Engine Nomenclature:

(1) **Top dead centre:** It is the dead centre when the piston is farthest from the crank shaft.
In case of horizontal engine TDC is known as inner dead centre (IDC).

(2) **Bottom dead centre (BDC):-** It is the dead centre when the piston is nearest to the crank shaft.
In case of horizontal engines it is known as outer dead centre (ODC).

(3) **stroke or stroke length (L):-** The distance between TDC and BDC is known as stroke or stroke length.

4) **Displacement / stroke / swept volume:- (V_s)**
It is the volume swept by the volum piston.

$$V_s = \frac{\pi}{4} D^2 L$$

D → diameter of cylinder (inner dia)

L → stroke length

if there are k no. of cylinders then the total swept volume or the

$$V_{Total} \Rightarrow K \times \frac{\pi}{4} D^2 L$$

4) **Displacement / stroke / Swept volume:- (V_s)**

It is the volume swept by the volum piston.

$$V_s = \frac{\pi}{4} D^2 L$$

D → diameter of cylinder (inner dia)

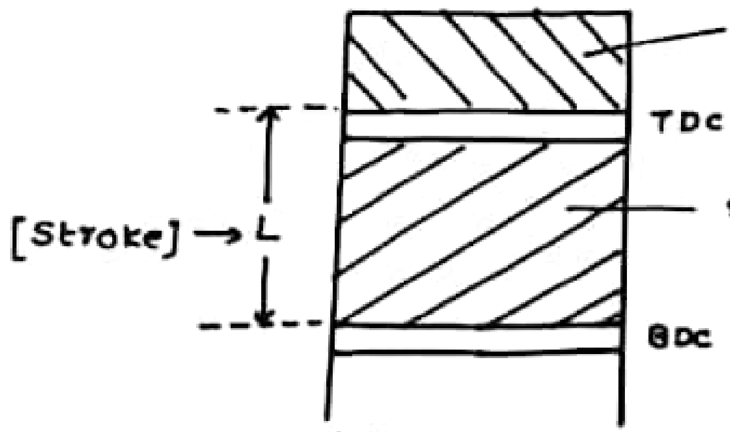
L → Stroke length

if there are k no. of cylinders then the total swept volume of the

$$V_{Total} \Rightarrow k \times \frac{\pi}{4} D^2 L$$

(5) **clearance Volume (V_c):-** It is the volume of the cylinder when the piston is at TDC or IDC.

clearance volume is provided to accommodate (or to provide space) valves and to prevent damaged to valves.



(6) **compression ratio (r):**

It is defined as the ratio of volume before compression to the volume after compression.

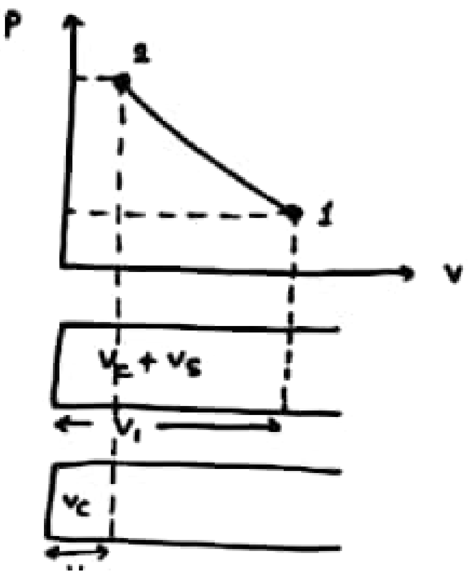
V_1 = Vol. before compression

$V_c + V_s$

V_2 = volume after compression

$V_2 = V_c$

$$r = \frac{V_1}{V_2} = \frac{V_c + V_s}{V_c} = 1 + \frac{V_s}{V_c}$$



Air standard Cycles—

Assumptions: Important

(1) The working fluid is air and it is treated as an ideal gas.

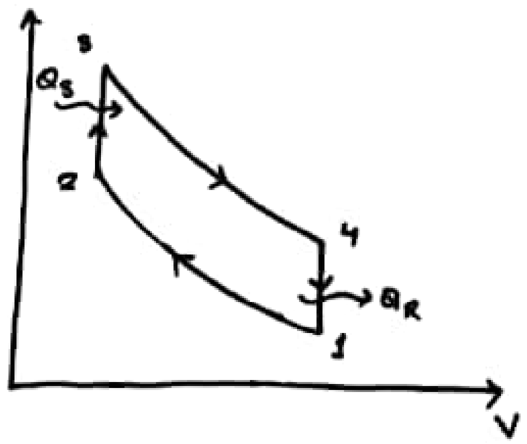
(2) Specific heat C_p & C_v are assumed to be constant.

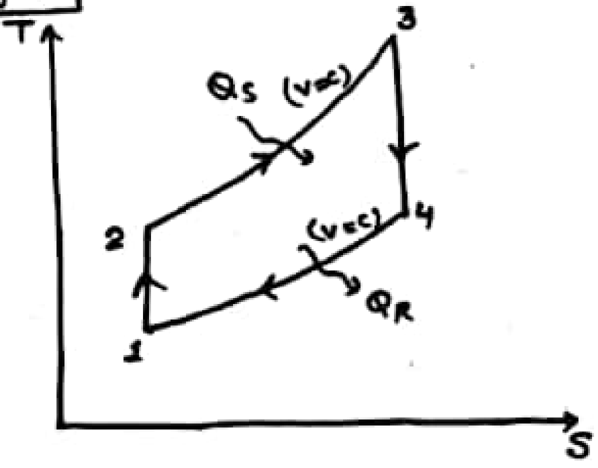
(3) The working fluid is of fixed mass. (closed system analy s)

(4) The working fluid doesnot undergo any chemical reaction i.e. it is constant chemical composition throughout the cycle.

