Gas power System

Internal combustion engine

Termenelogy swept volume = بيلزم حجم مزاح

1- Stroke

2- Top dead center / Bottom dead center

3- clearance

4- Compression ratio(r) = $\frac{\text{Clearance} + \text{Volume swept}}{\text{clearance}}$

BDC

TDC

How it works?

4 stroke or 2 stroke

كل شوط بعمل نص دورة

يعني دورتين ميكانيكيتين

بيعطينا دورة حرارية وحدة

1 in take stroke : from T → B

بتخش الهواء تضغط على المكبس فينزل لتحت

2 compression: بتتسكر الصمامات

والـ cylinder بتضغط الهواء للأعلى

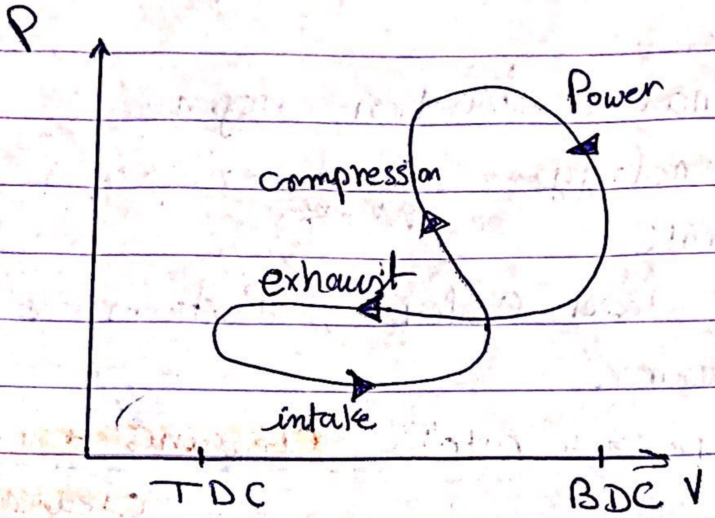
3- power stroke : ارتفاع الضغط والحرارة

و الصمام تنزل الهواء و ترتفع الـ cylinder وتطلع

الهواء سخن وهيله ليعطينا طاقة حرارية في الـ exhaust

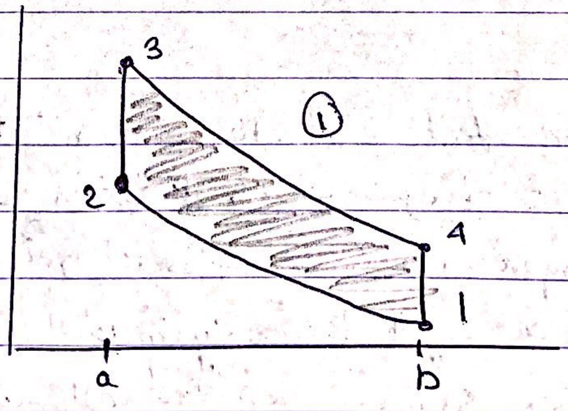
4- exhaust stroke

- P-V diagram for the process



- mean effective pressure

$$mep = \frac{\text{net work for one cycle}}{\text{displacement volume}}$$

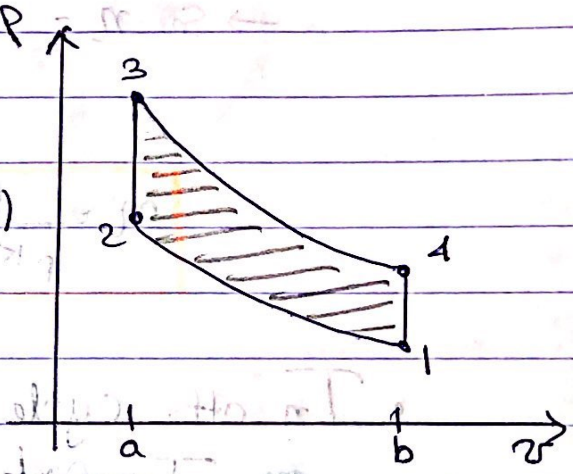


Air standard Cycles → Ott cycle

- Ideal Gas   Ignition & Exhaust ⇒ $W=0$

1 → 2 compresstion, Isentropic
2 → 3 constant volume heat addition
3 → 4 Expansion, Isentropic
4 → 1 constant volume heat Rejection

