സഹായി

SFI GEC PALAKKAD

Mod 1

Analysis Of Thermodynamic Cycle

Ideal gas equation:-

$$PV = mRT$$

p - Pressure in N/m^2 or pascal

v - Volume in m^3

m - mass in kg

R - characteristic gas constant J/kgK

T - Temperature in kelvin.

Boyles law :- $P \propto 1/V$ at const T.

charles law :- $V \propto T$ at const. P.

~~$PV = \bar{R}T$~~

$\bar{R}$ = Universal gas constant 8314 J/kgK 8.314 KJ/kgK.

$$R = \frac{\bar{R}}{\text{~~atomic~~ molecular weight}}$$

For air,

characteristic gas constant $R = \frac{\bar{R}}{29} =$ ~~8.2867~~ 287 J/kgK

~~Specifi~~

$$R_{CO_2} = \frac{\bar{R}}{44} = \frac{8314}{44} = 189 \text{ J/kgK}$$

Specific heat :- Amount of heat required to rise the temperature of Unit mass of a substance by 1°c.

Specific heat of water = 4.18 KJ/kgK

$$c = \frac{Q}{m\Delta T}$$

$$Q = mc\Delta T$$

c_p - Specific heat at Constant Pressure

C_v - Specific heat at constant Volume

For water $C_p = C_v = C$

For gasses $C_p \neq C_v$

$$C_p - C_v = R$$

C_p of air $= 1.005$ kJ/kgK

C_v " " $= 0.718$ kJ/kgK

$$1.005 - 0.718 = \cancel{0.305}\ 0.287$$

$\frac{C_p}{C_v} = \gamma$, adiabatic constant.

For air, $\gamma = 1.4$

$$\frac{1.005}{0.718} = 1.39 \approx 1.4$$

Process	P-V-T relation $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$	Q (heat)	W
Isobaric Process (P const)	$\frac{V_1}{T_1} = \frac{V_2}{T_2}$	$mC_p(T_2 - T_1)$	$P(V_2 - V_1)$
Isochoric	$\frac{P_1}{T_1} = \frac{P_2}{T_2}$	$mC_v(T_2 - T_1)$	0 ($\because$ V const)
Isothermal	$P_1V_1 = P_2V_2$	$P_1V_1 \ln(V_2/V_1)$	$P_1V_1 \ln(V_2/V_1)$
Adiabatic Process	$P_1V_1^{\gamma} = P_2V_2^{\gamma}$	0	$\frac{P_1V_1 - P_2V_2}{\gamma - 1}$

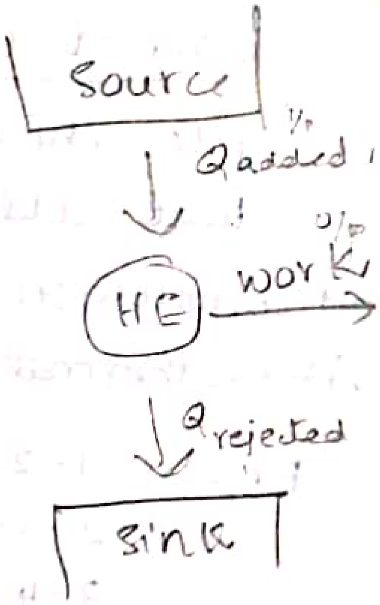
Reversible adiabatic process = Isentropic process.

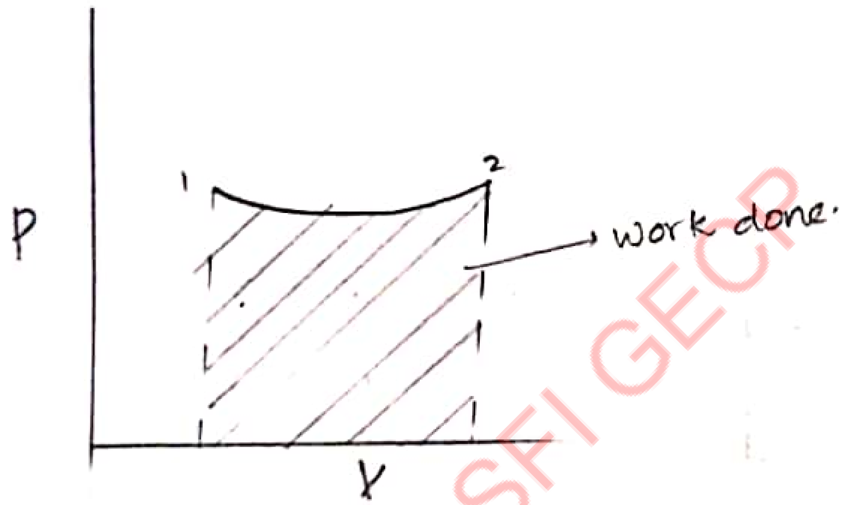
Air - standard efficiency

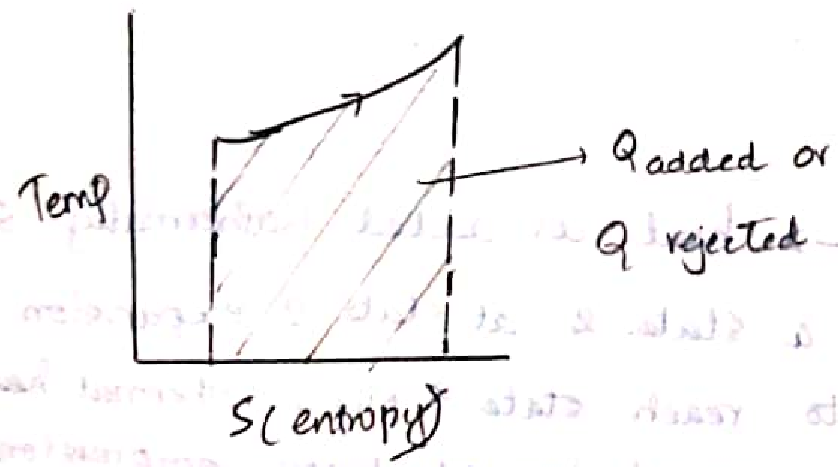
$$\eta = \frac{\text{Output}}{\text{input}}$$

$$= \frac{\text{work}}{Q\ \text{added}} = \frac{Q_{added} - Q_{rejected}}{Q_{added}}$$

$$\boxed{\eta = 1 - \frac{Q_{rejected}}{Q_{added}}}$$







carnot cycle :- carnot cycle is a reversible (ideal) cycle which consist of 4 process.

Heat-addition and heat rejecⁿ are carried out isothermally

→ compression and expansion are adiabatics.

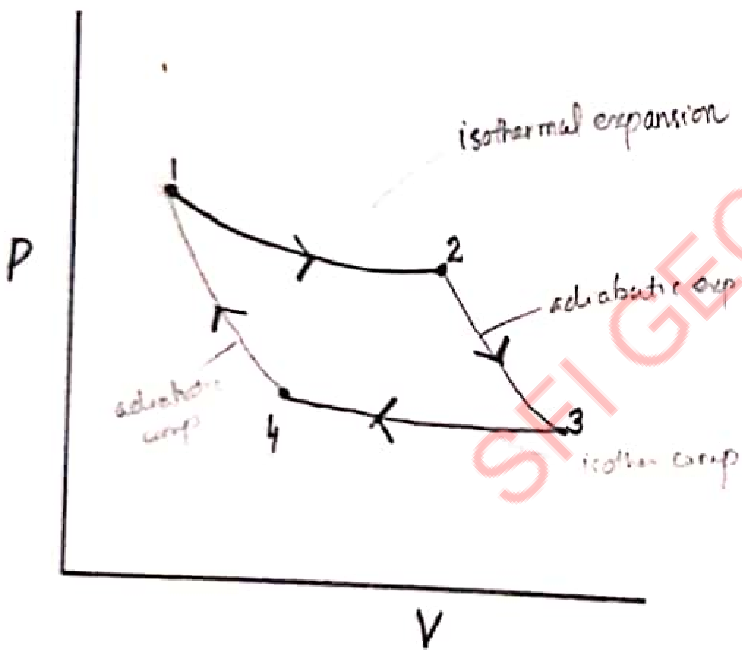
~~(i) isothermal expansion :- process (1 – 2)~~

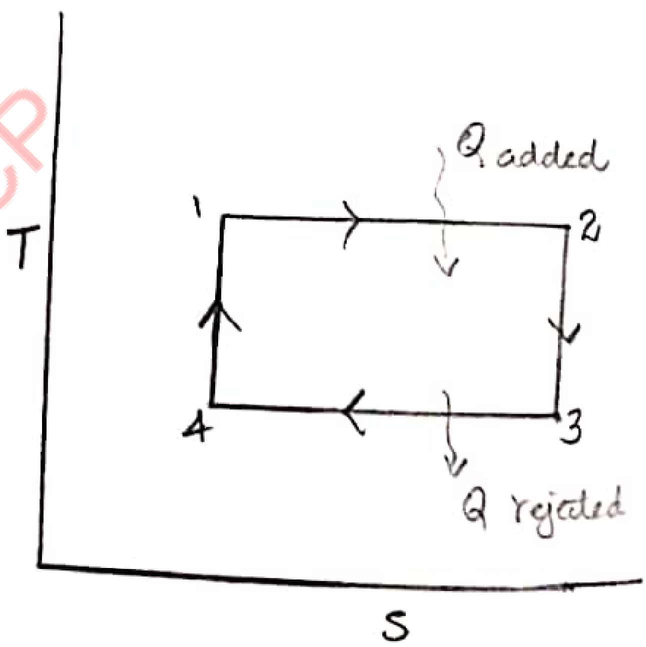
Process 1–2 :- isothermal expansion

" 2–3 :- adiabatic "

" 3–4 :- isothermal compression

4–1 :- adiabatic compression.





During process 1–2 heat is added isothermally so that it reaches to a state 2. at state 2 expansion is done adiabatically to reach state 3. Now, isothermal heat rejection take place followed by adiabatic compression.

$$\eta_{air\ stand} = 1 - \frac{Q_{rejected}}{Q_{added}}$$

$$= 1 - \frac{T_3(S_3 - S_4)}{T_1(S_2 - S_1)} \quad (1)$$ (Since area under Temp and S(entropy) gives ~~work~~ heat rejected or added)

but $S_3 = S_2$ & $S_4 = S_1$

$$(1) \Rightarrow\ = 1 - \frac{T_3(\cancel{S_2 - S_1})}{T_1(\cancel{S_2 - S_1})} = 1 - \frac{T_3}{T_1}$$

$$\boxed{\eta = 1 - \frac{T_{lower}}{T_{higher}}}$$ Temp in kelvin scale.

NOTE

For an engine working b/w two temp limits max efficiency will be carnot efficiency

? Find the carnot efficiency of an engine working b/w 37°c and 373°c

$$\rightarrow \quad \eta = 1 - \frac{T_{lower}}{T_{higher}}$$

$$= 1 - \frac{37 + 273}{373 + 273} = 1 - \frac{310}{646}$$

~~1 - 0.099 = 0.901~~ $1 - 0.479$

$= 0.521$

Ramu claims that his engine working b/w 30°c and 384°c is having an efficiency of 75% comment on this.