(5) All processes are assumed to be reversible (internally reversibl

Otto Cycle



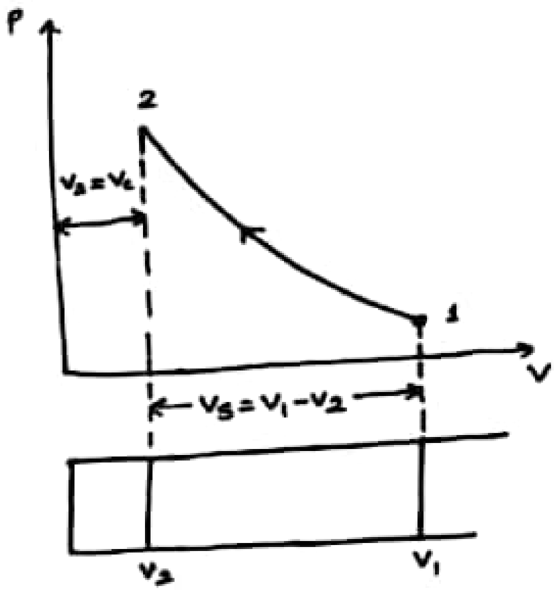


1-2 . rev. Adiabatic compression

2-3 - constant Volume Heat addition

3-4. rev. adiabatic expansion

4-1 - constant volume Heat Rejection



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

$$\eta = \frac{W_{net}}{Q_S}$$

$$\eta = 1 - \frac{Q_R}{Q_S}$$

2-3 process (v=c)

$$\delta Q = dU$$

$$\Rightarrow Q_S = mc_v(T_3 - T_2)$$

4-1 process (v=c)

$$Q_R = mc_v(T_1 - T_4)$$

$$-Q_R = mc_v(T_4 - T_1)$$ Heat Rejection

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

$-Q_R = mc_v(T_4 - T_1)$ Heat Rejection

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

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

1-2 (rev. adiabatic)

$$T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$$

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} = (r)^{\gamma-1} \quad \text{— (i)}$$

3-4 (rev. adiabatic expansion)

$$T_3 V_3^{\gamma-1} = T_4 V_4^{\gamma-1} \qquad V_4 = V_1, \; V_3 = V_2$$

$$\frac{T_3}{T_4} = \left(\frac{V_4}{V_3}\right)^{\gamma-1} \Rightarrow \left(\frac{V_1}{V_2}\right)^{\gamma-1}$$

$$\Rightarrow \frac{T_3}{T_4} = (r)^{\gamma-1} \quad \text{— (ii)}$$

From (i) and (ii)

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

$$\boxed{T_1 T_3 = T_2 T_4}$$ Imp. (Remember)^2

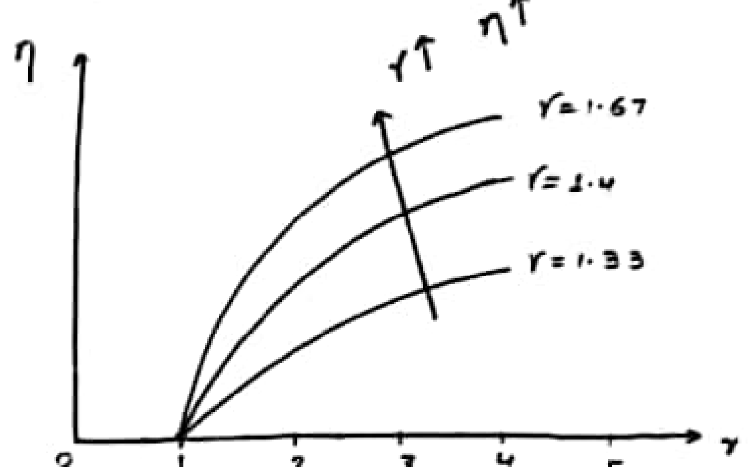
$$\Rightarrow \frac{T_4}{T_1} = \frac{T_3}{T_2} \qquad \Rightarrow \frac{T_4}{T_1} - 1 = \frac{T_3}{T_2} - 1$$

