Chapter 4: 1^{st} law of thermodynamics for a C.V system

Open system = control volume system

mass flow rate : $\dot{m} = \rho \dot{V} = \rho (V_{el})(A)$

Work of flow : $\dot{W}_{flow} = P.\dot{V} = P \dot{m} v$

Energy Balance law:-

$$\frac{dE_{c.v}}{dt} = \dot{Q}_{c.v} - \dot{W}_{c.v} + \dot{m}_i h_i - \dot{m}_e h_e$$

System
- Steady state Steady flow
- Transient

Steady state: $\frac{dE}{dt} = 0$ Steady flow: $\frac{dm}{dt} = 0$

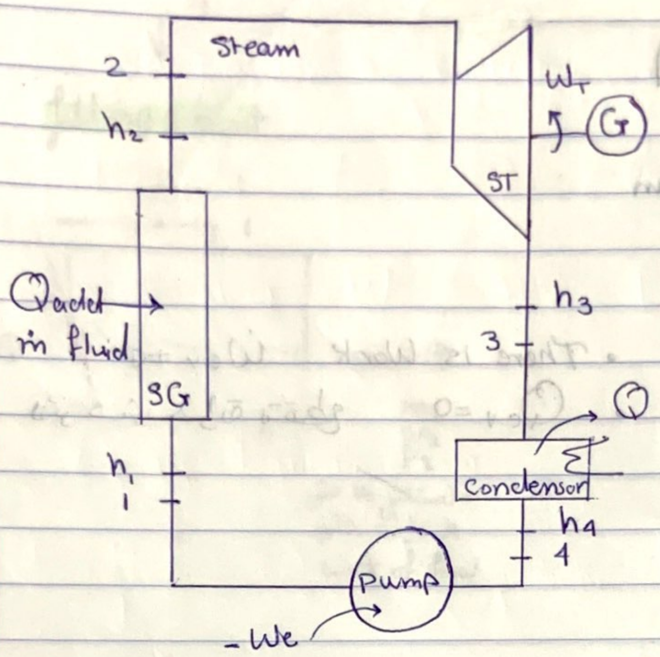
معناها مجموع مايدخل
يساوي مجموع مايخرج

if $\Delta KE = 0$, $\Delta P.E = 0$

$$\dot{Q}_{c.v} = \dot{m} (h_e - h_i) + \dot{W}_{c.v}$$

$\dot{W}_{c.v}$: work that is transformed to another type of energy.

Example: Steam Cycle : SSSF



For the Steam Generator:

$\dot Q_{c.v} = \dot m (h_2 - h_1) + \dot W_{c.v}$ But $\dot W = 0$

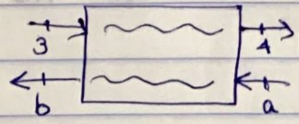
so $\dot Q_{c.v} = \dot m (h_2 - h_1)$ Note: h_1 can be considered as h_f

For the steam turbine:

$\dot Q_{c.v} = \dot m (h_3 - h_2) + \dot W_{c.v}$ ($\dot Q_{c.v} = 0$)

$\dot W_T = \dot W_{c.v} = \dot m (h_2 - h_3)$

For the condensor : heat exchanger



Q and $W = 0$

so $\sum \dot m_e h_e = \sum \dot m_i h_i$

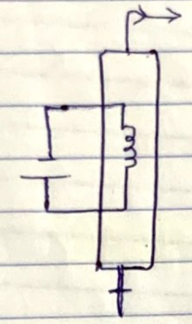
$\dot m_{st} h_{st_3} + \dot m_{wat} h_{c.w} = \dot m_{st} h_{st_4} + \dot m_{wat} h_b$

