Dt. Page

Thermodynamics IC engine.

Engine :- Power Producing Machine is called engine.

Heat Engines - The engine which convert heat energy of fuel into Mechanical energy.

Two types Engines -

1. S.I engine.
2. Compression Internal engine.

Types of heat engines -

(1.) Internal Combustion :- The engine in which combustion takes place inside the cylinder Example Petrol, Disel Engine.

(2.) External combustion engine :- The engine in which combustion takes place outside the cylinder Example coal engine.

CLASSIFICATION OF I.C ENGINE

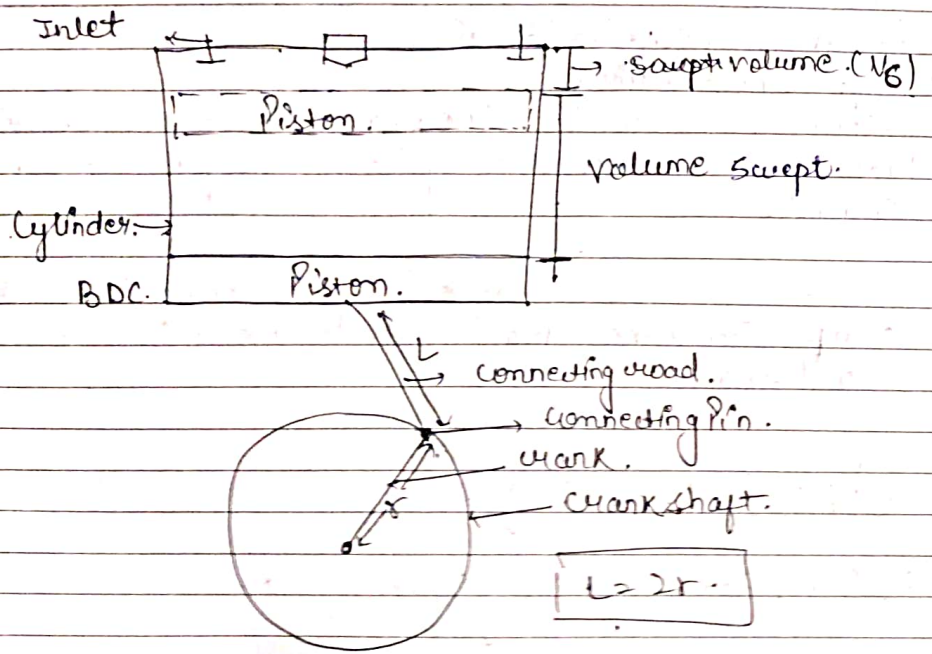
- Acc^{n} to stroke / working cycle.
  - 2 Stroke.
  - 4 Stroke.
- Acc^{n} to type of fuel.
  Petrol, Disel, CNG.

Acc^{n} to no. of cylinder's :-

1. Single cylinder.
2. Multi cylinder.

Acc^{n} to method of Ignition's :-

1. (S.I) Spark Ignition.
2. Combustion Ignition.



Basic Term's :-

1. Bore's :- Internal diameter of cylinder.
2. Connecting rod's :- It is use to transfer rotarty motion of crank shaft into translatery motion of piston.

Spiral

Teacher's Sign .....

TDC's :- (Top Dead center). It is the top most position of reciprocating motion of piston.

BDC's :- (Bottom Dead center) :- It is the Bottom most point of piston during reciprocating motion inside cylinder.

Clearance volume's :- It is the volume obtained in the cylinder when piston is at TDC.

Swept volume's :- It is the total volume sweep by the piston when moving from BDC to TDC.

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

D → Internal diameter.

$L = 2r$

Clearance ratio's :- It is the ratio of clearance volume to the swept volume : clearance ratio

Compression ratio's :- It is the ratio Total volume of cylinder to the clearance volume. compression ratio denoted by r, Volume, is called.

* Derivation's :-

$$r \Rightarrow \frac{V_T}{V_C}$$

$$\Rightarrow \frac{V_C + V_S}{V_C} \Rightarrow \frac{V_C}{V_C} + \frac{V_S}{V_C}$$

Spiral

Teacher's Sign .....