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

$$\boxed{\eta = 1 - \frac{1}{(r)^{\gamma-1}}}$$ (Remember)^3

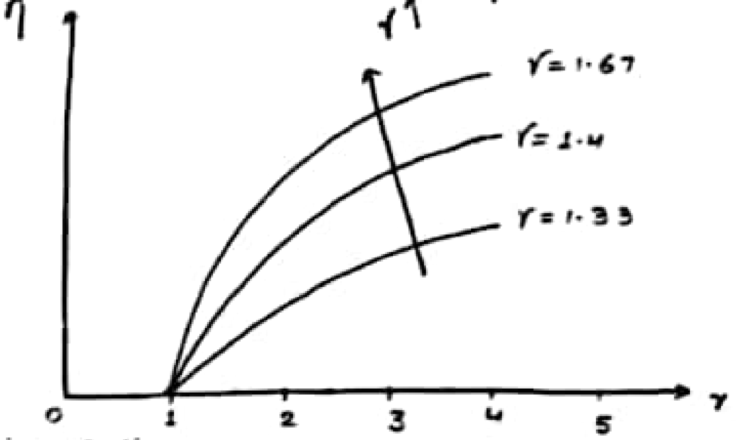
$r = 1 \quad \eta = 0$

$r \uparrow \quad \eta \uparrow$



$r = 1 \quad \eta = 0$

$r \uparrow \quad \eta \uparrow$

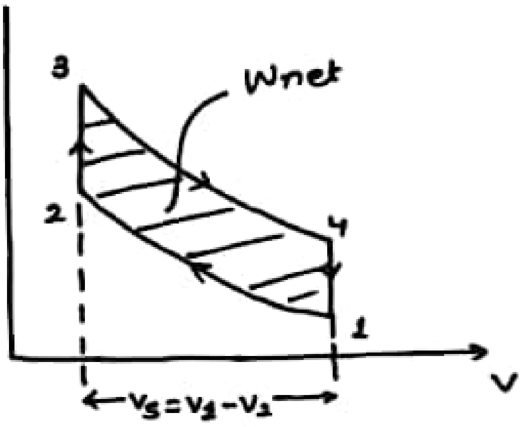


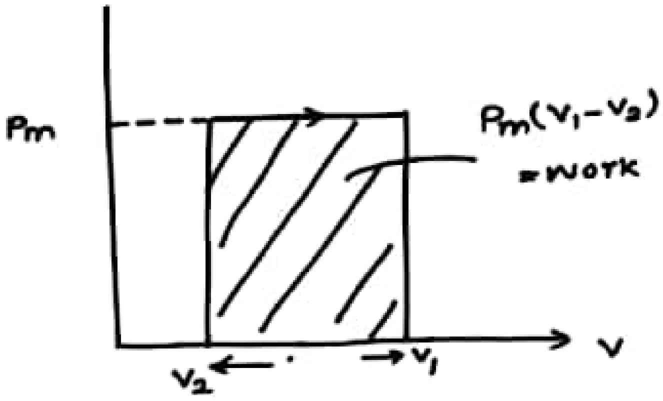
Significance of compression Ratio:-

compression ratio is an indicator of efficiency of the engine, greater the compression ratio, greater is the efficiency this is because if the compression ratio is high there is more scope for expansion and hence the Net work is more. Therefore for a given heat supply higher compression ratio mean the higher efficiency.

Mean effective pressure:- (Mep):-

It is the hypothetical (imaginary) const. pressure which gives same net work as that of the actual cycle for the same swept volume. (Same size of engine)



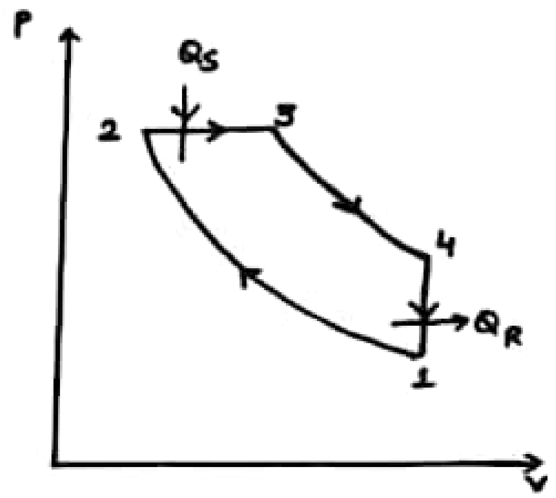


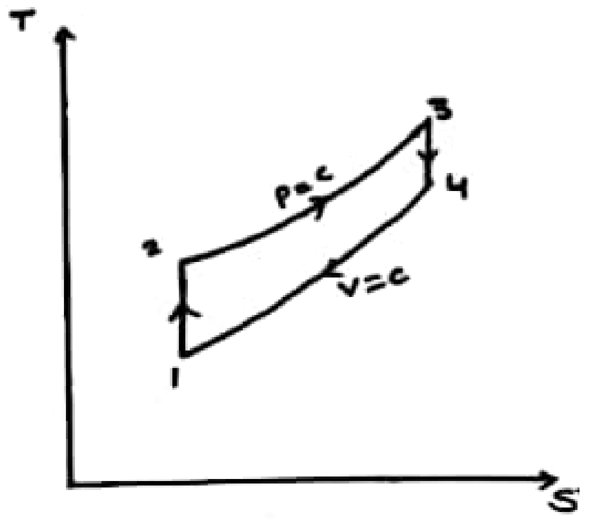
$$W_{net} = P_m (V_1 - V_2)$$

$$W_{net} = P_m \cdot V_s$$

$$\boxed{P_m = \frac{W_{net}}{V_s}}$$

Diesel cycle:-





1-2. rev. adiabatic compression

2-3. constant pressure HA

3-4. rev. adiabatic exponsion

4-1. const. volume HR

Airstandard ~~cycle~~ efficiency of diesel cycle.

compression ratio $(r) = \frac{V_1}{V_2}$

cutoff ratio $(r_c) = \frac{V_3}{V_2} = \frac{T_3}{T_2}$

$\left\{ \begin{array}{l} P = C \\ V \propto T \\ \frac{V_3}{V_2} = \frac{T_3}{T_2} \end{array} \right.$

"it is the ratio of volume after heat addition to the volume before Heat addition" i.e $\frac{V_3}{V_2}$

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

Expansion Ratio (r_e): It is the ratio of volume after expansion to the volume before expansion i.e.