$T_{lower} = 30°C = 303K$

$T_{higher} = 384°C = 657K$

$$\eta = 1 - \frac{30+273}{384+273} = 1 - \frac{303}{657}$$

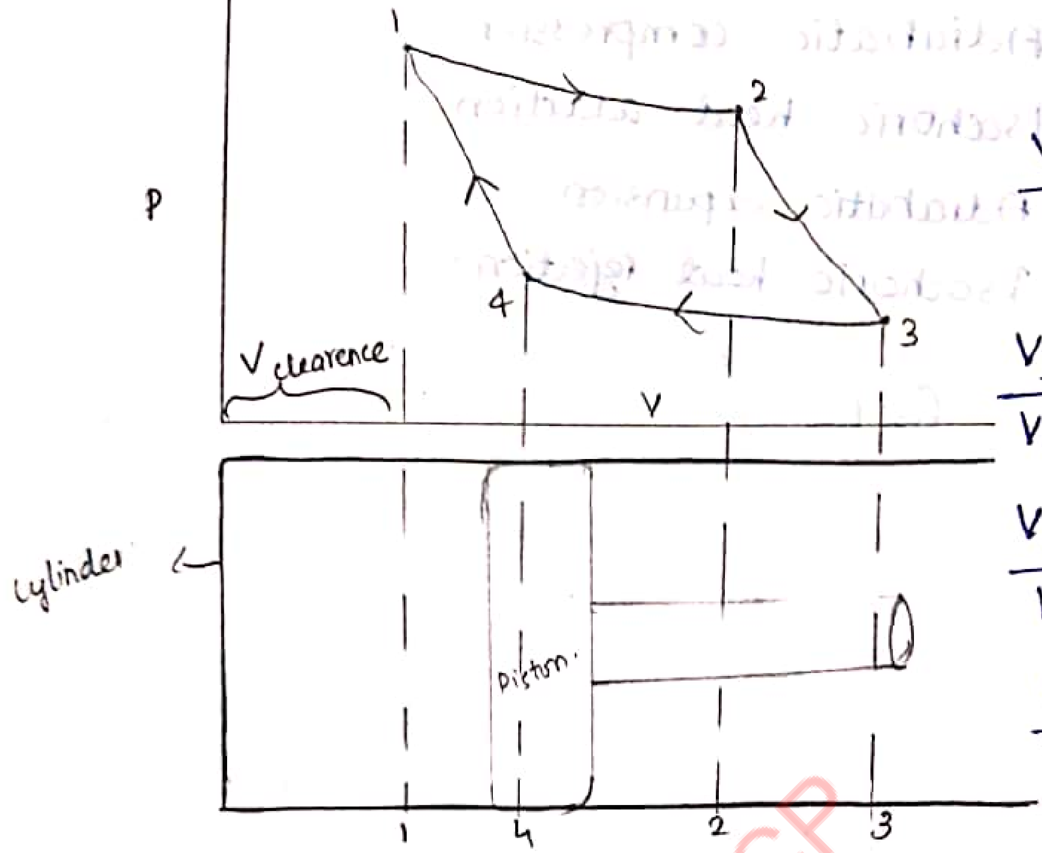
$$= 1 - 0.461 = \underline{\underline{0.54}}$$

efficiency is 54%.

As the Carnot efficiency is 54%. The given statement is wrong.

Assumptions in air standard cycle

1. Air is used as the working fuel.
2. System is a closed system undergoing a cycle.
3. compression and expansion are reversible adiabatics.
4. combustion is replaced by equivalent amount of heat addition process and exist is replaced by equivalent amount of heat rejecⁿ process.
5. C_p and C_v are constant with respect to temperature



$\frac{V_2}{V_1}$ = Isothermal expansion ratio

$\frac{V_3}{V_4}$ = Isothermal compression ratio

$\frac{V_4}{V_1}$ = Adiabatic compression ratio

$\frac{V_3}{V_2}$ = Adiabatic expansion ratio

impracticability of carnot cycle

Given heat addition and heat rejection to be done isothermally, which requires the perticular process to be carried out at very low speed so as to maintain constant temperature. at the same time compression and expansion are carried out isentropically. which is to be carried out quickly as possible.

Thus, sudden changes in the speed of engine in one cycle is not possible in ~~act~~ actual practice.

Otto Cycle

Petrol engine (spark ~~ignit~~ ignition engine / SI engine) works on the basis of otto cycle.

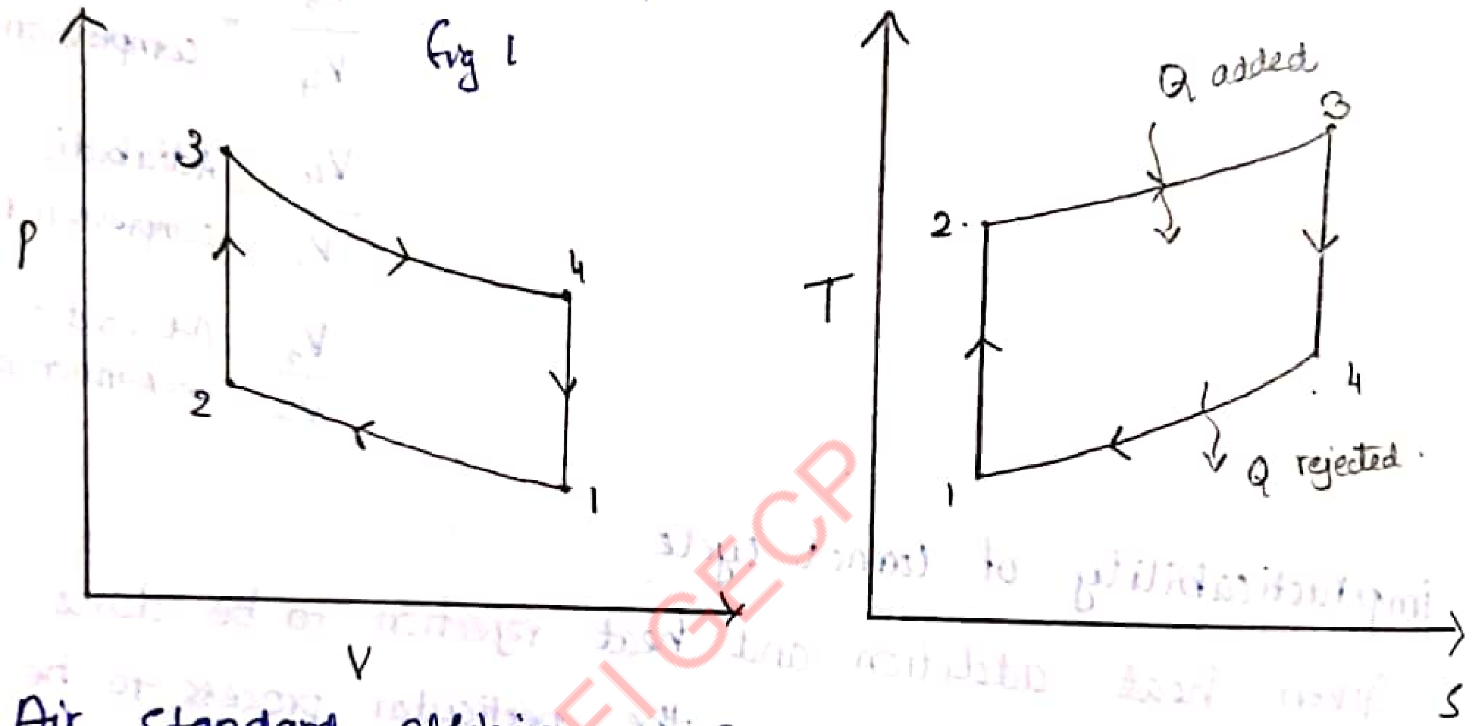
it consist of 4 reversible process as following

process 1–2 : Adiabatic compression

2–3 : Isochoric heat addition

3–4 :- Adiabatic expansion

4–1 :- Isochoric heat rejection.



Air standard efficiency of otto cycle

$$\eta = 1 - \frac{Q_{rejected}}{Q_{added}}$$

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

$\because$ $Q_{rejected} = mc_v(T_4 - T_1)$ from process 4–1

$Q_{added} = mc_v(T_3 - T_2)$ from Process 2–3

$$\eta_{otto} = 1 - \frac{(T_4 - T_1)}{(T_3 - T_2)} \quad \text{——— (1)}$$

From process 1−2

$\frac{V_1}{V_2}$ = compression ratio = r_c

From process 3−4

$\frac{V_4}{V_3}$ = expansion ratio = r_e

from fig 1.

$V_1 = V_4$ & $V_3 = V_2$

$\therefore \frac{V_1}{V_2} = \frac{V_4}{V_3} \Rightarrow r_c = r_e = r$. For otto cycle.

For an adiabatic process

$P_1V_1^{\gamma} = P_2V_2^{\gamma}$

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

from process 1-2

$P_1V_1^{\gamma} = P_2V_2^{\gamma}$

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

$\frac{T_2}{T_1} = r^{\gamma-1} \Rightarrow T_2 = T_1 r^{\gamma-1}$ ——— (2)

Process 3−4.

$P_3V_3^{\gamma} = P_4V_4^{\gamma}$

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

$\frac{T_3}{T_4} = r^{r-1} \Rightarrow T_3 = T_4 r^{\gamma-1}$ ——— (3).

~~eq^n (1)~~ (2) & (3) in eq^n (1)

$$\eta = 1 - \frac{T_4 - T_1}{T_4 r^{r-1} - T_1 r^{r-1}}$$

$$= 1 - \frac{T_4 - \cancel{T_1}}{r^{\gamma-1}(T_4 - \cancel{T_1})} = 1 - \frac{1}{r^{\gamma-1}}$$

$$\boxed{\eta_{otto} = 1 - \frac{1}{r^{\gamma-1}}}$$

r = compression / expansion ration

$\gamma \Rightarrow$ adiabatic index

for air $\gamma = 1.4$

r is compression ratio and value ranges from 6 – 10.