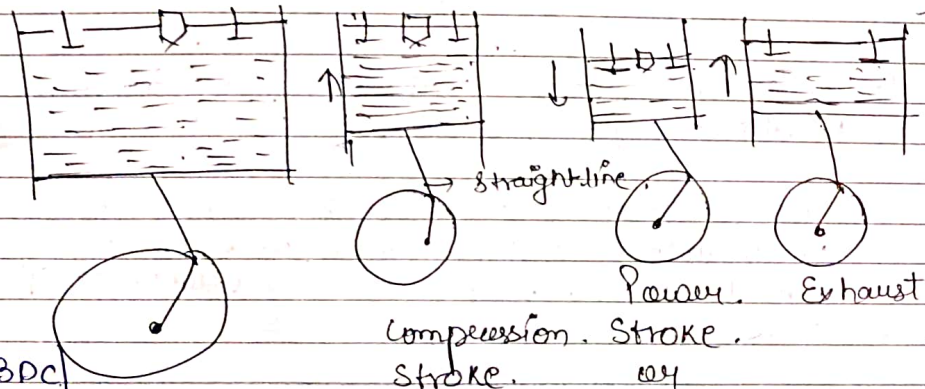
$r = \frac{1 + V_s}{V_c}$.

$r = 1 + \frac{1}{C}$.

Stroke :- It is the linear distance traveled by the piston from one dead center to another dead center.

Crank throw :- It is the distance from the center of the crank to the center of the crank pin are know as crank radius.

Piston speed :- It is the average speed of a piston in a reciprocating engine.



Open.
TDC to BDC
let valve. Suction Stroke
haust valve) are
Close. Intake Stroke.

Compression Stroke.

Power Stroke. or Expansion. Stroke.

Exhaust.

* 4 Stroke (Petrol) :- Consist of which are suction or Intake Stroke compression Stroke, Power stroke or Expansion, Exhaust Stroke.

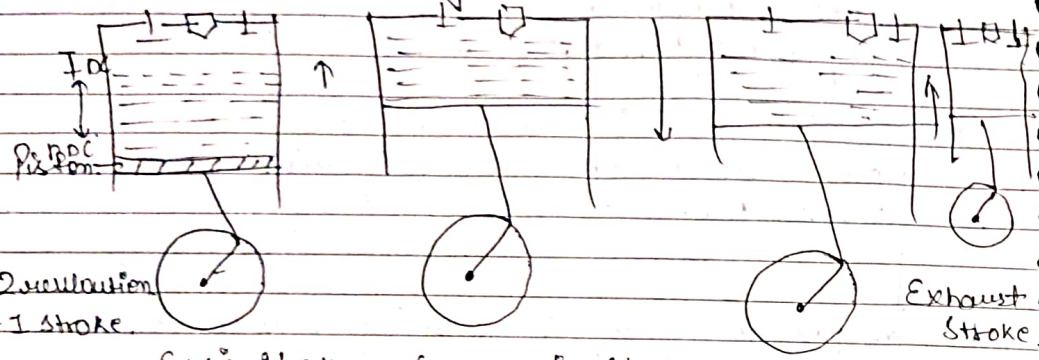
* Suction stroke :- During this stroke Piston moves from TDC to BDC with opening of Intake value mixture of air and fuel enters into cylinder.

* Compression stroke :- During this stroke both value Remain closed and Piston moves from BDC to TDC and compression of mixture take Place. Spark Plug provide a stroke to the compressed air fuel mixture.

* Power stroke :- (Expansion stroke). During this stroke combustion of fuel take pla and Piston moves TDC to BDC.

* Exhaust Stroke :- During this stroke Exhaust value Remain open and Exhaust gases moves out from cylinder when piston moves out from BDC to TDC.

4 Stroke Diesel engine.



Suction stroke. Compression Stroke. Power stroke.

1. Suction stroke :- During this stroke, piston move TDC to BDC with opening of intake valve. ~~mixture~~ Fresh of air enter into cylinder.

2. Compression stroke :- In this stroke Piston moves from BDC to TDC and air get compressed both value remain closed. compressed diesel gets Injector in compressed air.

3. Power stroke :- Combustion of fuel takes place During the stroke and Piston are move from TDC to BDC.

4. Exhaust stroke :- In this stroke Exhaust valve remain open piston moves from TDC to BDC and burnt gases remove out of cylinder.

Spiral

Teacher's Sign .....

