조사.
→ 추가 낙하하면서 물갈퀴판이 회전하여
물과 날개의 마찰에 의해 열이 발생하여
온도 상승
→ 역학적일의 양은 추의 낙하거리로부터 산출.
물이 얻은 열량은 온도계로 측정

1 cal → 4.19×10^7 erg 열의 일당량

단열과정.
△E = $E_2 - E_1$ = -Wad = △KE + △PE+ △U
비단열과정.
Q = △E + W → △E = Q - W

Prob 2.

Initial conditions

P_1 = 100 kPa , T_1 = 20°C , $PV^{1.3}$ = Constant

$$W_2 = \int_1^2 PdV = \frac{P_2V_2 - P_1V_1}{1-n} = \frac{mR(T_2 - T_1)}{1-n}$$

where $R = \frac{R_u}{M_{N_2}}$, n = 1.3

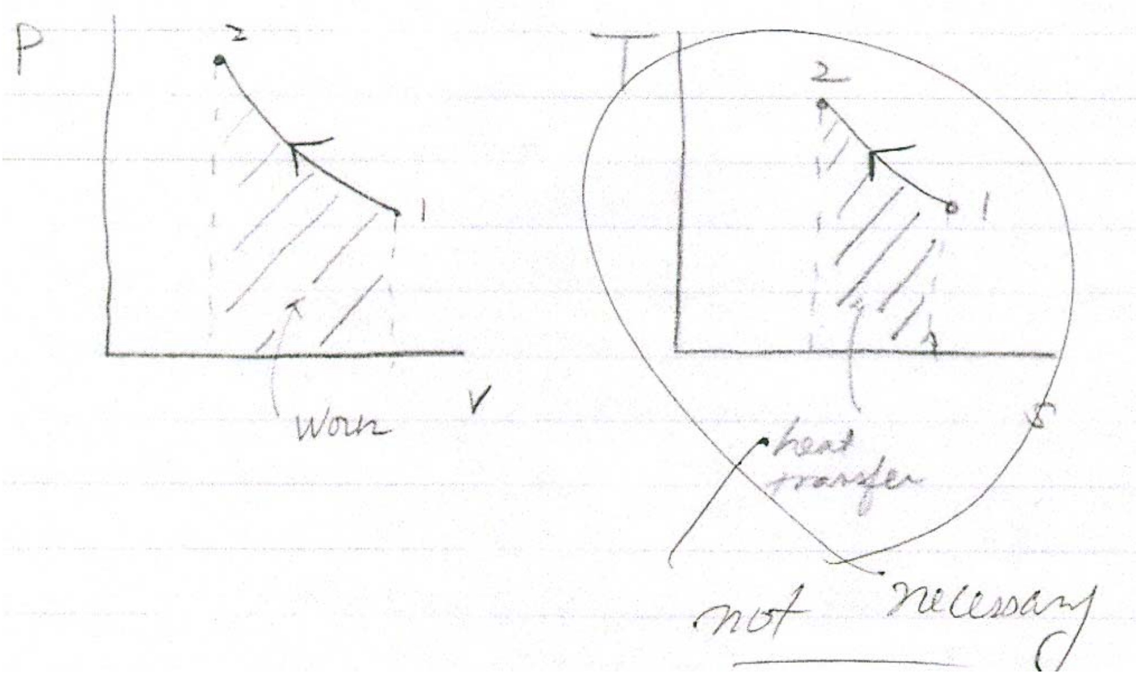
$$q_2 = u_2 - u_1 + w_2 = C_V(T_2 - T_1) + {}_1w_2$$

Assume ideal gas

$$(\frac{T_2}{T_1}) = (\frac{P_2}{P_1})^{\frac{n-1}{n}} \qquad \therefore T_2 = (\frac{500}{100})^{\frac{0.3}{1.3}}(273+20) = 424.8\,K$$

$$ {}_1w_2 = \frac{{}_1W_2}{m} = \frac{R(T_2 - T_1)}{1-n} = -130.4\,kJ/kg$$

$$ {}_1q_2 = C_V(T_2 - T_1) + {}_1w_2 = -32.2\,kJ/kg$$



Prob 3.

Analysis

From the first law (Eq. 6.12) we have

$$\dot{Q}_{C.V.} + \dot{m}\left(h_i + \frac{\mathbf{V}_i^2}{2} + gZ_i\right) = \dot{m}\left(h_e + \frac{\mathbf{V}_e^2}{2} + gZ_e\right) + \dot{W}_{C.V.}$$

use ~~exact~~

$\dot{m} = 1.0$ not 1.5

with

$$\dot{Q}_{C.V.} = -8.5 \text{ kW}$$

Solution

$\dot{m} \neq 1.5$
$\dot{m} = 1.0$

From the steam tables, h_i = 3137.0 kJ/kg. Substituting inlet conditions gives

$$\frac{\mathbf{V}_i^2}{2} = \frac{50 \times 50}{2 \times 1000} = 1.25 \text{ kJ/kg}$$

$$gZ_i = \frac{6 \times 9.8066}{1000} = 0.059 \text{ kJ/kg}$$

$h_e = h_g = 2675.5$

Similarly, for the exit h_e = 2675.5 kJ/kg and

$$\frac{\mathbf{V}_e^2}{2} = \frac{100 \times 100}{2 \times 1000} = 5.0 \text{ kJ/kg}$$

$$gZ_e = \frac{3 \times 9.8066}{1000} = 0.029 \text{ kJ/kg}$$

Therefore, substituting into Eq. 6.12, we obtain

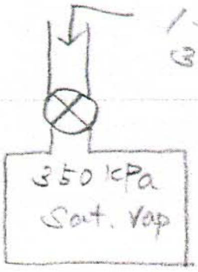
$$-8.5 + 1.0(3137 + 1.25 + 0.059) = 1.0(2675.5 + 5.0 + 0.029) + \dot{W}_{C.V.}$$

$\dot{W}_{C.V.} =$ ~~$-8.5 + 4707.5 - 4020.8 = 678.2$ kW~~

$= -8.5 + 3138.31 - 2680.53 = 449.28$ kW check!

If Eq. 6.13 is used, the work per kilogram of fluid flowing is found first.

Prob 4.



$Q_{cv} = W_{cv} = 0$, $m_e = 0$

1st law : $m_i h_i = m_2 u_2 - m_1 u_1$

Continuity : $m_2 - m_1 = m_i$

Combining the continuity and 1st law,

$$(m_2 - m_1) h_i = m_2 u_2 - m_1 u_1$$

or $m_2 (h_i - u_2) = m_1 (h_i - u_1)$ (i)

We also know $V = 0.4\ m^3$

$$= m_2 v_2 \quad \text{(ii)}$$

Sub (ii) into (i) and rearranging,

$$\frac{V}{v_2}(h_i - u_2) - m_1 (h_i - u_1) = 0 \quad \text{(iii)}$$

So we need to find v_2 and u_2. We need to guess T_2 to look up the superheated vapor table

Guess → $T_2 = 342°C$ (Trial and Error!)

From the table with $P_2 = 1.4$ MPa

Evaluate (iii) with

$$v_2 = 0.1974\ m^3/kg, \quad u_2 = 2855.8\ kJ/kg$$

We have

$$\frac{0.4}{0.1974}(3040.4 - 2855.8) - 0.763(3040.4 - 2548.9) \approx 0$$

Guess is good. So $m_2 = \frac{0.4}{0.1974} = 2.026$ kg

∴ Mass of steam entering the tank, $m_i = m_2 - m_1 = \underline{1.263\ kg}$