? An engine works on the basis of otto cycle. with an efficiency of 40%. take $\gamma = 1.4$ find compression ratio

→

$\eta = 40\%$

$= 0.40$

$\gamma = 1.4$

$$\eta = 1 - \frac{1}{r^{\gamma-1}}$$

$$0.40 = 1 - \frac{1}{r^{1.4-1}}$$

$$0.40 \cancel{-1} = \frac{1}{r^{1.4-1}}$$

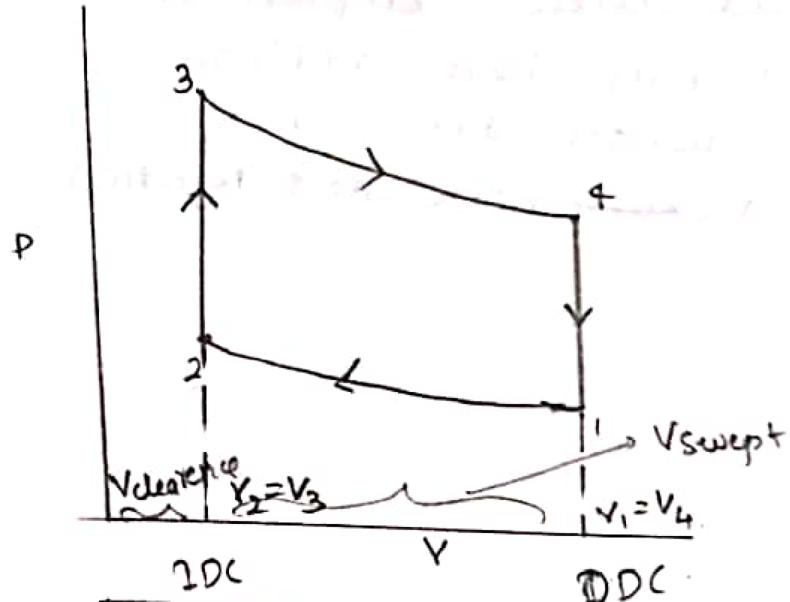
$$0.\cancel{4}6 = \frac{1}{r^{0.4}}$$

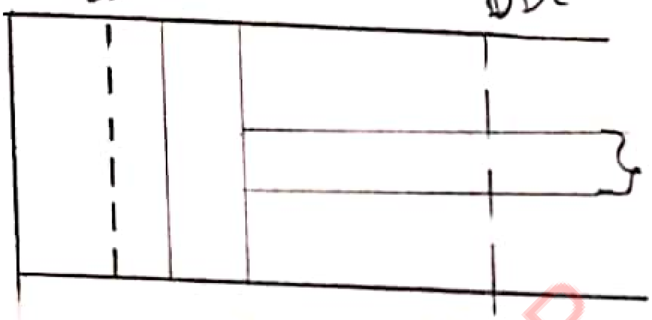
$$\frac{1}{0.6} = r^{0.4}$$

$$r^{0.4} = (1.6)^{(1/0.4)}$$

$$= \underline{3.2}$$

SFIGECP





V_2 = clearence volume

$V_{S} = V_1 - V_2$

total volume $= V_1$

~~$V_1 = (V_2 + V_1)$~~

$V_1 = V_2 + (V_1 - V_2)$

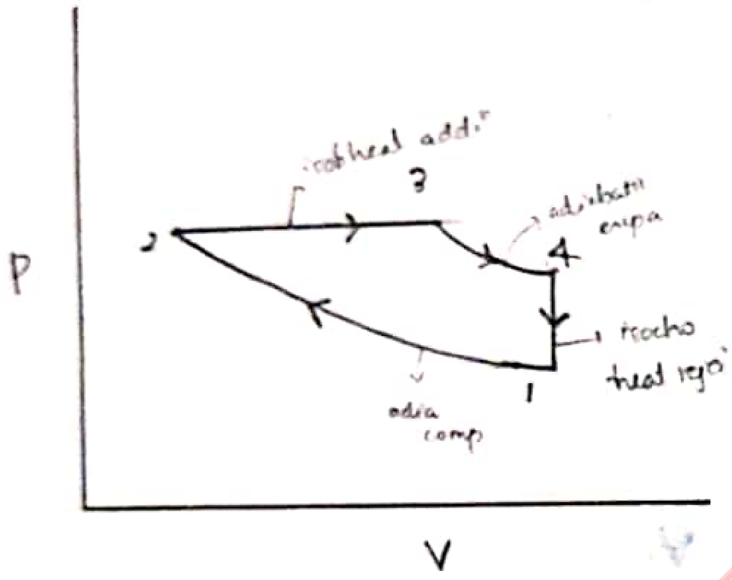
$$\boxed{V_{Total} = V_c + V_s}$$

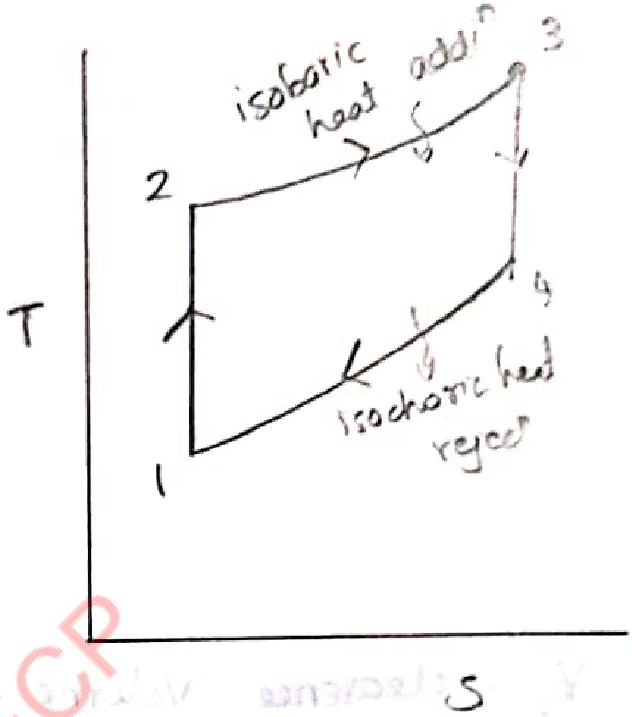
Diesel cycle

Disel engine (compression ignition engine / CI engine) works on the basis of Diesel cycle. it consist of four reversible process.

Heat addition take place isobarically and heat rejection take place isochorically. compression and expansion are reversible adiabatics.

Process 1-2 : adiabatic compression
" 2-3 : isobaric heat addition
3-4 : adiabatic expansion
4-1 : iso~~baric~~choric heat rejection.





compression ratio, $r_c = V_1/V_2$

expansion ratio, $r_e = \frac{V_4}{V_3}$

$r_c \neq r_e$.

cutt off ratio, $\rho = V_3/V_2$

$$\frac{r_c}{r_e} = \frac{V_1}{V_2} \times \frac{V_3}{V_4}$$

$$= \frac{V_3}{V_2} \quad [\because V_1 = V_4] \quad = \rho.$$

$$\boxed{\frac{r_c}{r_e} = \rho}$$

Air standard efficiency of diesel cycle

$$\eta_{diesel} = 1 - \frac{Q_{rejected}}{Q_{added}}$$

From 2-3 pro $\Rightarrow$ $Q_{added} = MC_p(T_3 - T_2)$

4-1 $\Rightarrow$ $Q_{rejected} = MC_v(T_4 - T_1)$

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

$$= 1 - \frac{1\,(T_4 - T_1)}{\gamma\,(T_3 - T_2)} \quad \text{—— (1)}$$

From pro 1-2 $\Rightarrow$ $P_1V_1^{\gamma} = P_2V_2^{\gamma}$

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

$$\frac{T_2}{T_1} = r_c^{\gamma-1}$$

$$T_2 = T_1 r_c^{\gamma-1} \quad \text{—— (2)}$$

From 2-3

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

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

$$T_3 = T_2\,\rho$$

$$T_3 = T_1 r_c^{\gamma-1}\rho \quad \text{—— (3)}$$

From 3-4

$$P_3 V_3^{\gamma} = P_4 V_4^{\gamma}$$

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

$$T_4 = \frac{T_3}{(r_e)^{\gamma-1}}$$

$$= \frac{T_3}{\left(\frac{r_c}{\rho}\right)^{\gamma-1}}$$

$$\frac{r_c}{r_e} = \rho$$

$$r_e = \frac{r_c}{\rho}$$

$$= \frac{T_1 r_c^{\gamma-1} \rho}{(r_c)^{\gamma-1}} \times \rho^{\gamma-1}$$

$$T_4 = T_1 \rho^{\gamma} \quad \text{--- (4)}$$

Substitute eqn no 2, 3, 4 in (1)

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

$$= 1 - \frac{(T_1 \rho^{\gamma} - T_1)}{\gamma\left(T_1 r_c^{\gamma-1} \rho - T_1 r_c^{\gamma-1}\right)}$$

$$= 1 - \frac{\cancel{T_1}(\rho^{\gamma} - 1)}{\gamma\left[\cancel{T_1} r_c^{\gamma-1}(\rho - 1)\right]}$$

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

$$\eta_{diesel} = 1 - \frac{1}{r_c^{\gamma-1}} \left[\frac{1}{\gamma} \frac{\rho^{\gamma}-1}{r(\rho-1)} \right]$$

Where
r is the compression ratio (16-20).
γ is adiabatic index
ρ cutoff ratio.

Actual working of Engines

Engines are mainly of two types.

1. External combustion engine (EC engine)
here combustion process takes place externall[y] power so obtained is used to drive applications lik[e] steam engine → bulky dimension.

2. Internal combustion engine (IC engine)
Here combustion take place inside a closed c[hamber] and the power obtained from the same is used to c[...] applica^n's like the automobile, generator.
→ compact design

Stroke :- movement of piston from one dead centre [to] other dead centre is termed as stroke. (ie, either TDC to BDC or BDC to TDC)

Based on no. of strokes in a cycle IC engin[es] classified into two.

(i) four stroke engine
If one cycle of opera^n is compled in 4 stro[kes]

piston or two revoluⁿ of ~~frankshaft~~ crankshaft. Then it is called 4 stroke engine.

eg:- 4 stroke petrol and 4 stroke diesel engine.

