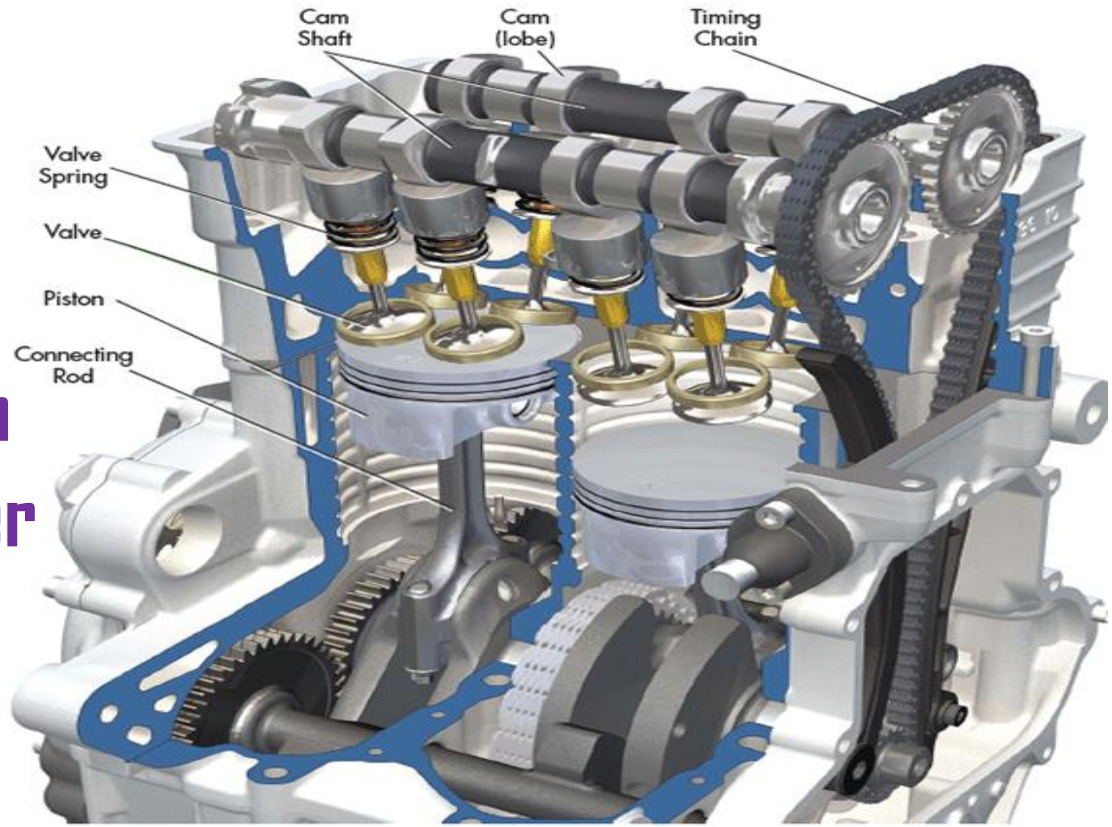
I C Engine, Steam & Nuclear Power



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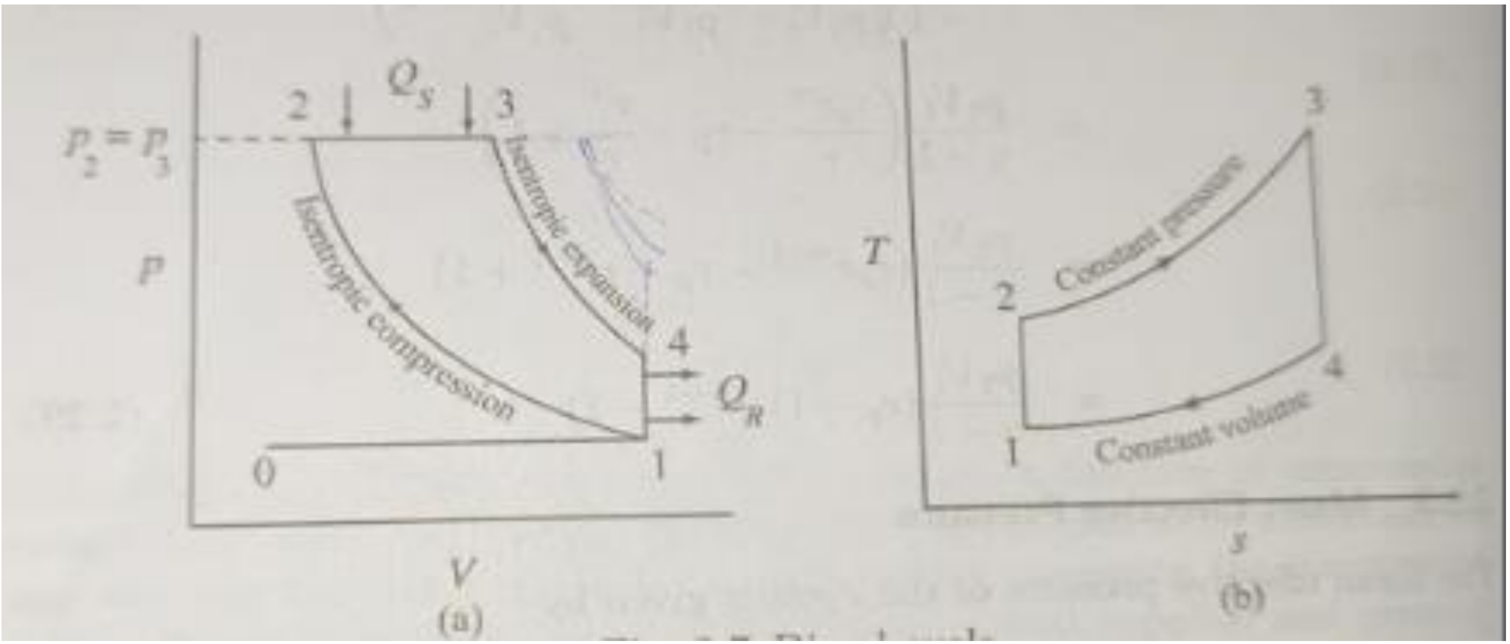
Diesel Cycle