- $_1W_2 = u_2 - u_1$ (control mass)

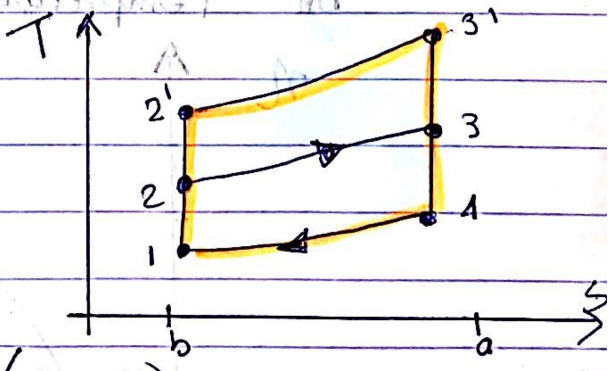


$W_{cycle} = W_{34} - W_{12}$
$= (u_3 - u_4) - (u_2 - u_1)$
$= (u_3 - u_2) - (u_4 - u_1)$

- $_2Q_3 = u_3 - u_2$

- $_3W_4 = u_3 - u_4$

- $_4Q_1 = u_4 - u_1$



Cycles efficiency :-

$\eta = (u_3 - u_2) - (u_4 - u_1) / (u_3 - u_2)$

- If compression ratio ↑ then cycle becomes 1, 2', 3', 4

and since it's an ideal Gas
we can use relation $C_v \Delta T = \Delta h$

So effeciency becomes:

$$\eta = 1 - \frac{C_v (T_4 - T_1)}{C_v (T_3 - T_2)}$$

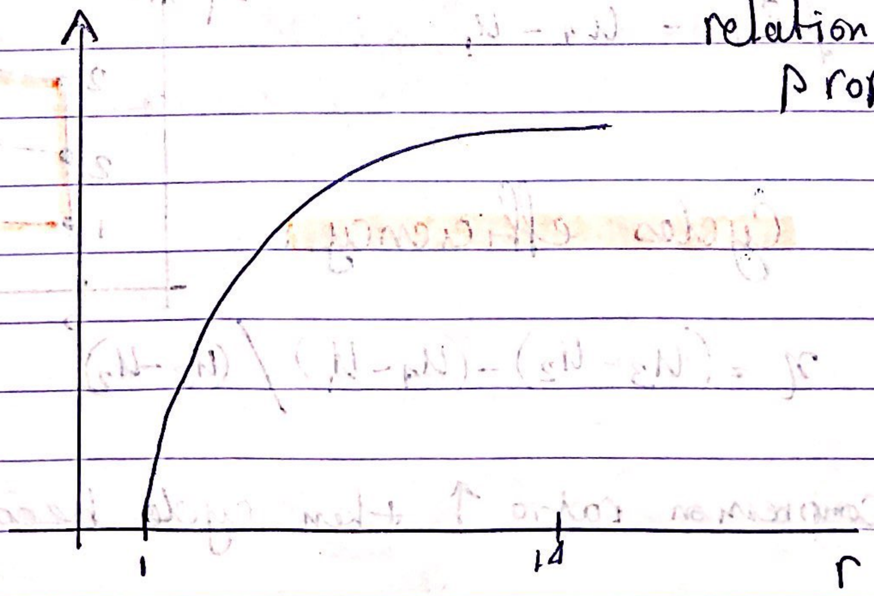
now : $\frac{T_4}{T_1} = \frac{T_3}{T_2}$ ← This relation is obtained from compression ratio