(II) Two stroke engine

If one ~~stroke~~ cycle of operaⁿ is completed by two strokes of the piston or one revoluⁿ of ~~Crankshaft~~ crankshaft is called two stroke engine

Eg:- 2 stroke petrol and 2 stroke diesel engine.

working of 4 stroke petrol engine

Here one cycle of operaⁿ is completed by 4 strokes of piston or two revoluⁿ of ~~frankshaft~~ crankshaft

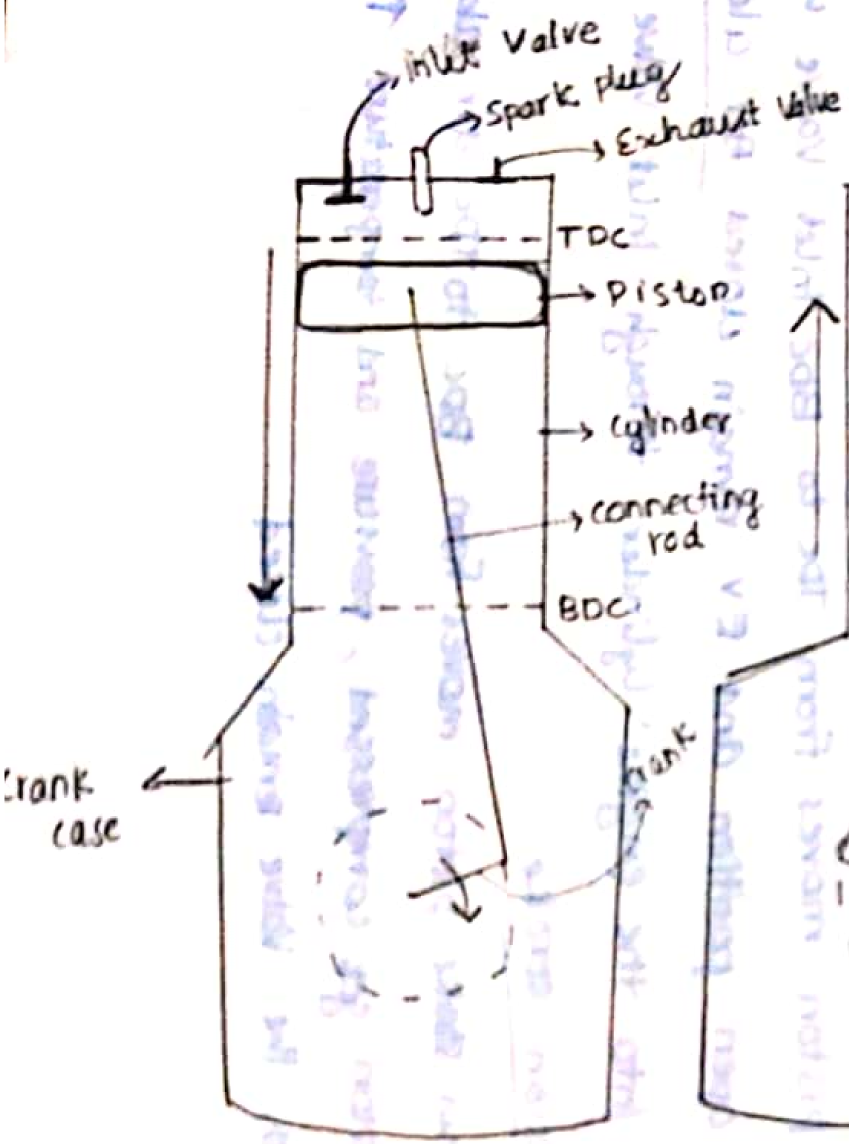
working fuel is petrol.

Suction stroke

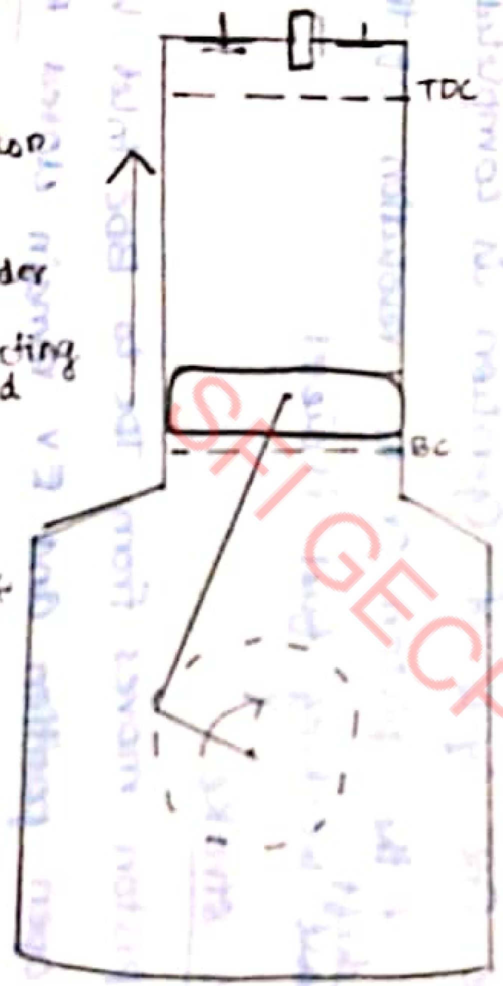
During this stroke piston moves from TDC to BDC at this time inlet value (IV) remains open and exhaust value (EV) in closed position. Air-petrol mixture from carborator enters into the engine cylinder through (IV)

compression stroke

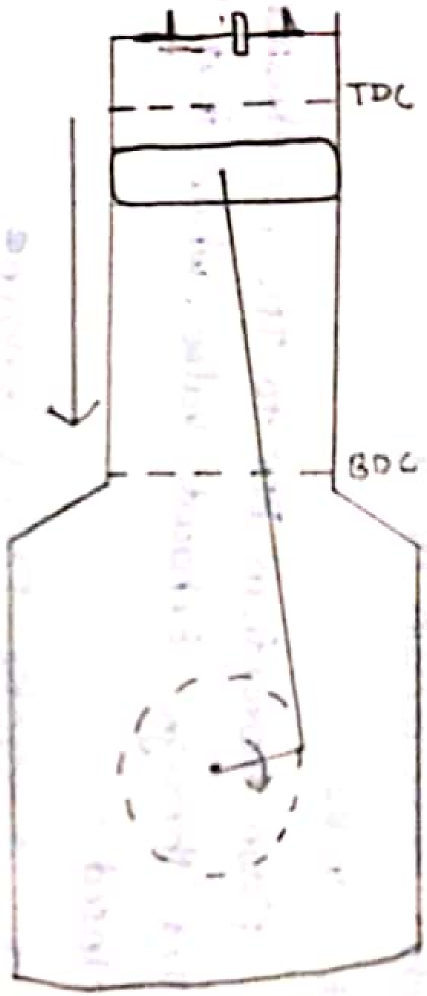
During this stroke piston moves from BDC to TDC, both valves remain closed air petrol mixture above the piston get compressed. pressure and temp of mixture rises.



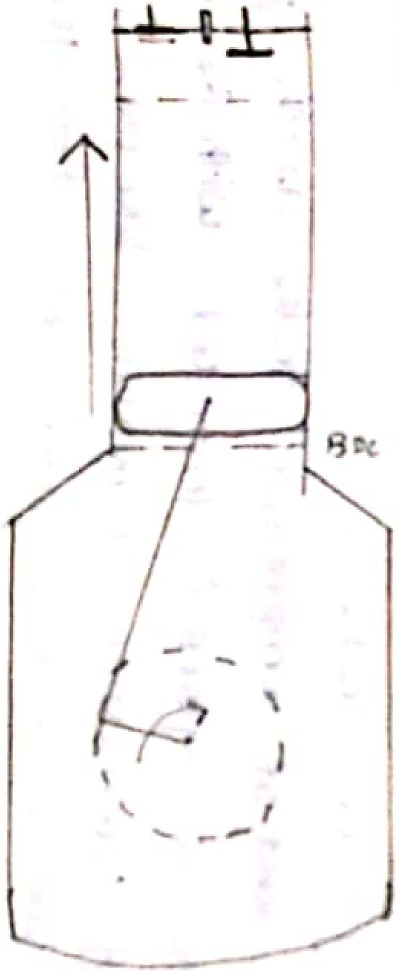
Suction stroke



compression stroke



expansion | Power stroke



Exhaust Stroke

Expansion/ power stroke

at the end of compression stroke as the piston reaches TDC a spark is initiated with the help of spark plug. combustion of mixture take place and with a large amount of force piston moves from TDC to BDC here both valves remain closed.

Exhaust stroke

Here piston moves from BDC to TDC, combustion products are expelled through Exhaust Valve. while inlet Valve remain closed.

working of 4 stroke Diesel engine

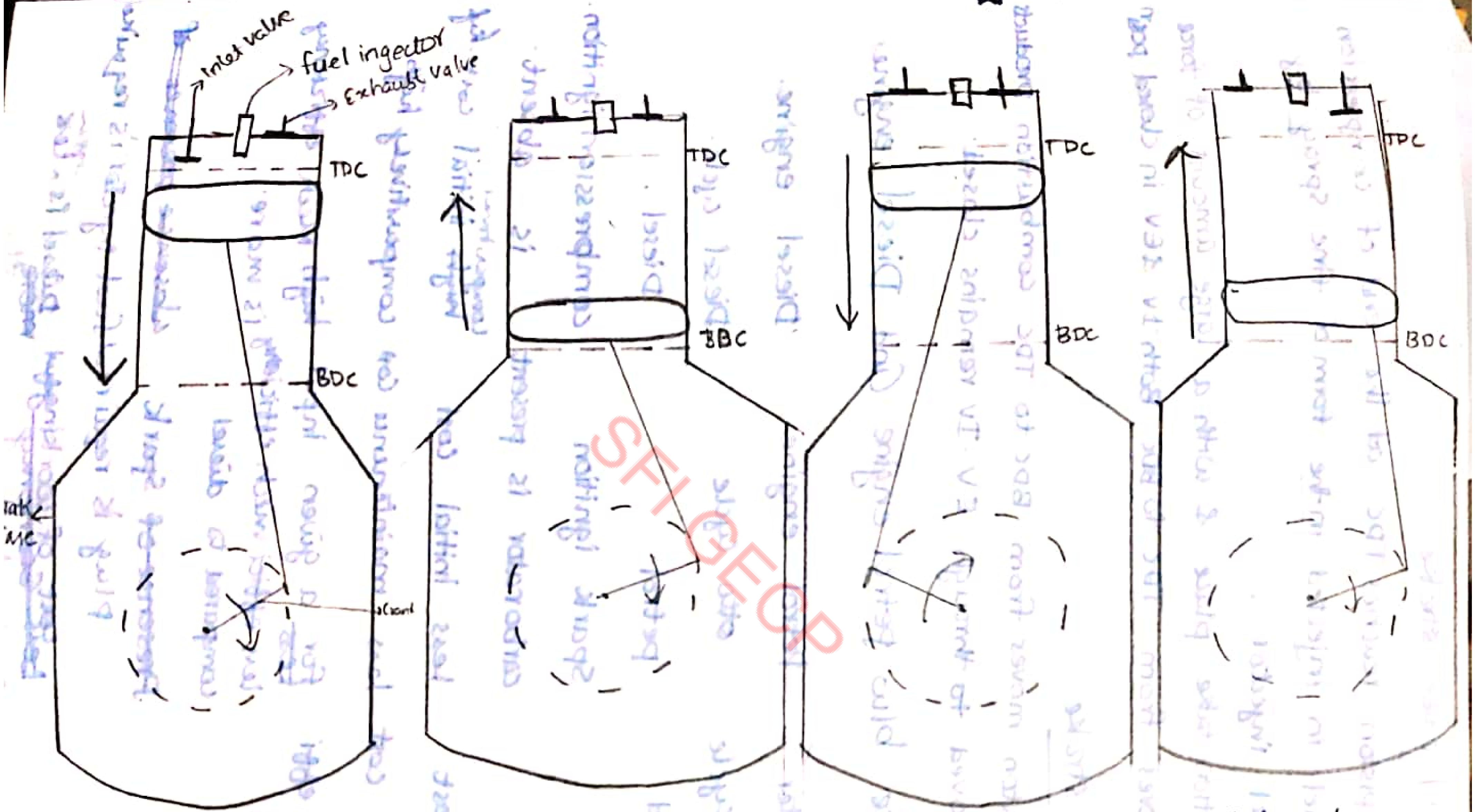
Here One Cycle of Operation is completed by 4 strokes of the piston or two revolution of the ~~crankshaft~~ crankshaft. working fuel is diesel.