For the Pump: SSSF

$\dot{W}_{pump} = \dot{m}(h_1 - h_4)$

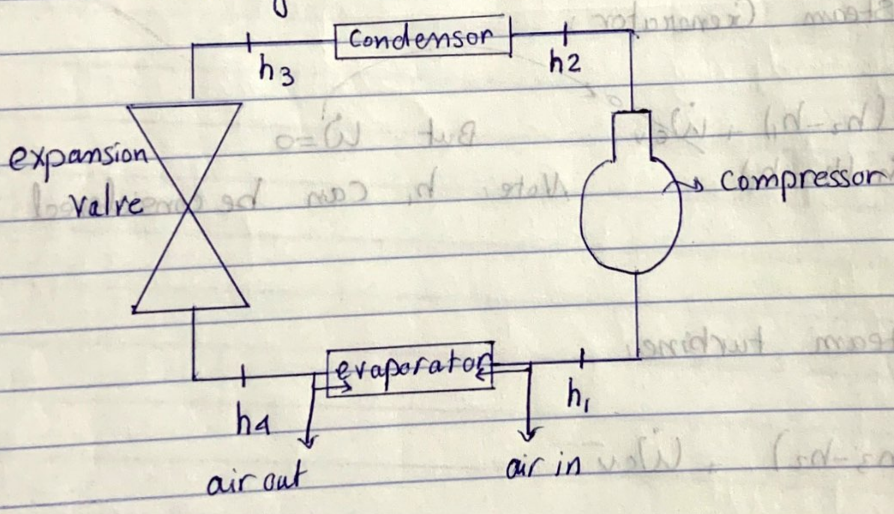
negative ↓ less than

Note:



- There is Work $\dot{W}_{c.v} \neq 0$
- $\dot{Q}_{c.v} = 0$ لأنو فش حرارة بتقطع

refereregeration Cycle:



For the condensor: $\dot{W}_{c.v} = 0$

and $\dot{Q}_{con} = \dot{m}_{ref}(h_3 - h_4)$

For the evaporater

$\dot{Q}_{evap} = \dot{m}_{ref}(h_1 - h_4)$

$= \dot{m}(h_{air\,in} - h_{air\,out})$

For the Compressor: $\dot{Q} = 0$

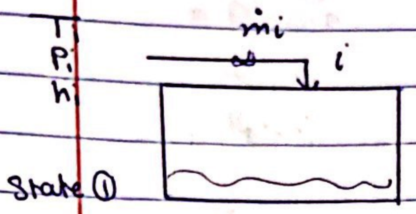
$\dot{W}_{c.v} = \dot{m}_{ref}(h_2 - h_1)$

For the expansion valve

Rigid Tank $V_1 = V_2$

Transient: SSSF ← rate إذا عبينا وفضينا بتغير ال

filling a tank



State ①: m_1, v_1, P_1

$t=0 \longrightarrow t=t$

State ②: m_2, v_2, P_2

ونستعمل u_1 مش h لأنه فش Work of flow

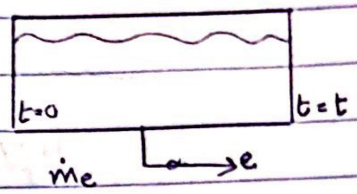
ونستعمل u_2 مش h لأنه فش Work of flow

- Mass Balance: $m_2 = m_i + m_1$
- Energy Balance: $Q_{c.v} + m_i h_i = m_2 u_2 - m_1 u_1 + W_{c.v}$

$m_e = 0$

Discharging a tank

State ①: m_1, P_1, v_1, u_1



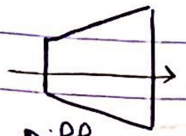
State ②: m_2, P_2, v_2, u_2

- Mass Balance: $m_2 = m_1 - m_e$
- Energy Balance:

$Q_{c.v} = m_2 u_2 - m_1 u_1 + m_e h_e + W_{c.v}$

$m_i = 0$

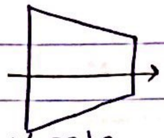
Nozzle / diffuser :-



Diffuser

$A_2 > A_1$

$V_2 < V_1$



Nozzle

$A_2 < A_1$

$V_2 > V_1$

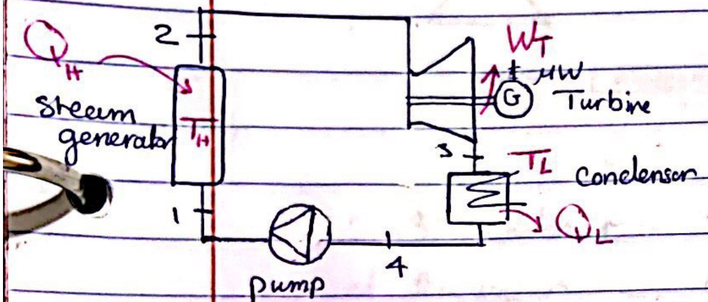
$Q = 0$, $W = 0$:- $0 = (h_1 - h_2) + \frac{(V_1^2 - V_2^2)}{2}$

Chapter 5: 2nd law of thermodynamics

There are two types of cycles (carnot cycles)