→ So $\eta = 1 - \frac{T_1}{T_2} = \frac{1}{r^{k-1}}$

$$\boxed{\eta = \frac{1}{r^{k-1}}}$$

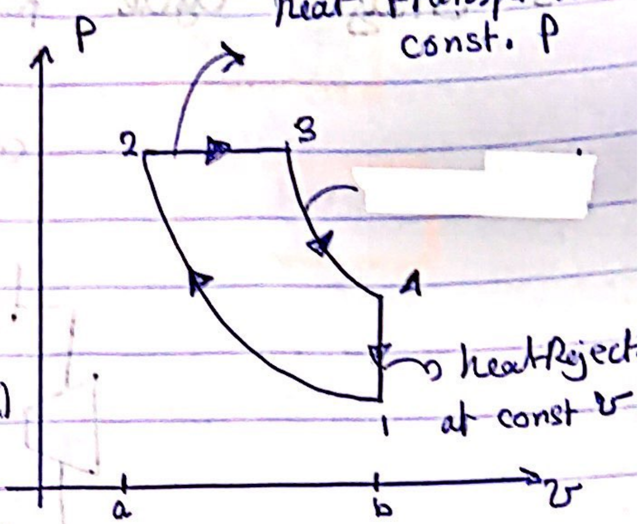
- In otto cycle : efficiency does not depend on Tempreture but on r (r>1)

relation is propotional



In ott v is constant not P

→ 2. Diesel Cycle



heat transfer at const. P

heat Reject at const v

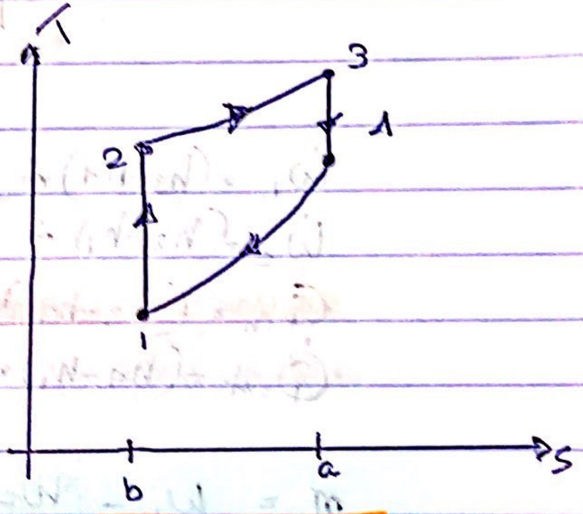
$${}_2W_3 = P_2(v_2 - v_3)$$

or

$${}_2W_3 = Q_{23} - (u_3 - u_2)$$

$$\rightarrow {}_2Q_3 = (u_3 - u_2) + p(v_3 - v_2)$$
$$= h_3 - h_2$$

- $${}_4Q_1 = u_4 - u_1$$
- $$\eta = 1 - \frac{u_4 - u_1}{h_3 - h_2}$$



r_c : cut-off ratio

$\rightarrow T_3 = r_c T_2$

$P_3 = P_2$

$\rightarrow V_3 = r_c V_2$

$\rightarrow \frac{V_4}{V_3} = \frac{r}{r_c}$

$$\boxed{r_c = \frac{V_3}{V_2} = \frac{T_3}{T_2}}$$

$$\boxed{r = \frac{V_1}{V_2}}$$

$$\frac{T_2}{T_1} = r^{k-1}$$

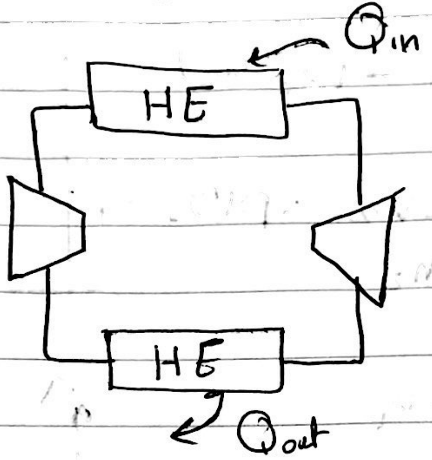
$$\frac{T_4}{T_3} = \left(\frac{r_c}{r}\right)^{k-1}$$