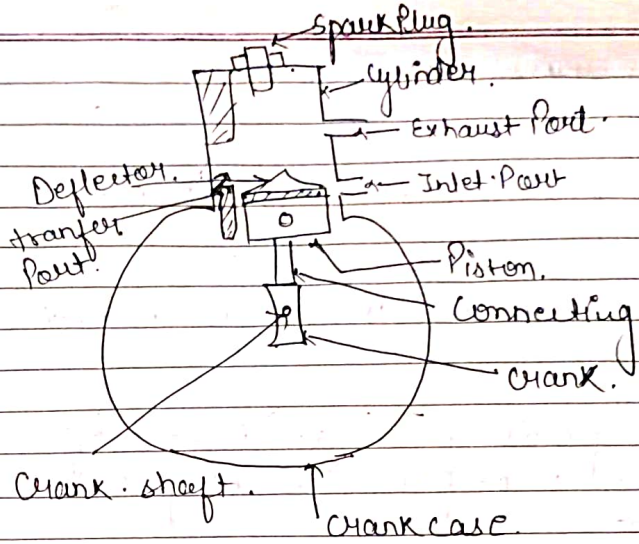
Diffrenc b/w S.I engine and C.I engine.

S.I engine	C.I engine
1. It works on otto cycle or constant volume cycle.	1. It work on diesel cycle or Constant Pressure cycle.
2. During suction stroke mixture of air and Petrol is sucked.	3. During suction stroke into of air sucked into the cylinder.
3. Compression ratio in S.I engine is 5:1 to 9:1	3. Compression ratio of C.I engine 14:1 to 22:1.
4. Spark plug is use in S.I engine	4. C.I fuel injectors is use In C.I Engine.
5. thermal efficency of S.I engine is 25%	5. Thermal efficency of C.I engine. 40%
6. Maintenance cost is less	6. Maintenance cost is more.
7. Initial cost is less.	2. Initial cost more, due to heavy weight complex constructi
8. A/f mixture is use during section stroke, high speed engine.	8. only Air is use during section stroke, Low speed engine.

Spiral

Difference b/w · 2 Stroke and 4 Stroke.

2 Stroke.	4 Stroke.
(1.) There is one Power stroke in one complete revolution.	(1.) There is 1 Power stroke in two revolution of shaft.
(2.) Inlet port transfer Port and Exhaust Port are in 2 Stroke engine.	(2.) Inlet, outlet are used for tranfer of fuel and exhaust gases.
(3.) No. of moving parts is less.	(3.) No. of moving parts more.
(4.) It thermal efficiency is low.	(4.) It has high thermal efficiency. Is more.
(5.) It Maintance is high.	(5.) Maintance is low.
(6.) Fuel consumption is high.	(6.) Fuel consumption is low.



Suction and compression
Expansion & Exhaust.

In two stroke valve are use in Steel of valve.
Inlet Port Exhaust transfer port.
The two stroke in this engine are :-

(1.) Stroke one :- In this stroke intake of fuel and compression takes place simultaneously.

(2.) Stroke two :- In this stroke intake of fuel both takes place simultaneously.

In 2 stroke diesel engine stroke of piston and one revolution of crank shaft.

Suction and compression stroke is done at one stroke

Expansion and Exhaust stroke is done at

In two stroke ports are use instead of valves ~~the~~ for inlet port Exhaust port transfer port.

The 2 stroke in this engine are;-

Stroke one;- In this stroke intake of fresh air and compression takes places simultaneous

Stroke two;- In this stroke expansion with the help of fuel injector and Exhaust of gases both process takes place simultaneously.

Location and function of various parts of IC engine and material used for them;-

(1.) Cylinder;- It is a cylindrical vessel in which piston reciprocates. It is covered with cylinder head. It should be made up of material which retain

at high temperature and it should be good conductor of heat generally cylinder are made of cast iron and for heavy duties made of alloy steel.

(2.) Cylinderhead;- It enclose one end cylinder. It contain inlet exhaust valve and Spark plug. It is generally cast as one piece from cast iron or aluminium alloys.

(3.) Piston;- Piston is cylinderical component which fits into the cylinder its main function is to compressed the charge and to transmit the force extered by gases to the connecting road. the piston should be strong enough to bear stress and light in weight to reduced inertia loads on the bearings. It is generally made up of aluminium alloys cast iron and cast steel.

(4.) Piston Rings;- Piston Rings are inserted in the circumferencial grooves provided on the outer surface of piston to provided a tight seal b/w piston and cylinder. value. In oder to prevent leakage of high pressure gases. It is made up of silicon cast iron.