$$\boxed{r_e = \frac{V_4}{V_3} = \frac{V_1}{V_3}}$$

$V_1 = V_4$

$r_c . r_e = \frac{V_3}{V_2} \times \frac{V_1}{V_3} \Rightarrow \frac{V_1}{V_2} = r$ (compression ratio)

$$r = r_e r_c$$

We calculate thermal efficiency b/c input is heat Supply (thermal).

$$\eta_{th} = \eta = \frac{W_{net}}{Q_S} = \frac{Q_S - Q_R}{Q_S}$$

$$\eta = 1 - \frac{Q_R}{Q_S}$$

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

$$\eta = 1 - \frac{1}{\gamma} \frac{T_1[T_4/T_1 - 1]}{T_2[T_3/T_2 - 1]}$$

1-2. (reversible adiabatic)

$$T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$$

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

2-3. $P = c$

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

3-4. (Rev. adiabatic expansion)

$$T_3 V_3^{\gamma-1} = T_4 V_4^{\gamma-1}$$

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

$V_4 = V_1$

$$\Rightarrow T_3 \left| \frac{V_3}{V_2} \cdot \frac{V_2}{V_1} \right|^{\gamma-1} = T_4$$

$$T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$$

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

2-3. $P = c$

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

3-4. (Rev. adiabatic expansion)

$$T_3 V_3^{\gamma-1} = T_4 V_4^{\gamma-1}$$

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

$$\Rightarrow T_3\left|\frac{V_3}{V_2}\cdot\frac{V_2}{V_1}\right|^{\gamma-1} = T_4 \qquad V_4 = V_1$$

$$T_3\left[(r_c)^{\gamma-1}\cdot\left(\frac{1}{r}\right)^{\gamma-1}\right] = T_4$$

$$T_3\cdot\left[(r_c)^{\gamma-1}\cdot\right]\frac{T_1}{T_2} = T_4 \qquad \frac{T_3}{T_2} = r_c$$

$$\Rightarrow \boxed{r_c^{\gamma} = \frac{T_4}{T_1}}$$

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

$$\boxed{\eta = 1 - \frac{1}{\gamma}\cdot\frac{1}{(r)^{\gamma-1}}\left[\frac{r_c^{\gamma}-1}{r_c-1}\right]}$$

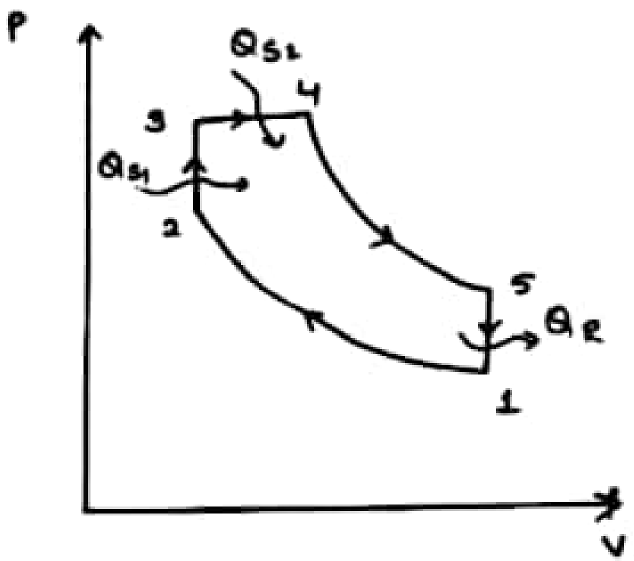
Efficiency of diesel cycle depends on compression ratio and cutoff ratio.

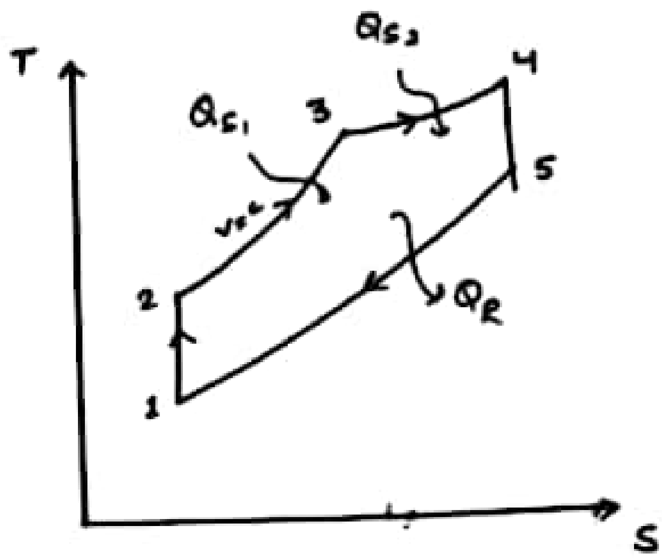
η of diesel cycle ↑ with ↑ in compression ratio.

η ↓ with ↑ r_c.

Dual Cycle:-

In actual engines heat is neither added at constant vol. nor at constant pressure a dual cycle is developed and it has features of both otto and diesel cycle.