Suction stroke

Here, piston moves from TDC to BDC. inlet valve will be in open position and EV remain closed. Air alone Enters into the engine cylinder through inlet valve.

compression stroke

in this stroke, piston moves from BDC to TDC air above the piston get compressed, pressure and temperature ↑s. Here both the Valve remain closed



Sucn stroke

Compression

Expann stroke

Exhaust stroke.

Expansion/Power stroke

As the piston reaches TDC at the end of compression stroke fuel in injected in the form of fine spray by using fuel injector..

combustion take place & with a large amount of force piston moves from TDC to BDC. Both IV & EV in closed pos

Exhaust stroke

here piston moves from BDC to TDC combustion product are removed ~~to~~ through EV. IV remains closed.

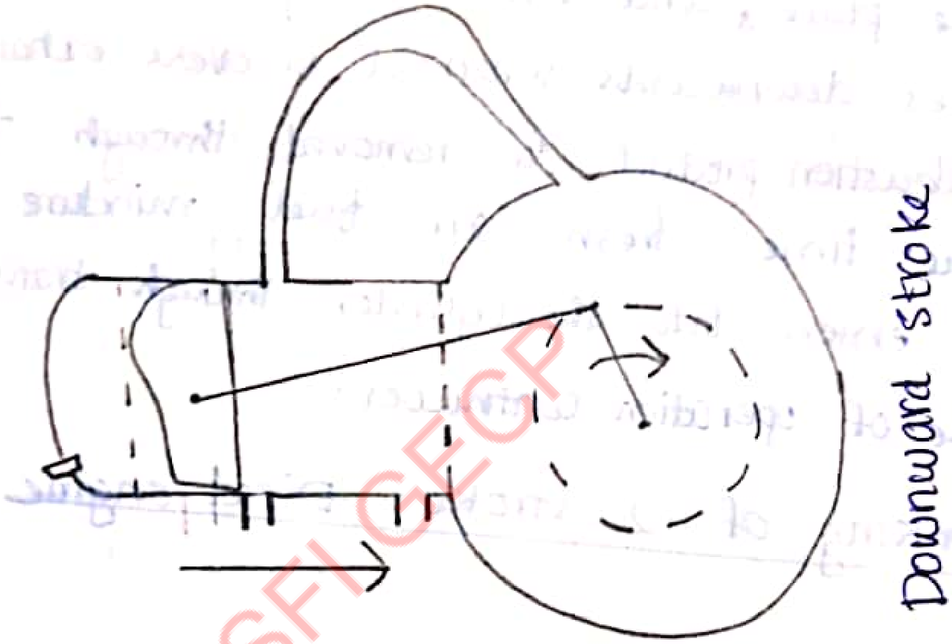
Difference b/w petrol engine and Diesel engine

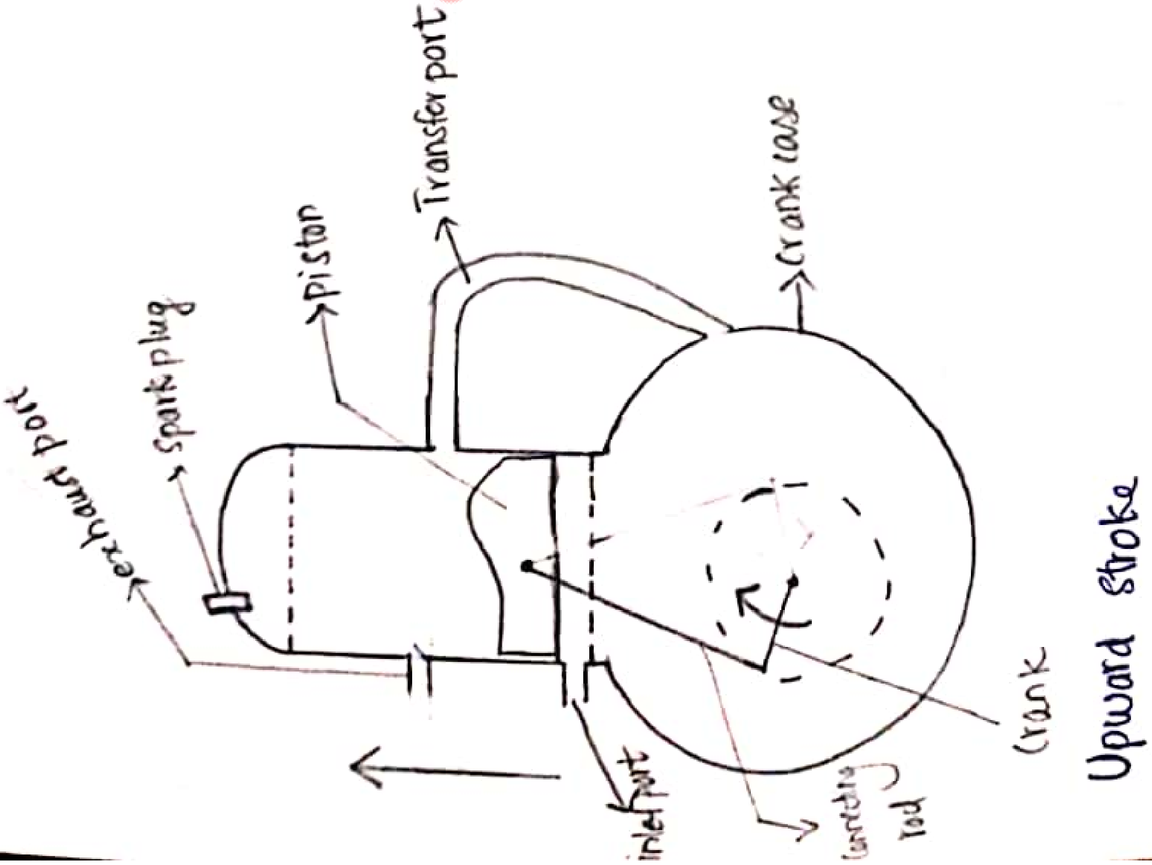
	Parameter	Petrol engine	Diesel engine.
1.	working cycle	otto cycle	Diesel cycle.
2.	fuel Used	petrol	Diesel.
3.	Ignition	Spark ignition	compression ignition.
4.	—	carborator is present	is absent.
5	Initial cost	Less initial cost	Comparitive ~~high~~ initial cost high
6.	Maintenence cost	less maintenence cost	compaaritively high
7.	Mechanical efficieny	for ~~less~~ a given Input less ~~effici~~ mech efficiency compared to diesel	~~high~~ Mech efficiency is more.
8.	—	~~Presence of~~ Spark plug is required	~~absence~~ ~~presence~~ of fuel injector is required
9	Economy	~~Less~~ ~~economy~~ cost of working fuel Petrol is high	Diesel is compar less ~~more~~

10	construction	compact in size comparitively	higher dimensions due to increased compression ratio.
11	compression ratio	6-10	16-20.

Two stroke petrol engine

Here one cycle of operation is completed two strokes of piston and one revolⁿ of crankshaft.
working fuel used is petrol



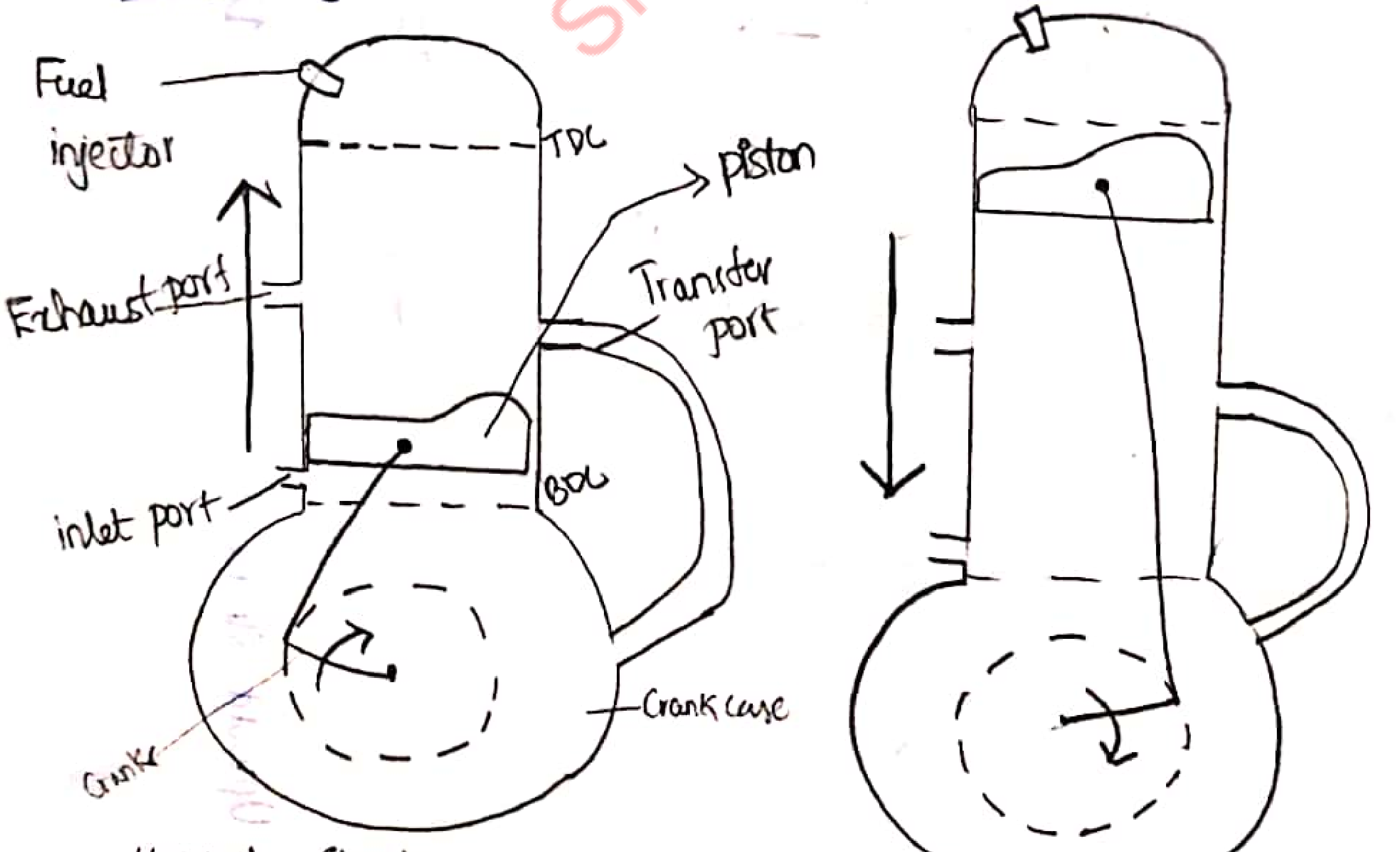


During the Upward stroke as the piston Uncovers inlet port fresh air fuel mixture from the carborator enters the Crank case the mixture which was alredy present above the piston during the last stroke now get compressed and pressure and temp of the mixture rises.

