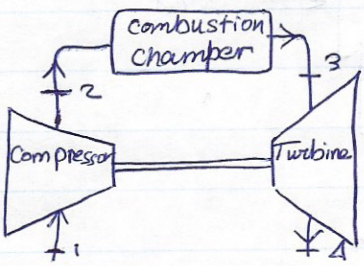
Chapter 10: Power & Refrigiration Systems

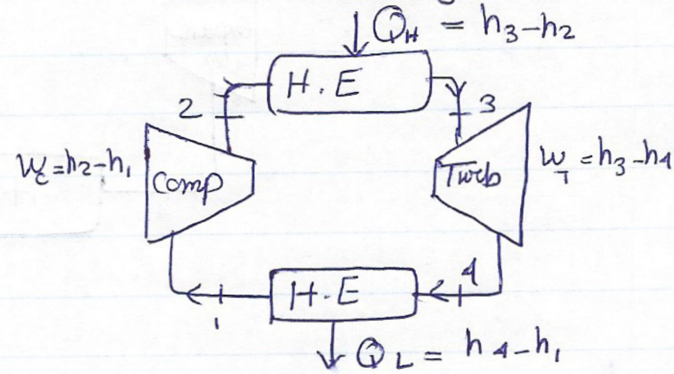
Brayton Cycle

- Ideal cycle for the simple gas turbine
- Types:-

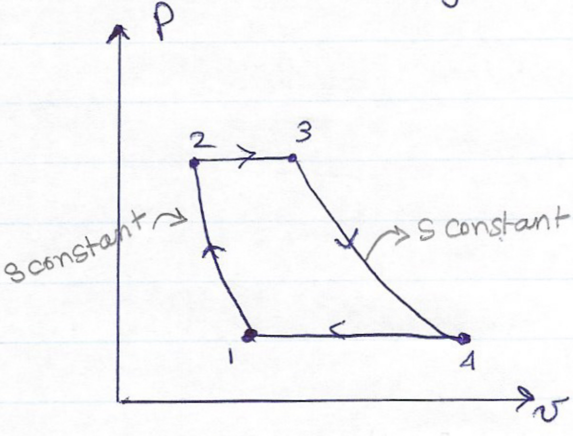
open cycle

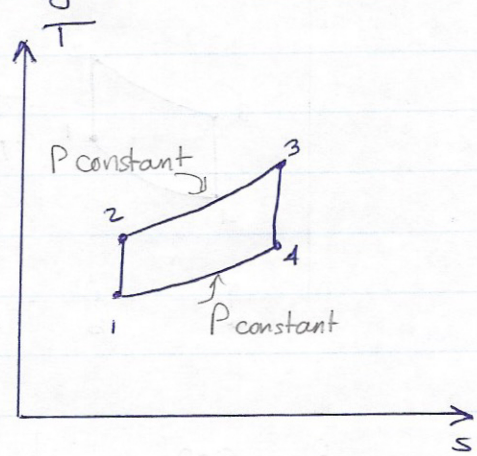


closed cycle



P-v & T-s Diagram for the cycle:-





$$\eta_{th} = 1 - \frac{T_1}{T_2} = 1 - \frac{1}{(P_2/P_1)^{(k-1)/k}} = \frac{\dot{W}_T - \dot{W}_C}{\dot{Q}_{in}}$$

Note:

$P_3 = P_2 = \text{constant}$

$P_4 = P_1 = \text{constant}$

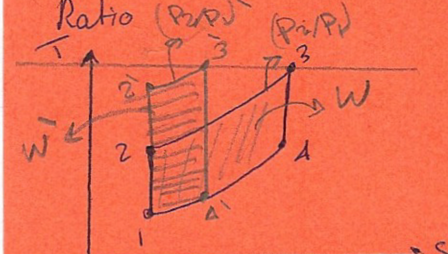
$\left.\right\} \frac{P_4}{P_3} = \frac{P_1}{P_2}$

${}_3q_4 = 0$, ${}_2q_1 = 0$

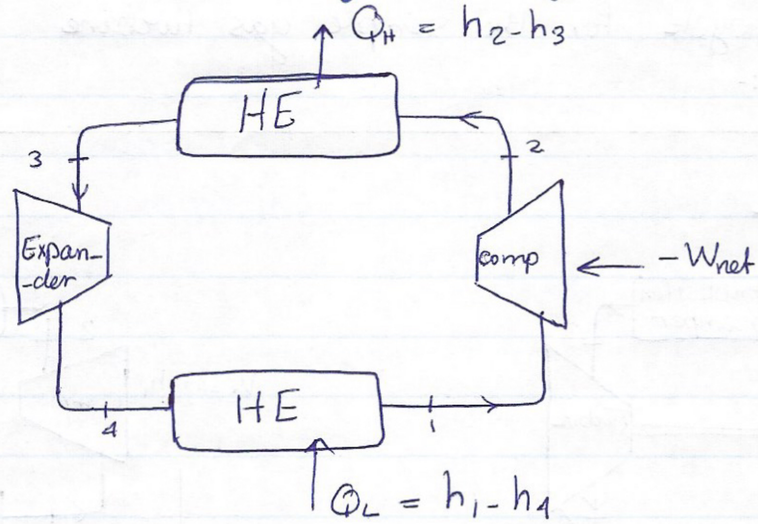
$T_2 = T_1 \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}$, $T_4 = T_3 \left(\frac{P_4}{P_3}\right)^{\frac{k-1}{k}}$