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

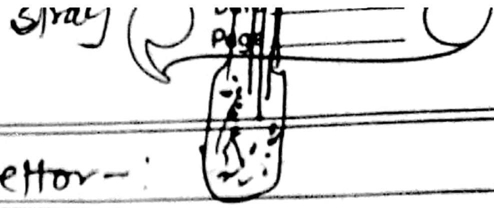
$$r_c = \frac{V_4}{V_2} = \frac{V_4}{V_3} \qquad r_e = \frac{V_5}{V_4}$$

$$\eta = 1 - \frac{Q_R}{Q_S}$$

$$Q_S = Q_{S_1} + Q_{S_2}$$

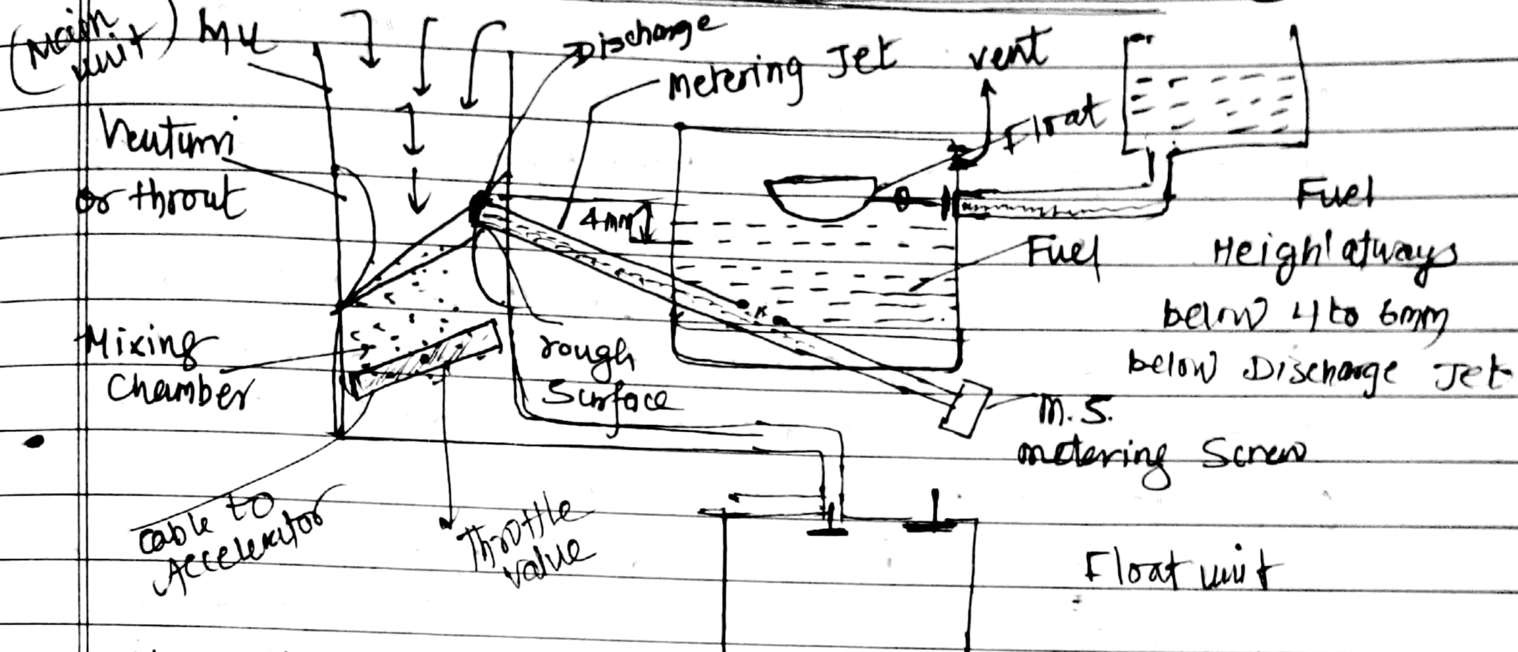
$$Q_{S_1} = mc_v(T_3 - T_2) \quad ; \quad Q_{S_2} = mc_p(T_4 - T_3)$$

$$Q_R = mc_v(T_5 - T_1)$$



CARBURETTORS.

working of a simple plain tube Carburettor -



Atomization, vapourization, uniform distribution.
↓ Proper combustion — uniform mixing

A simple plain tube Carburettor consist of two different section one section is known as the main unit of the Carburettor, (MU) the other section is known as the float chamber. A pipe extends from the main unit to the inlet valve of the engine cylinder this pipe is known as the intake ~~fold~~ manifold.

when suction takes place inside the engine cylinder, the vaccum extends to the Main unit this vaccum in the Main unit sucks the air from the atmosphere. after filtering. the air of x-s/c of the main unit keeps on decreasing in the direction of the air flow at a Particular Point the area of x-s/c is minimum and is known as the throat or Venturi, the velocity of the air is maximum at the throat

→ the Fuel From the float chamber enters the main unit through a Pipe known as the Metering Jet the tip of metering Jet ends at the throat of the main unit.
this tip is known as the Discharge Jet or orifice.

Working OF the Four-stroke Petrol engine-: 4-S. ENGINE

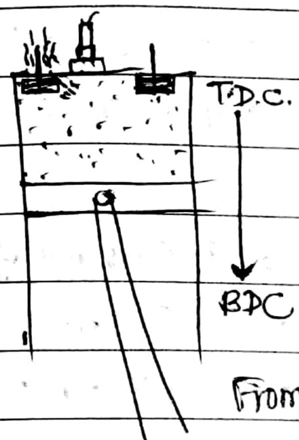


Fig.1

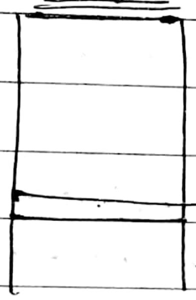


Fig1. inlet valve is Fully opened-the outlet valve is closed Piston moves From TDC to BDC. Fresh air Fuel mixture (AFM) enter the engine cylinder through the inlet valve From the Carburettor. The energy For the Motion of the Piston is supplied From the Flywheel that is attached to the shaft of engine. the Motion of the Piston From TDC to BDC during is known as Suction stroke.