1→2 : isentropic compression **2→3 : reversible constant pressure heating**

3→4 : isentropic expansion **4→1 : reversible constant volume**

Thermal efficiency of Diesel Cycle

$$\eta_{Diesel} = \frac{W_{net}}{q_s} = \frac{q_s - q_R}{q_s}$$

Heat supplied, $Q_1 = C_p(T_3 - T_2)$

Heat rejection, $Q_2 = C_v(T_4 - T_1)$

Compression ratio, $r = \frac{V_1}{V_2}$

Cut off ratio, $r_c = \frac{V_3}{V_2}$

Thermal efficiency, $\eta = \frac{Q_1 - Q_2}{Q_1} = \frac{C_p(T_3 - T_2) - C_v(T_4 - T_1)}{C_p(T_3 - T_2)} = 1 - \frac{1}{\gamma}\frac{(T_4 - T_1)}{(T_3 - T_2)}$

In adiabatic compression process 1-2,

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1}$$

$$T_2 = T_1.(r)^{\gamma-1}$$

Cut off ratio : It is the ratio of volume after heat addition to the volume before heat addition

In process 2-3, pressure constant, then

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

$$T_3 = T_2 . r_c = T_1 . (r\ )^{\gamma-1} . r_c$$

In adiabatic expansion process 3-4,

$$\frac{T_4}{T_3} = \left(\frac{V_3}{V_4}\right)^{\gamma-1} = \left(\frac{V_3}{V_2}\ \frac{V_2}{V_4}\right)^{\gamma-1} = (r_c)^{\gamma-1}\ \frac{1}{(r\ )^{\gamma-1}}$$

$$T_4 = T_3 . (r_c)^{\gamma-1}\ \frac{1}{(r\ )^{\gamma-1}} = T_1 . (r\ )^{\gamma-1} . r_c . (r_c)^{\gamma-1}\ \frac{1}{(r\ )^{\gamma-1}} = T_1 . r_c$$

$$\eta_{th} = 1 - \frac{1}{\gamma}\frac{(T_4 - T_1)}{(T_3 - T_2)} = 1 - \frac{1}{\gamma . (r\ )^{\gamma-1}}\left[\frac{(r_c)^{\gamma} - 1}{r_c - 1}\right]$$

$$\eta = 1 - \frac{(r_c)^{(\gamma)} - 1}{\gamma\,(r)^{(\gamma-1)}(r_c - 1)}$$

Engine performance Parameters

1. Indicated Power (I_p) – Power developed inside the cylinder.

$I_p = \frac{P_m LAKNn}{60 \ x \ 1000}$ kW

$$P_m = mean \ effective \ pressure$$

$P_m = \frac{work \ out \ put}{Swept \ Volume} = \frac{W_{net}}{V_s}$

$V_s = V_1 - V_2$ = cubic capacity

L = stroke , A= area of piston , N= speed in rpm

K = no. of cylinder

2. Break power (BP) - power available at out put shaft.

BP = Tω = $\frac{2\pi NT}{60\ X1000}$ Kw

3. Frictional Power (f_p)

f_p = I_p - BP

4. Mech. Efficiency

$$\eta_m = \frac{BP}{IP}$$

5. Indicated Thermal Efficiency

$\eta_{it} = \frac{IP}{m_f C_V}$ m_f= mass flow rate of fuel in kg / sec

C_V = calorific value in J/kg

6. Break Thermal efficiency (η_{bth})

$$\eta_{bth} = \frac{BP}{m_f C_V}$$

$$\eta_m = \frac{\eta_{bth}}{\eta_{ith}}$$

Indicated specific fuel consumption (isfc)

It is the fuel consume for developing indicated power .

ISFC = $\frac{m_f}{IP}$ unit = $\frac{kg/sec}{W}$

Sfc – sfc is measure of how efficiency the fuel supplied to the engine is used to produce power clearly a low value of sfc is

Desirable . Since for given power less fuel is consumed .

Brake specific fuel consumption (isfc)

It is the fuel consume for producing **BP.**

BSFC = $\frac{m_f}{BP}$; $\eta_m = \frac{isfc}{bsfc}$