(5.) Piston Pin;- (or Gudgeon Pin)(wrist Pin). Piston Pin connects the piston to the connecting road it is made up of case hardened steel to reduced weight and.

inertia effect of reciprocating parts it is made hollow.

(6.) Connecting Rod :- Connecting rod joins piston and the crank. Its function is to convert the reciprocating motion of piston to the rotary motion of crank shaft the special steel alloy are All steel Alloys are used to manufacture connecting rod.

(7.) Crank and crank shaft :- The crank is hold together with the crank shaft with the help of key the crank shaft is supported to the main bearing and has flywheel to decrease the fluctuation of turning moment the power is taken from the crank shaft only It is considered as the backbone of I.C engine.

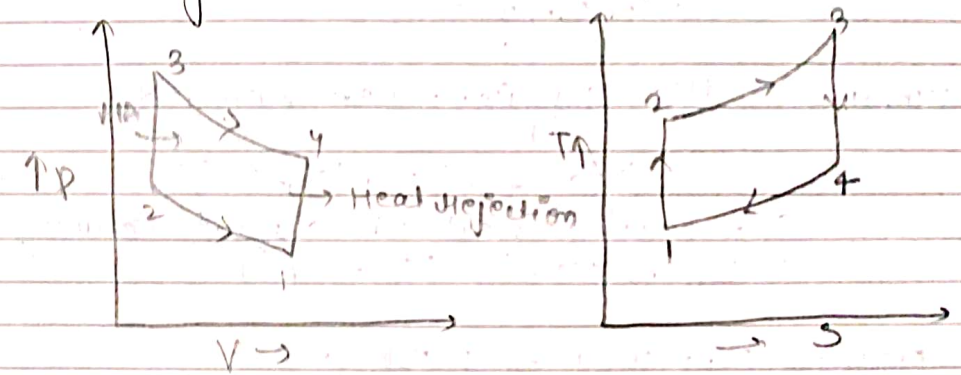
(8.) Valves :- There are two valves use in the engine one is inlet valve or is exhaust valve. Inlet valve is use to suck the air and fuel mixture in the cylinder, and exhaust valve is used to through out gases. inlet valve is made up of nickel chromium alloy steel. while exhaust valve made up of An Alloys of silicon and chromium. nowadays silicron.

(9.) Flywheel :- Acts as energy reservoir It stores energy. When it is in excess amount and gives up the same when required for the next stroke. It is made of cast iron.

(16.) Camshaft :- camshaft control the opening and closing of valves at proper time it made up of alloy or medium carbon steel.

(11.) Carburetor :- It mixes the petrol and air in proper amount in proper proportion and supply the mixture to the cylinder at proper time. It made up of gun metal and aluminium alloys.

OTTO cycle :-



- The petrol engine work on the otto cycle. It is also known as constant volume cycle. It consist of four process.

Process 1-2 :- It is reversible adiabatic compression. (isentropic compression) in which fuel get compressed.

Process 2-3 :- It is a heat addition process.

done at constant volume. heat is added. with the help of spark plug.

Process 3-4 :- It is reversible adiabatic Expansion process. Insentropic expansion which is done due to combustion of fuel.

Process :- (4-1) It is heat Reduction process done at constant volume in this process. Exhaust gases remove out of cylinder.

Derivation :- for Petrol engine.

work done = Heat Supplied - Heat rejected.

$$C_v(T_3 - T_2) - C_v(T_4 - T_1)$$

C_v = specific heat at constant volume.

$$= C_v[(T_3 - T_2) - (T_4 - T_1)]$$

Thermal efficiency = $\frac{\text{work done}}{\text{Heat Supply}}$

$$\frac{C_v[(T_3 - T_2) - (T_4 - T_1)]}{C_v(T_3 - T_2)}$$

$$\Rightarrow \frac{(T_3 - T_2) - (T_4 - T_1)}{(T_3 - T_2)}$$

Spiral

Teacher's Sign .....