Suction Stroke

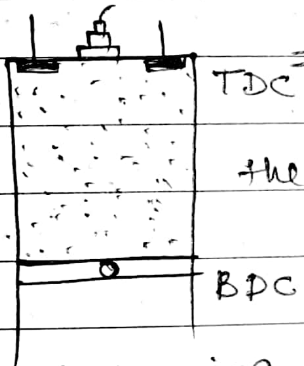


Fig.2

Fig.2 -: Due to the Continuous rotation of the shaft, the Piston moves up From BDC and the ~~the~~ inlet valve Closes immediately the outlet valve remains closed. Compression takes for the upward motion of the Piston From BDC to TDC. this ~~kno~~ motion is known as the Compression stroke)

Compression stroke

Current

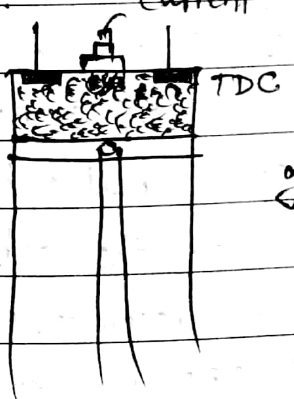


Fig.3

Fig.3 -: at a end of the Compression stroke, the Piston is at T.DC and current is supplied to the Sparp plug. the Fuel Particle with the AFM inside the cylinder gets ignited and heat From the Fuel is transffered to air. this heat addition takes place at constant volume. the voltage supplied to the Sparg plug during this h.A about 10000 — 12000 Volts.

H.A at Const volume

Fig.4 at the end of HA. the strong and Hot gases expands and Pushes the Piston down From TDC to BDC useful Power is obtained during this motion of the Piston. the motion of the Piston is Known as expansion or the Power stroke.

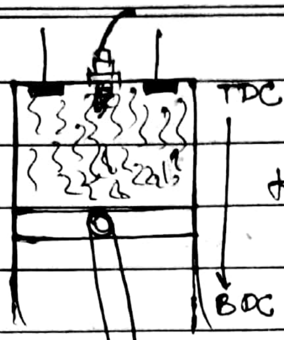


fig.4

Expansion or Power stroke

Fig.5 H.R. at the end of expansion the Piston is at BDC and the outlet valve is open. the Pressure of the expanded gases at this Point is much above the atmospheric Pressure. the expanded gases Flow out of the cylinder through the exhaust valve ~~during~~ due to difference in Press. about 90—95% of a expanded gases leaks out of the cylinder during HR.

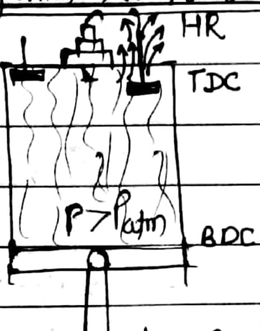


fig.5

HR. at Const. Volume

H-5% gas remaining

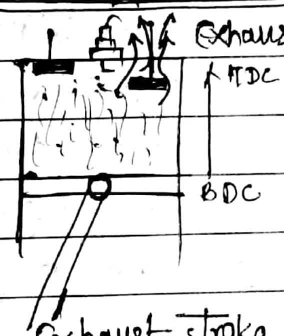


Fig.6 the left over gases after HR is Push out of a outlet valve by the upward motion of the Piston From BDC to TDC. the energy leaving the cylinder with the gases is Negligible in comparison to HR. the flow of the gases during this upward motion of the Piston Known as Exhaust and the Piston motion called Exhaust stroke

fig.6

Exhaust stroke

× No entry

1.2 bar > Patm

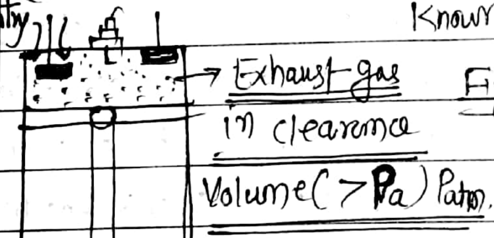


Fig.7 – at the end of exhaust stroke the Piston is at TDC and some exhaust gas will Remain in the clearance Volume. the Pressure of this gas is above atmospheric. the outlet valve closes and the inlet valve open.

fig.7

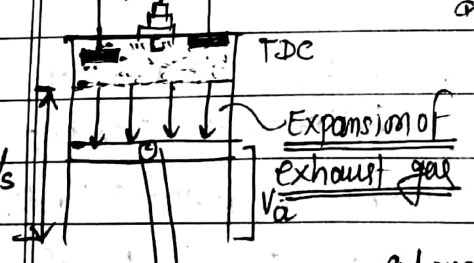


Fig.8 – Suction stroke begins for the Next cycle. but Fresh AFM is not able to enter in as the Press. inside the cylinder is above atmospheric hence, the space created by the downward motion of the Piston. is filled by the exhaust gas in the clearance volume. when the Press. becomes equal to the atm Pressure inside the cylinder then Fresh AFM will enter in till the end of the suction stroke. it is thus clear that the actual Volume of air (Va) entering the cylinder during suction is less than the stroke volume.