Effect of Pressure Ratio on Preformance

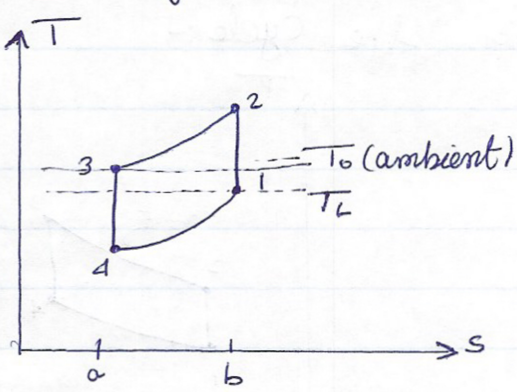
- higher Pressure Ratio → higher efficiency
- But we need a larger mass flow to achieve the same work achieved by lower Pressure Ratio



2- Air-standard Refrigeration Cycle



T-S Diagram;



$$\beta = COP = \frac{1}{r_p^{(k-1)/k} - 1} \quad , \quad r_p = \frac{P_2}{P_1}$$

Reciprocating engine power cycles (engine)

$S = 2R_{crank}$

↑ stroke

$V_{disp} = N_{cyl}\,(V_{max} - V_{min})$

↑ number of cylinders

Terminology
- stroke
- TDC
- BDC — slide(2)
- Volume swept
- compression ratio r_p

4 strokes ICE
- Intake
- compression
- Power
- Exhaust

slide (3)

→ in Watt

$$Power = N_{cyc}\, m\, W_{net}\, \frac{RPM}{60} = P_{meff}\, V_{disp}\, \frac{RPM}{60}$$

- If the engine is a four-stroke engine then multiply by $\frac{1}{2}$
- to convert from <u>hp</u> to <u>Watt</u> multiply by 745.699
- (mep) = P_{meff} = network for one cycle / displacement Volume

→ otto cycle

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{k-1}, \quad \frac{T_3}{T_4} = \left(\frac{V_4}{V_3}\right)^{k-1}$$

$$\frac{T_2}{T_1} = \frac{T_3}{T_4}$$

$$\eta_{Th} = 1 - \frac{T_1}{T_2} = 1 - \frac{1}{r_v^{\,k-1}}$$

r_v → compression ratio

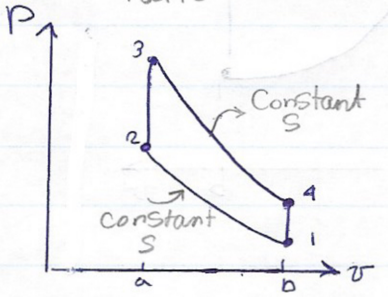
$$r_v = \frac{V_1}{V_2} = \frac{V_4}{V_3}$$

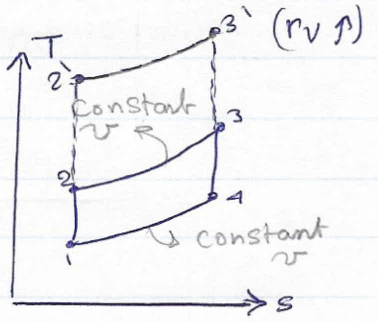
$_1W_2 = u_2 - u_1$

$_3W_4 = u_3 - u_4$

$_2Q_3 = u_3 - u_2$

$_4Q_1 = u_4 - u_1$





$r_v \uparrow \Rightarrow \eta \uparrow$

→ Diesel Cycle

$${}_2W_3 = P_2(v_3 - v_2) \quad , \quad {}_2Q_3 = W_{23} + m(u_3 - u_2)$$

$${}_2Q_3 = h_3 - h_2$$

$${}_4Q_1 = u_4 - u_1$$

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

$$P_3 = P_2 \quad , \quad V_4 = V_1$$

$$T_3 = r_c T_2$$ (r_c → cut off ratio)

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

$$\frac{V_4}{V_3} = \frac{V_1}{V_2} \cdot \frac{V_2}{V_3} = \frac{r}{r_c}$$

$$\frac{T_2}{T_1} = r^{k-1} \quad , \quad \frac{T_4}{T_3} = \left(\frac{r_c}{r}\right)^{k-1}$$