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

We know that :-

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

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

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

Further, $\frac{T_3}{T_4} = \left(\frac{V_4}{V_3}\right)^{\gamma-1}$ [from insentropic Expansion curve]

$$\frac{T_3}{T_4} = (\delta)^{\gamma-1} \quad \left[r = \frac{V_4}{V_3} = \text{Expansion ratio}\right]$$

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

$$\eta = 1 - \left[\frac{\frac{T_3}{\delta^{\gamma-1}} - \frac{T_2}{r^{\gamma-1}}}{T_3 - T_2}\right]$$

Spiral

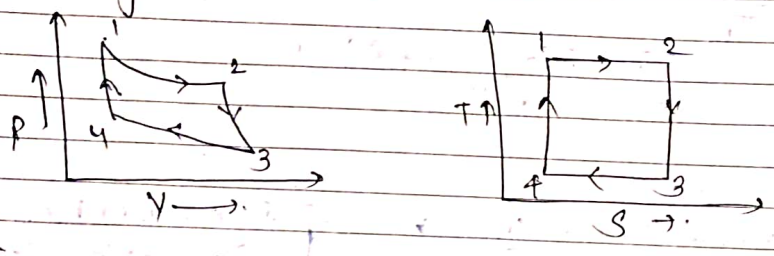
Teacher's Sign .....

$$\Rightarrow \frac{1-(T_3-T_2)}{r^{\gamma-1}(T_3-T_2)}$$

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

r = compression ratio.

Carnot cycle:-



(1) First process (1-2):- In this process air expands Isothermal expension. at constant temp. (T_1) from V_1 to V_2 it means $T_1 = T_2$

(2) second (2-3) Isentropic expansion:- As the cylinder is assume to be a perfect insulator of Heat so no Heat flow. Takes place the Temp. fala from $T_2 = T_3$.

(3) Isothermal compression:- The air is compressed at constant Temp. T_3 from V_3 to V_4 it means, $T_3 = T_4$.

(4). Isentropic compression:- Again the cylinder head become perfect insulator of heat so that no Heat flow occurs the compression process form reversible adiabatic process during which Temp. raises from T_2 to T_1.

Derivation:-

Work done = Heat supplied - Heat rejected

$$= P_1V_1 \log\left(\frac{V_2}{V_1}\right) - P_2V_2 \log_e\left(\frac{V_3}{V_4}\right)$$

$$MRT_1 \log_e\left(\frac{V_2}{V_1}\right) - MRT_2 \log_e\left(\frac{V_3}{V_4}\right)$$

$MRT_1 \log_e M - MRT_1 \log_e M$

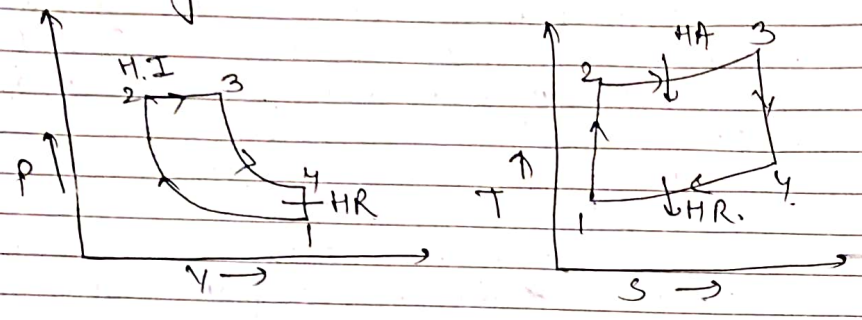
$M = \frac{V_2}{V_1}$ = Ratio of compression during isothermal process.

$\frac{V_3}{V_4}$ Ratio of during expansion.

efficiency η = $\frac{\text{work done}}{\text{Heat supplied}} = \frac{-MRT_1 \log M - MRT_1 \log}{MRT_1 \log M}$

$$\frac{T_1 - T_2}{T_1} = \eta = \frac{1 - T_2}{T_1}$$

* Diesel cycle :-



(I) Process (1 to 2) :- It is reversible adiabatic compression process in which air gets compress when piston move from BDC to TDC.

(II) Process (2 to 3) :- It is heat addition process. takes place at constant pressure in which compressed fuel injected inside the cylinder.

(III) Process (3 to 4) :- It is reversible adiabatic expansion process in which combustion of fuel take place from TDC to BDC

(IV) Process (4 to 1) :- It is Heat rejection process take place at constant volume exhaust gase remove out from cylinder.

Derivation :-

Heat supplied during process 2-3
$= c_p(T_3 - T_2)$

Heat reject during process 4-1 $c_p(T_4 - T_1)$

workdone = Heat supplied − Heat rejected.