fig.8

Working of the Two stroke engine -: 2-S ENGINE

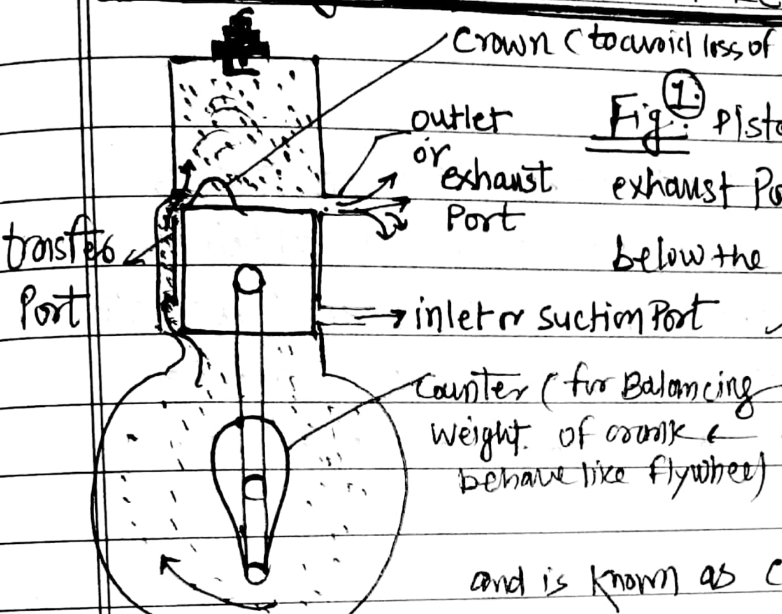


Fig-1

Fig ①: Piston is at BDC both the transfer port and the exhaust Port are open. the Partly Compressed Fresh AFM. below the Piston flows through the transfer port to the space above the Piston. A small quantity of Fresh AFM. ~~Flow~~ will Flow out through the exhaust Port to avoid this Flow a Projection is Provided at the top of the Piston and is Known as Crowning the Fresh A.F.M. Collides with the Crown and rises to the top. this AFM. Rushes the left over exhaust gas of the Previous Cycle through the exhaust Port. this operation is Known as "Scanvenging"

Fig-2 When the Piston is about to Move up, compression begins ~~for the fresh AFM.~~ if the space above the Piston. when the Piston has completed about 30% of the Compression stroke the inlet Port is open to the Space ~~to~~ below the Piston the Fresh AFM. of the Next cycle enters the cylinder below the Piston. this Suction Process Continues till the end of the compression stroke

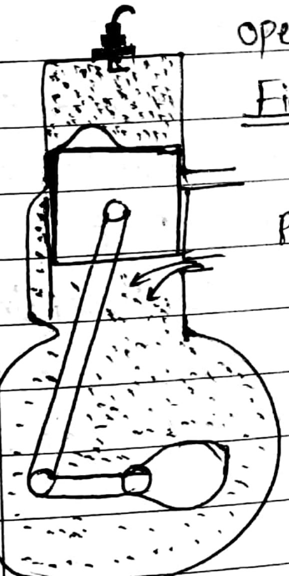


Fig-2

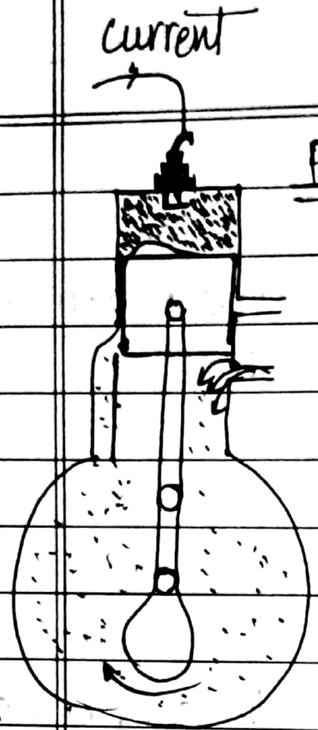


Fig.3. at the end of compression stroke the Piston is at TDC, and current is supplied to the Spark plug. Heat addition takes place at Const. volume.

Fig.3

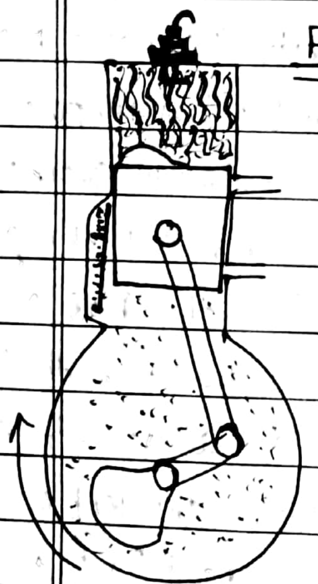


Fig.4 at the end of Heat addition the Hot gases Pushes the Piston down useful Power is obtained. as the Piston completes about 70% of the Power stroke the inlet Port is closed. Further downward motion of the Piston will Partly compressed Fresh AFM. below the Piston.

Fig.4

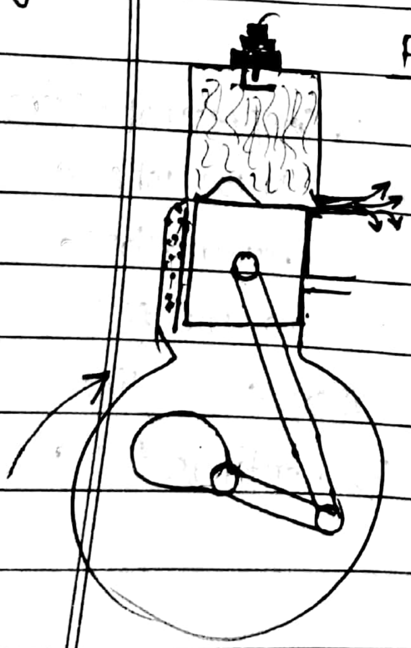


Fig.5. When the Piston has completed about 90% of the Power stroke, the exhaust Port is open and a Measure Portion of the expanded gases leaves the cylinder through the exhaust Port. during the remaining motion the of the Powerstroke as the Piston reaches BDC, the operations are repeated in the same manner as explained.