Scanned with CamScanner

3- Brayton Cycle

بتشبه ال Rankine بس بدل ال pump
نحط compressor

وبدل ال Boiler ، Combustion chamber



$$\dot{W}_t = (h_3 - h_4)\dot{m}$$
$$\dot{W}_c = (h_2 - h_1)\dot{m}$$
$$\dot{Q}_{in} = (h_3 - h_2)\dot{m}$$
$$\dot{Q}_{out} = (h_4 - h_1)\dot{m}$$

$$\eta = \frac{\dot{W}_t - \dot{W}_c}{\dot{Q}_{in}} = \frac{(h_3 - h_4) - (h_2 - h_1)}{h_3 - h_2}$$

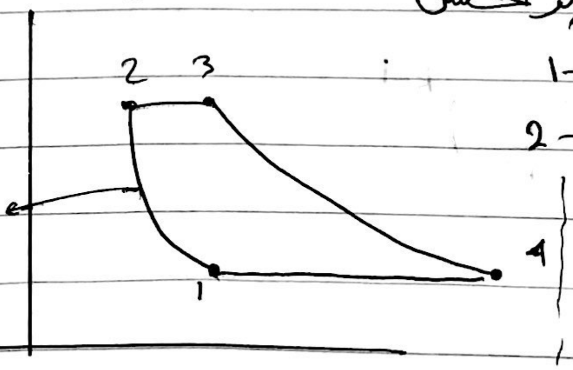
- Back- Work Ratio (Work of comp from turbine)

$$bwr = \frac{h_2 - h_1}{h_3 - h_4}$$ From 10% ⇝ 80% of W_t

كلما أصغر أحسن

3-4: Isentropic expansion

4-1- Constant P heat rejection



1-2 : Isentropic Comp

2-3 : Constant P heat addition

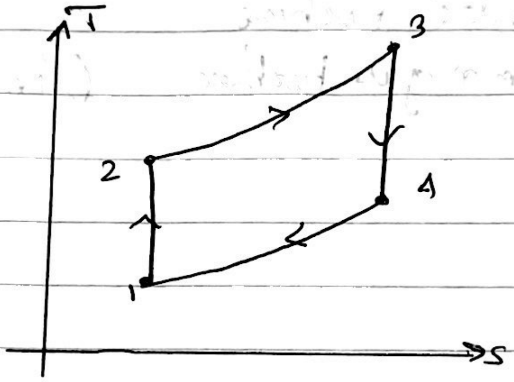
- Relations

$$T_2 = T_1 \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}$$

$$T_4 = T_3 \left(\frac{P_4}{P_3}\right)^{\left(\frac{k-1}{k}\right)}$$

$$\frac{P_4}{P_3} = \frac{P_1}{P_2}$$

$$k = C_p / C_v$$



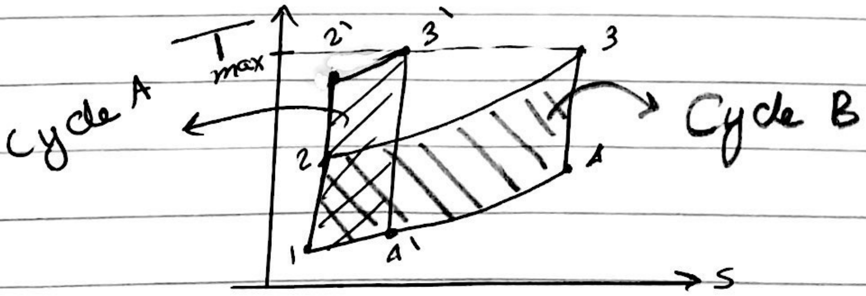
Compressor pressure

* effect of pressure Ratio on preformance

r of Cycle A > r of cycle B

However, Area of B > Area of A

← الفكرة : نقدر نخلي A تعطينا نفس الـ Power الي تعطيها B
بس لازم نزيد الـ mass flow فبنا نظام أكبر



- Thermodynamic Power equipement
    - Radial flow fan
    - Axial flow Pump
    - Centrifugal comp
    - Axial flow compr
    - Centrifugal pump
    - Propeller turbine
    - Steam or gas turbine (Axial flow)