Look @ 1^{st} law for SSSF systems

some notation

$${}_1Q_2 = \Delta E + {}_1W_2$$

$${}_1Q_2 = \Delta U + \Delta KE + \Delta PE + {}_1W_2$$

$$q = u + e_k + e_p + w$$

where $q \equiv \frac{Q}{m}$; $w \equiv \frac{W}{m}$

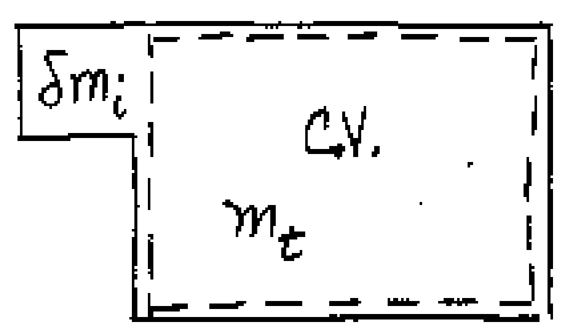
$u \equiv \frac{U}{m}$

$e_k \equiv \frac{KE}{m} = \frac{1}{2}v^2$

$e_p \equiv \frac{PE}{m} = gz$

now, look @ how we define system & control volume

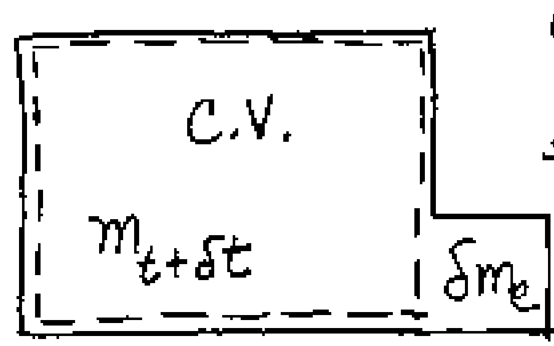
initially, @ time t ①



control volume is stuff inside the device. - - - - -

system includes the device AND fluid about to come in, δm_i

finally, @ time $t+\delta t$ ②



control volume is stuff inside device.

system includes the device AND fluid that has just exitted the device, δm_e

1^{st} law [for the time period δt]

$$Q - W = \Delta E$$

$$Q - W = E_2 - E_1 \qquad E_2 = E_{m_{cv(t+\delta t)}} + E_{\delta m_e}$$

$$E_1 = E_{m_{cv(t)}} + E_{\delta m_i}$$

$$Q - W = E_{m_{cv(t+\delta t)}} + E_{\delta m_e} - E_{m_{cv(t)}} - E_{\delta m_i}$$

for SSSF, m_{cv} does not change, and $\frac{dE_{cv}}{dt} = 0$

$$\therefore E_{m_{cv(t+\delta t)}} = E_{m_{cv(t)}}$$

leaving,

$W = W_{cv} + W_{fw}$ $\quad$ W_{cv} = work associated w/ the C.V.

W_{fw} = flow work

$$Q - (W_{cv} + W_{fw}) = E_{\delta m_e} - E_{\delta m_i}$$

$$Q - W_{cv} = W_{fw} + E_{\delta m_e} - E_{\delta m_i}$$

$$Q - W_{cv} = p_e v_e \delta m_e - p_i v_i \delta m_i + E_{\delta m_e} - E_{\delta m_i}$$

$$Q - W_{cv} = (E_{\delta m_e} + p_e v_e \delta m_e) - (E_{\delta m_i} + p_i v_i \delta m_i)$$

$$= (e_e \delta m_e + p_e v_e \delta m_e) - (e_i \delta m_i + p_i v_i \delta m_i)$$

$$= (e_e + p_e v_e)\delta m_e - (e_i + p_i v_i)\delta m_i$$

$$= (u + e_k + e_p + pv)_e \delta m_e - (u + e_k + e_p + pv)_i \delta m_i$$

$$= (h + e_k + e_p)_e \delta m_e - (h + e_k + e_p)_i \delta m_i$$

with respect to time

$$\dot{Q} - \dot{W}_{cv} = (h + e_k + e_p)_e \dot{m}_e - (h + e_k + e_p)_i \dot{m}_i$$

for SSSF $\quad \dot{m}_e = \dot{m}_i$

$$\frac{\dot{Q}}{\dot{m}} - \frac{\dot{W}_{cv}}{\dot{m}} = (h_e + e_{ke} + e_{pe}) - (h_i + e_{ki} + e_{pi})$$

$$\boxed{q - w = (h_e - h_i) + \frac{(V_e^2 - V_i^2)}{2} + g(z_e - z_i)}$$

and remember, $\boxed{\begin{array}{l}\dot{Q} = q\dot{m} \\ \dot{W} = w\dot{m}\end{array}}$ $\quad$ note, if $\frac{\dot{Q}}{\dot{m}} = q \quad \frac{kJ/s}{kg/s} = \frac{kJ}{kg}$

likewise for w

mult. thru by $\dot{m}$

$$\dot{Q} - \dot{W}_{cv} = (h_e - h_i)\dot{m} + \left(\frac{V_e^2 - V_i^2}{2}\right)\dot{m} + g(z_e - z_i)\dot{m}$$

or, more generally

$$\boxed{\dot{Q} - \dot{W}_{cv} = \sum_e \left(h_e + \frac{V_e^2}{2} + g z_e\right)\dot{m}_e - \sum_i \left(h_i + \frac{V_i^2}{2} + g z_i\right)\dot{m}_i}$$