~~During the downward~~

As the piston reaches TDC combustion of the mixture take place, be with help of spark plug. and with a large amount of force piston moves downwards. when it Uncovers exhaust ~~pto~~ port combustion products are removed through the exhaust port at the same time fresh air fuel mixture from the crank case enters into the cylinder through transfer port Cycle of operation continues.

Working of 2 stroke Diesel engine

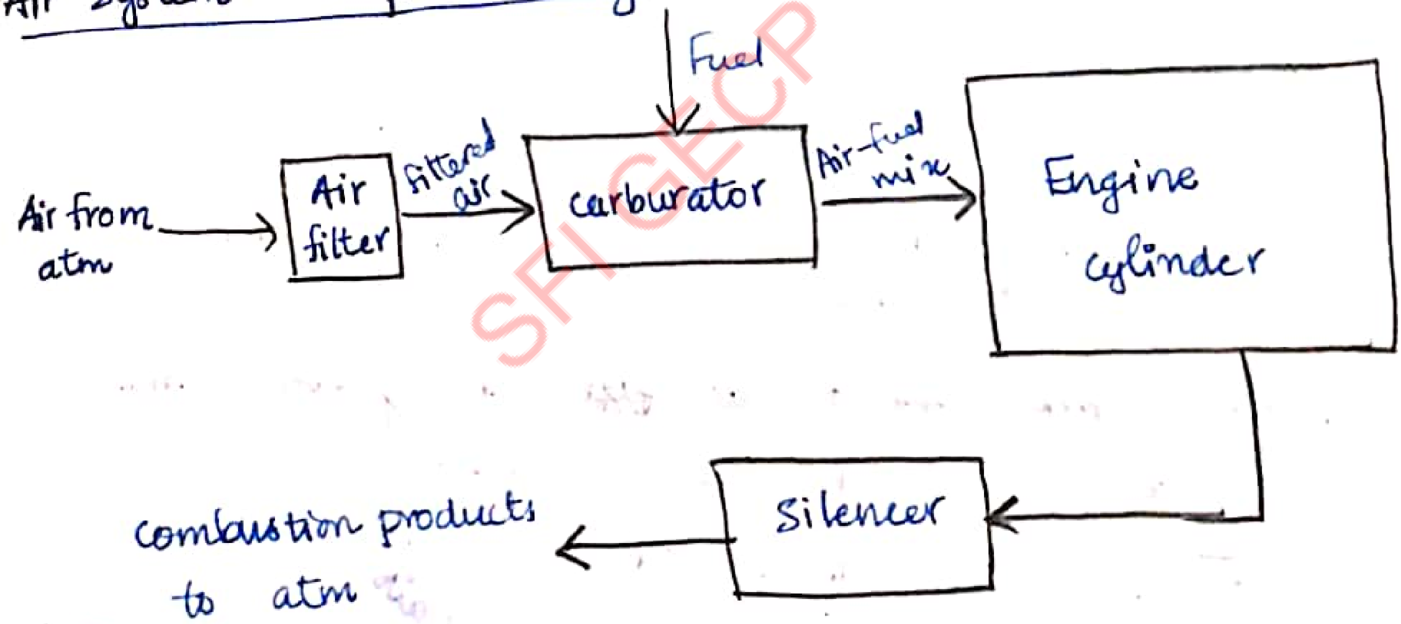


Upward Stroke

During the upward stroke as the piston uncovers inlet port air alone enters into the crankcase. the compressed air above the piston (entered through transfer port) get compressed further and as the piston reaches TDC combustion take place when fuel is injected in the form of fine sprays through fuel injector.

With a large amount of force piston moves downwards. as it uncovers exhaust port combustion products are removed through the same, the air coming through transfer port also help in pushing the exhaust products through exhaust port. cycle of operation continues.

Air System in petrol Engine



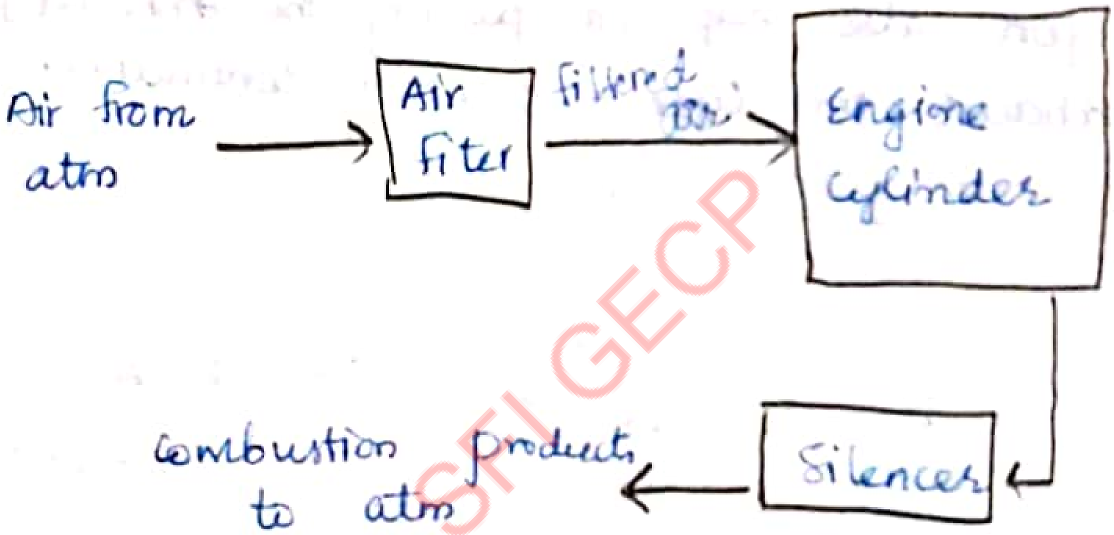
atmospheric air get filtered with the help of air filter then it is passed into the carburator. air-fuel mixing takes place inside the carburator.

for complete combustion recomended air-fuel ratio 15 : 1. Air fuel ratio ranges from 8:1 to 20:1

During starting, acceleration rich air fuel ratio is required while during normal running 15:1 for the purpose.

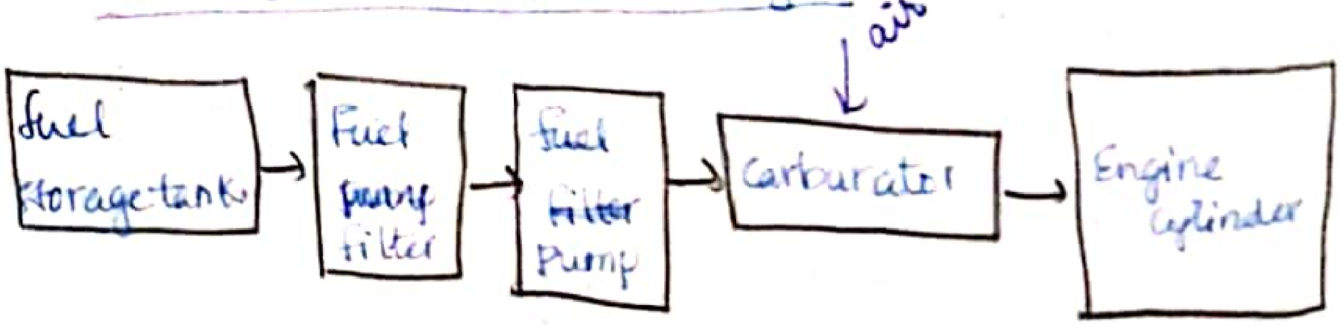
The combustion take place inside engine cylinder and combustion products are removed through exhaust pipe. A silencer or muffler is used to reduce the noise.

Air System in Diesel Engine



NB: never talk about air fuel mixing here. Since Carburettor is not required in diesel engine.

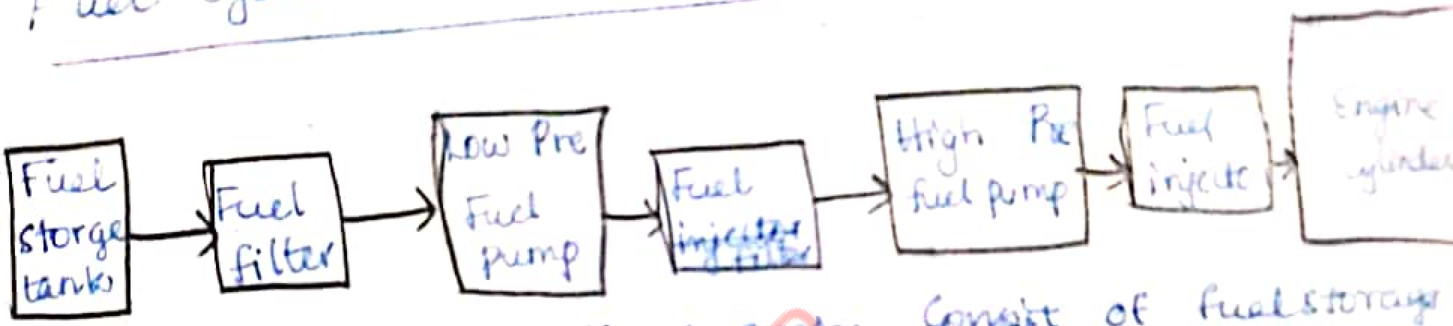
Fuel System in petrol Engine



Fuel System of a petrol engine consist of a fuel storage tank, fuel pump, fuel filter, carborator.

Fuel from the storage tank get filtered after passing through the fuel filter. A fuel pump is used to force the fuel into the level of carburator. After carburator it reaches the engine cylinder.

Fuel System in Diesel Engine



Fuel System of a diesel engine consist of fuel storage tank, fuel filter, Low pre & High pre pump, Infuel injector and Fuel after passing through fuel filter is taken through a low press fuel pump at first and after a high pressure fuel pump is used. Then fuel is injected in the form of fine sprays through fuel injector. There are two type of injection, Air injection & solid injection

Here fuel is injected with the help of compressed air produced with this type is not used nowadays so power input for compressor is in compressed air, taken from engine itself.