Fig. 5

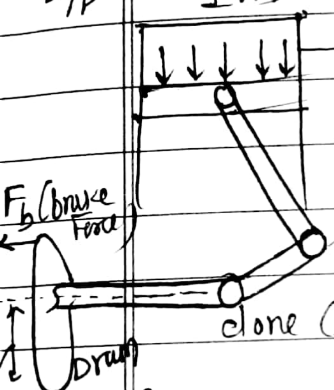
(b) Four stroke engine – (one cycle – Four stroke) Two rotation are completed

→ one suction → volume of air taken in = V_s

∴ For 1 rotation, Average volume of air = $\frac{V_s}{2}$

For N rotation, volume of air taken in = $V_s \times \frac{N}{2}$

(2) Mechanical efficiency –



→ Input to Piston due to expansion of air. Pressure & volume change, work done is found from P-V diagram. P-V diagram is also known as indicator diagram. Thus, the input to the piston is known as Indicated work done (IWD).

the work output from the piston is found by a brake mechanism and is therefore known as the Brake work done (BWD) the ratio of the Brake work done to the indicated work done is defined as the Mechanical efficiency of the engine. it is given by

$$\eta_m \text{ (Mech. efficiency)} = \frac{BWD}{IWD}$$

$$\eta_m = \frac{bmep \times V_s}{imep \times V_s} = \frac{bmep}{imep}$$

bmep – brake mean effective pressure

Scanned by CamScanner

(3) **Power (P) =** $P = \frac{\text{Work done}}{\text{time}} = \frac{W/D}{sec}$; $\frac{\text{Joule}}{sec}$ = watt.

Brake Power = $\frac{\text{Brake WD}}{sec}$, Indicated Power = $\frac{IWD}{sec}$

(4) **Heat added.** - Heat Produced to burn 1kg of Fuel

$HA/\text{kg of fuel}$ = calorific value (CV)

$H.A = m_f \times C.V.$

$$H.A/sec = m_f/sec \times C.V$$

m_f = mass of fuel

$$H.A/sec = HA/\text{kg of fuel} \times m_f/sec$$

(5) **Thermal efficiency**

$$\eta_{th.} = \frac{\text{Work done}}{\text{Heat added}}$$

$$\eta_{\text{Brake Thermal}} = \frac{BWD}{HA}$$

$$\eta_{\text{indicated Thermal}} = \frac{IWD}{HA}$$

(6) ∴ **Specific fuel consumption (S_{fc})**

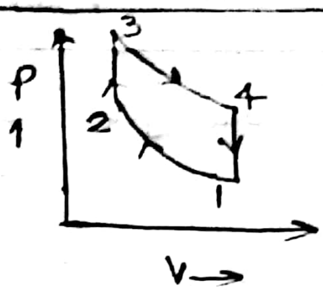
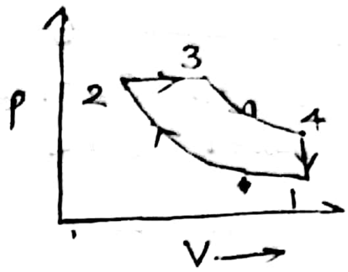
$$S_{fc} = \frac{m_f/hr}{\text{Power (KW)}}$$

bs_{fc} = brake specific Fuel Consumption

$$= \frac{m_f/hr}{\text{Brake Power (KW)}}$$

$$is_{fc} = \frac{m_f/hr}{\text{Indicated Power (KW)}}$$

(7) Average Piston Speed = 2LN

	Basis	Petrol Engine	Diesel engine
			
1	Name	SI (spark ignition)	CI (Compression ignition)
2.	Additional equipement	Carburettor, Spark Plug	Fuel Injector
3.	Suction	(A+F) Mixture	only Air
4.	Ignition	Spark plug	Compressed Hot gas
5	Cycle	Otto Cycle	Diesel Cycle
6.	Heat Addition	Constant Volume	Constant Pressure
7.	efficiency	$\eta = 1 - \frac{1}{(r)^{\gamma-1}}$	$\eta = 1 - \frac{1 \, (r_c^{\gamma} - 1)}{(r)^{\gamma-1} \gamma (r_c - 1)}$
8.	Construction	Light	Heavy
9.	Compression Ratio	Low (6—10)	High (16-20

Two stroke engine	Four stroke engine
1. one Cycle (Suction, Compression Power, Exhaust) is Completed in two strokes of Piston and one revolution of Crank shaft	1. One Cycle (Suction, Compression Power, Exhaust) is Completed in four strokes of Piston and two revolution of Crankshafts
3. Suction (Inlet Port) and Exhaust (Outlet Port) is used	3. Inlet and outlet Valves is used.
4. Lubricating oil is taken is mixed with Petrol before being taken inside the Fuel tank	4. The lubricating oil is taken in Separately (It is not mixed with the Fuel)
5. The Lubricating oil enters into the Combustion chamber along with the Fuel hence a small quantity of lubricating oil gets burn. due to this Region the Friction Losses are More in two-stroke engine	5. The Lubricating oil does not enter the Combustion chamber