Steam Cycle
Heat engine : produces Work

Refregiration Cycle
Heat pump
→ next page



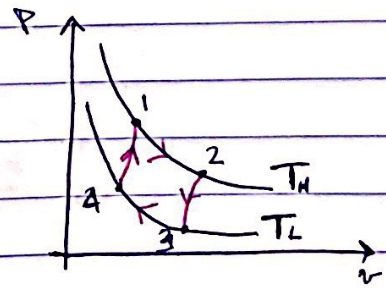
1→2 : Heat addition :- Isothermal
$T_H = T_{\text{water in Boiler}}$

2→3 : expansion :- adiabatic
$T_H \rightarrow T_L$

3→4 : Heat rejection : Isothermal
$T_L = T_{\text{condensate}} = $ Sat liq : so $T_L = T_{sat}$, $h = h_f$ at T_{sat}

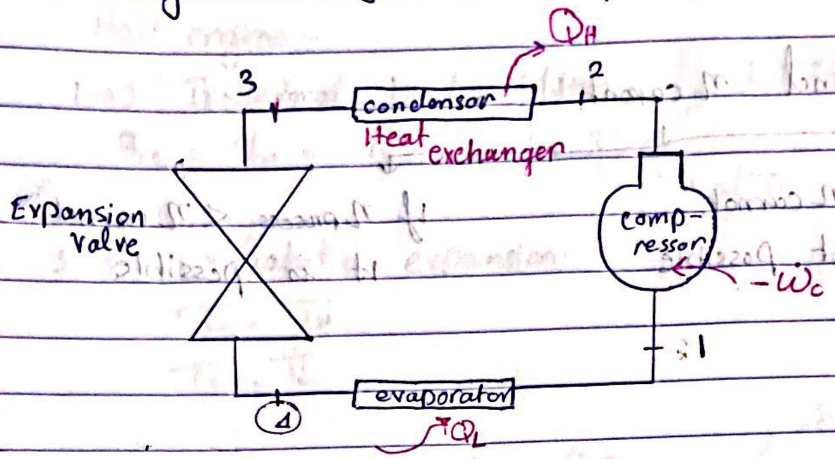
4→1 : compression : $T_L \rightarrow T_H$ adiabatic

$\eta_{th} = \frac{T_H - T_L}{T_H} = \frac{W}{Q_H}$ ~ $\dot{m} \times H.V$



$\eta_{th} > 1$ is not possible
$\eta_{th} < 1$ always

2- Refregeration Cycle : heat pump : to obtain cool effect.



- 2 - 3: Condensor :- Isothermal
  at 2 :- vapor , at 3 :- liquid
- 1 - 2 : Compression : adiabatic Isothermal
- 4 - 1 , evaporation : Not adiabatic : there are heat absorbtion from the outside : Q_L
  $T_L \rightarrow T_H$
  at 4, It is liquid
  at 1: It is vapor
- 3 - 4 , expansion valve :
  $T_H \rightarrow T_L$, adiabatic

β

Cooling: $\beta = \frac{Q_L}{W_c}$

Heating: $\beta = \frac{Q_H}{W_c}$

$$\frac{T_L}{T_H - T_L} = \frac{Q_L}{Q_H - Q_L}$$

$$\frac{T_H}{T_H - T_L} = \frac{Q_H}{Q_H - Q_L}$$

How to Know if a process is possible or not:

Find η_{carnot}

- If $\eta_{process} > \eta_{carnot}$
  It is not possible
- If $\eta_{process} < \eta_{carnot}$
  It is possible

+ If the substance is an ideal gas:-

Heat engine :-

1→2: Isothermal heat addition at T_H

$q_{12} = q_H = R T_H \ln \frac{v_2}{v_1}$ → at T_H $\quad v_2 > v_1$ Isothermal

2-3: adiabatic expansion:

$T_2 = T_H$

$T_3 = T_L$

$0 = C_{v0} \ln \frac{T_L}{T_H} + R \ln \frac{v_3}{v_2}$ (v_3 at T_L, v_2 at T_H)

3-4: Iso thermal : $T_3 = T_4 = T_L$

$q_L = -q_{34} = R T_L \ln \frac{v_3}{v_4}$ (v_3 at T_L, v_4 at T_L) $\quad v_3 < v_4$

$\eta_c = \frac{q_H - q_L}{q_H}$ $\qquad W = q_H - q_L$