Solid injection

here for injecting fuel high pressure and pump is

4 stroke	2 stroke
→ One cycle operaⁿ is completed by 4 stroke of piston & two revoluⁿ of crankshaft	One cycle of operaⁿ is completed [illegible] 2 stroke of piston and one [illegible] of crankshaft.
→ valves are present	instead of valves pores are provided.
→ One power stroke is obtained during 4 strokes of piston	One power stroke is obtained during 2 strokes of piston
→ comparitevely less torque	better torque performance
→ less polluting	more polluting since poor thermal efficiency.
→ less noises producing	Heavy noise producing.
→ for same power size of 4 stroke engine is more	for same power lesser in size

A cooling of I.C engine:

Here fuel is injected with the help of compressed air. This type is not used nowadays so produced for compressed air power input for compressor is taken from engine itself

Solid injection

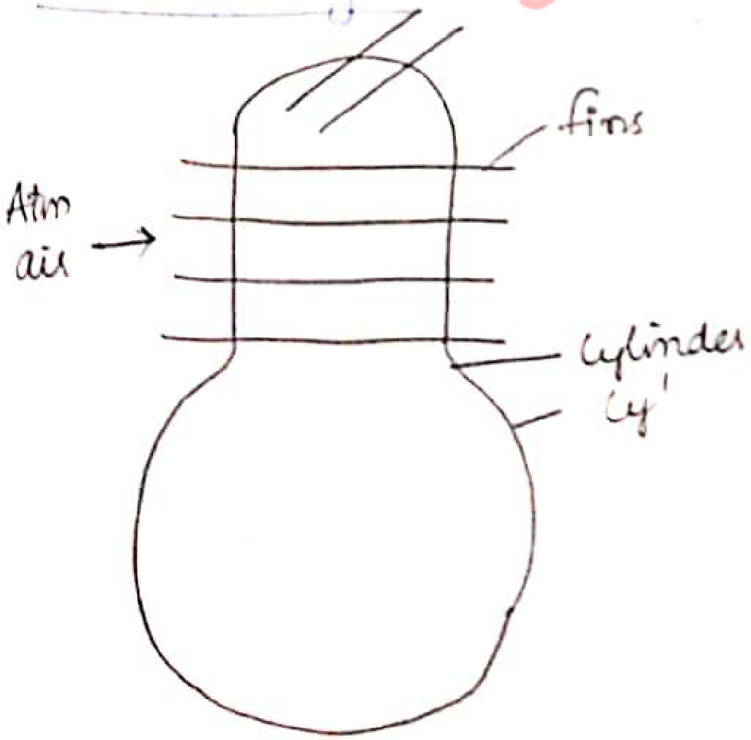
here for injecting fuel high pressure pump is [illegible]

this is followed nowadays in most of engines from the total heat generated by combustion of fuel only 30% is converted to actual work some 30% is absorbed by the engine parts & remaining heat through Exhaust gas.

If heat absorbed by engine parts is not removed in proper manner Excessive temperature might happens in engine components which may seriously effect the performance of engine. So engine parts must be provided with some means of cooling such that the temperature of these part dont exceed permissible limits. The purpose of cooling system is to keep the engine parts from not getting too hot & not to keep the engine parts cool.

2 types are normally used.

1. Air Cooling



The basic principle [illegible] cooling system is to have a current of air flowing continuously over the heated surface from where the heat is air, after getting conducted through the cylinder. Fins are provided on the outer surface of cylinder & cylinder head, [illegible] to ↑ the area exposed through the current of air. In mobile engine the forward velocity of engine ↑ the air velocity

Advantage

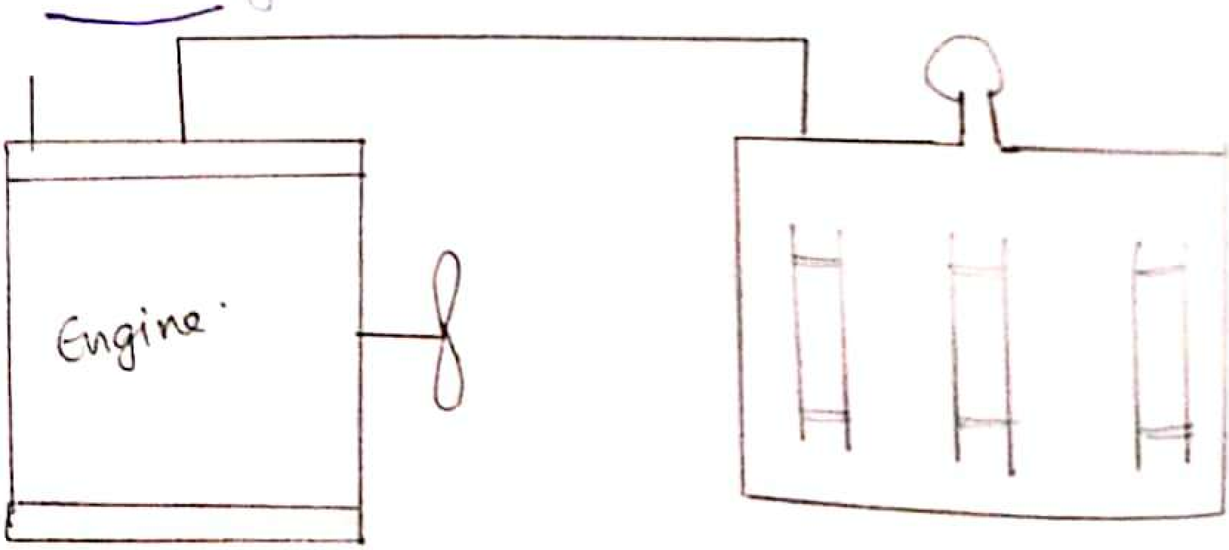
→ simplicity
→ lightness
→ cheapness

absence of seperate cooling system components

disadvantages

1. non uniformity
2. difficult to control cooling rate

water cooling



in this water is generally used as the cooling medium. passages where water circulate are called cooling jacket. The circulation of water is obtained either by pump or gravity.

water after passing through the cooling jacket flows through radiator. In the radiator the heated water gets cooled by an air flow ~~produced by~~ porched by the forward motion of automobile. To increase the heat transfer area the radiator tubes are provided with fins. mostly a fan is provided to establish forced circulation of air ~~for~~ over the radiator tube which increase the heat transfer rate.

radiator essentially consist of an upper filler tank and a lower tank the upper tank is connected to the water outlet from the jacket by a upper hose and the lower tank is connected by a hose to the jacket inlet.

Under extreme cold to avoid the freezing of the H_2O in radiator tubes antifreeze solution (ethilene glycol) is added with the cooling water.

Lubrication System in IC

Lubrication is done inorder to reduce the friction b/w moving parts of the engine. whenever moving parts are in contact with each other considerably friction and heat is generated. which can be reduced by a film of lubricating oil b/w the moving parts it will also reduce the wear.

functions of lubricating oil

1. it must remove the heating from parts it contacts
2. prevent friction & wear by maintaining a oil film b/w the moving and stationary surface.
3. Oil must clean the metal part in coming contact

main parts to be lubricated in a IC engine are

- crankshaft, piston, wearing, crankpin, cylinder valves, cams, gears.

Types of lubrication system

Splash system: Simplest method of lubrication design with a oil reservoir in the base of engine when the connecting rod moves up. it splashes oil in the form of oil spray the internal parts of the engine are lubricated by this oil spray.

applications

1. Small single engine
2. Splash & circulating system.

Similar to splash system except that an oil pump is employed to keep the reservoir with oil

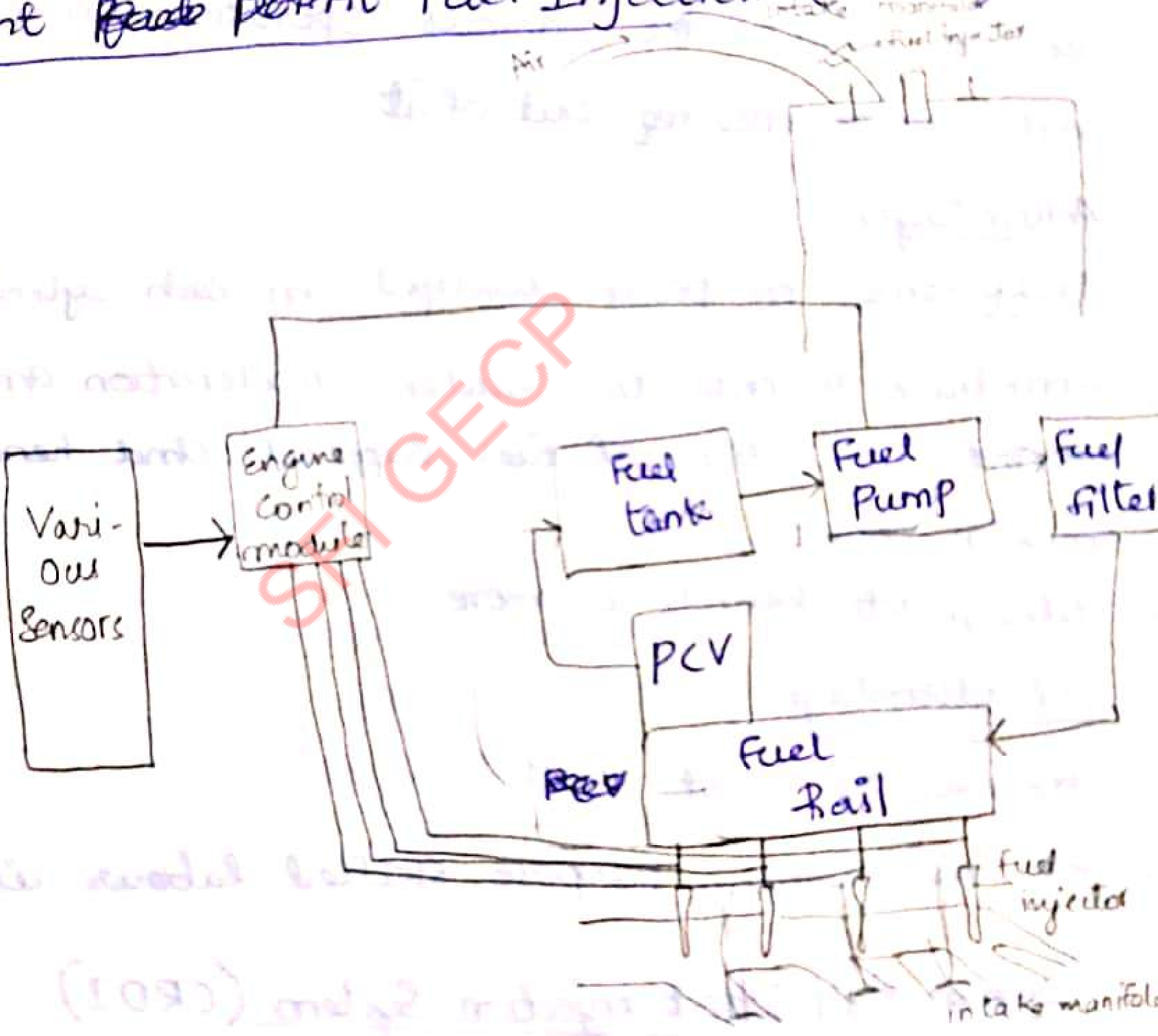
3. Splash and pressure system.

an oil pump supplies oil under pressure to main & crankshaft bearings. the oil pumps also supplies oil to the reservoir. other parts to be lubricated get oil by splash system

4. Forced feed system

Oil is forced by oil pump to all main bearings, connecting rod bearings, crankshaft bearing & the cylinder wall, piston are lubricated by oil spray thrown off from the connecting rod & crankshaft. Most of the present engines are lubricated by this type of lubrication.

Multipoint Fuel Injection (MPFI)



fuel is injected in more than one location. This system injects fuel into individual cylinder based on the commands from Onboard engine management System computer popularly known as engine control unit (ECU). The ECU controls the ignition type and Quantity of fuel to be injected

The ECU is controlled by data input from a set of sensors located all of engines and auxillaries. these Sensors detect the Various operating condiⁿ of the engine and perfomance req out of it

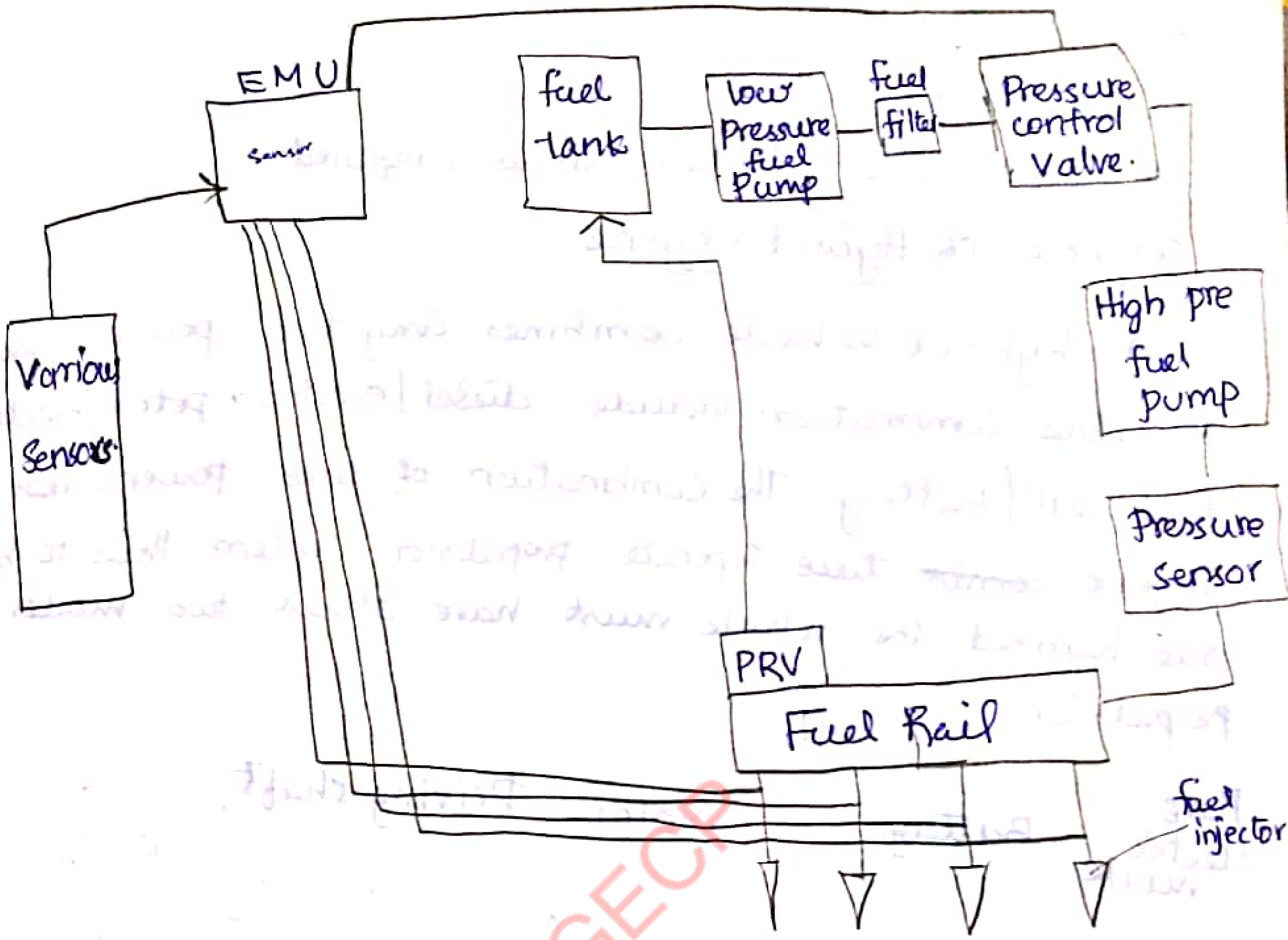
Advantages

1. Difference in power developed in each cylinder is minimum
2. immediate response to Sudden acceleration and deceleration
3. effective utilisation of fuel supplied and hence low emission level.
4. Mileage of Vehicle is more,

Disadvantage

1. increses the cost
2. for maintanence purpose skilled labour is required.

Common Rail Direct injection System (CRDI)



Direct injection of fuel into the cylinders of an engine via a single common line called the common rail which is connected to all the fuel injectors.

The Electronic control Unit (ECU) modifies injection pressure Precisely as needed based on the data obtained from sensors.

Advantages

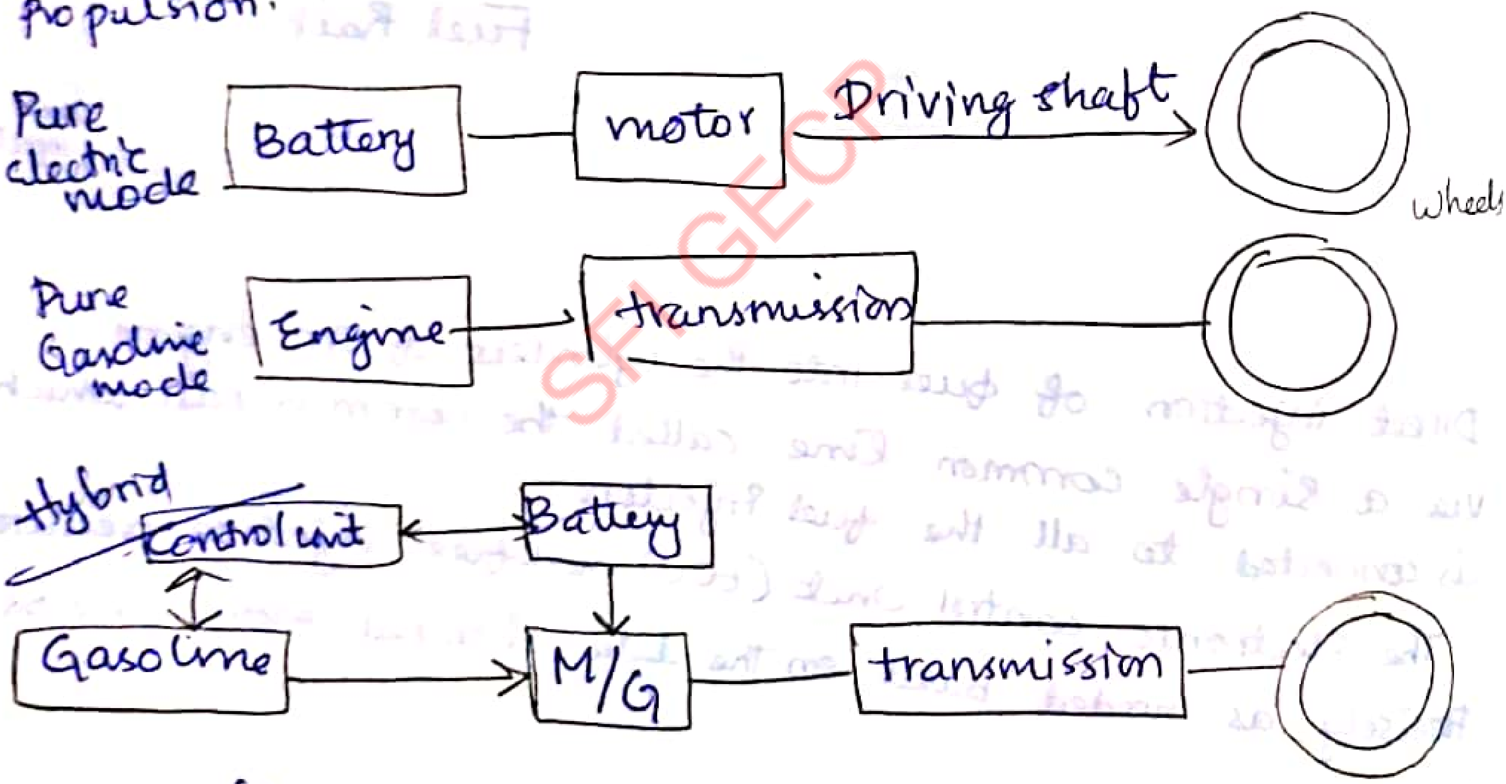
1. More power and more mileage even at low RPM
2. High Pressure injection
3. Reduced noise and Vibration
4. Reduced Smoke.

Disadvantage

1. Increase cost
2. for maintanence skilled labour is required.

concept of Hybrid engine

A hybrid vehicle combines any two power source possible combination include diesel / electric, petrol / electric, fuel cell / Battery. The combination of two power sources may support ~~combt~~ two seperate propulsion system. thus to be a true hybrid the vehicle must have atleast two modes of propulsion.



Advantage

→ less polu^n
→ saving of energy

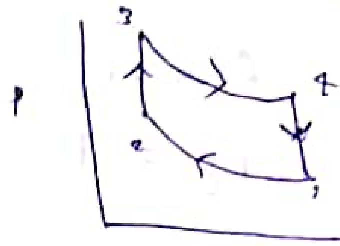
Disadvantage

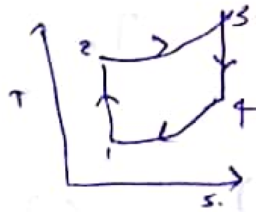
→ Similar performance cannot be expected from both the modes

→ weight of the system increses.

problems

1. In an Ottocycle Condiⁿ of air is 27°c, 1 bar at the star[t] of compression. If the clearence volume is 20% of swept vol[ume] estimate
(1) ~~At~~ temp at end of compression
(2) efficiency of the cycle.





→ Given,
$T_1 = 27°c$ $P_1 = 1$ bar. $V_{clearence} = 20\%$.
$= 300K$ $= 1\times10^5 N/m^2$.

$V_c = \cancel{V_2} = 0.2(V_s)$

$V_2 = 0.2(V_1 - V_2)$

$V_2 = 0.2V_1 - 0.2V_2$

$1.2V_2 = 0.2V_1$

$\frac{V_1}{V_2} = 6 = r_c$

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

$= 300 \times 6^{1.4-1} = 300 \times 6^{0.4}$
$= 614.301 K$

(ii) $\eta = 1 - \frac{1}{r^{\gamma-1}} = 1 - \frac{1}{6^{0.4}}$

$= 0.51 = 51\%$

... and