$c_p(T_3 - T_2) - c_p(T_4 - T_1)$

Thermal efficiency = $\frac{\text{workdone}}{\text{Heat supplied.}}$

$$\frac{c_p(T_3 - T_2) - c_v(T_4 - T_1)}{c_p(T_3 - T_2)}$$

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

{ where $\gamma = \frac{c_p}{c_v}$ Adiabatic process. }

Let us assume that cylinder volume is (V) and clearance volume is unity.

$V_1 = V_4 = r$.

cut off ratio $\frac{V_3}{V_2} = \rho$, compress ratio $\frac{V_1}{V_2} = r$

Expansion ratio $\frac{V_4}{V_3} = \frac{r}{\rho}$, volume of cut off $= V = \rho$.

We know that :-

$\frac{T_2}{T_3} = \frac{V_2}{V_3}$ (From constant pressure curve)

$T_2 = T_3 \frac{V_2}{V_3} \Rightarrow T_2 = \frac{T_3}{\rho}$ —②.

Further $\frac{T_3}{T_4} = \left(\frac{V_4}{V_3}\right)^{\gamma-1}$ (From isentropic expansion curve)

$$\frac{T_3}{T_4} = \left(\frac{r}{\rho}\right)^{\gamma-1} \Rightarrow T_4 = T_3 \left(\frac{\rho}{\gamma}\right)^{\gamma-1} \quad (3)$$

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

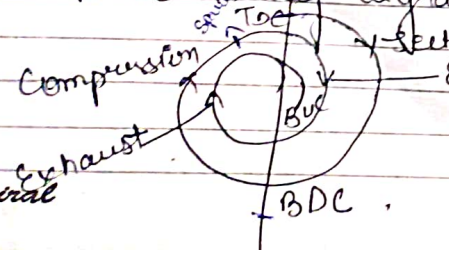
$$\frac{T_2}{T_1} = (r)^{\gamma-1} \Rightarrow T_1 = \frac{T_2}{r^{\gamma-1}} = \frac{T_3}{\rho \gamma^{\gamma-1}} \quad (4)$$

Put the value of T_2, T_3 and T_1 in eq (5)

Thermal efficiency $1 - \frac{1}{r}\left[\frac{T_3 \frac{\rho^{\gamma-1}}{\gamma^{\gamma-1}} - \frac{T_3}{\rho}\frac{1}{\gamma^{\gamma-1}}}{T_3 - \frac{T_3}{\rho}}\right]$

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

Valve timing diagram for 4 Stroke petrol engine.



(1) The inlete valve opens before the piston reaches TDC (Now the piston at TDC and the section stroke start the piston reaches BDC and the inlet valve closes little beyond the BDC.

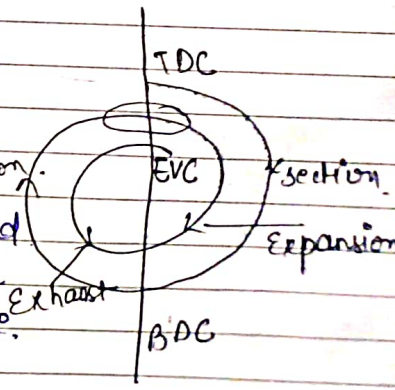
This is done As the incoming charge continues to flow into the cylinder Now the charge compressed and the expansion stroke takes place.

(i) No the exhaust valve opens before piston reaches BDC and the Burn gases start living the engine cylinder.

(ii) The Intake valve opens before the piston reaches TDC to stelet section stroke again the exist valve close little beyond the TDC this is Done as the Burn continous speaks the engine cylinder although the pistons is moving down word.

* 4 Stroke diesel engine's -

- Now the piston reaches TDC the suction stroke start the piston reaches a BDC and trah start moving up the inlete valve closes the little beyond BDC.



Teacher's Sign .....

(iii) This Because the Incoming air continous to flow into the cylinder although the piston is moving upward from BDC ~~cylinder although the piston is moving upward ff~~

Now the air is compressed the fuel values open a little before the piston reaches TDC the fuel is injected in the form of very fine spray which get ignited Due to high temp. of compress air fuel value closes a little away from the TDC the Burn gas push the piston down work and expansion stroke Take place.

Chapter-2

Fuel supply and Ignition System in Petrol Engine.

 # Carburation :- The process of mixing the proper amount of fuel with air is called carburation.

- A carburator is a device for atomizing and vaporization the fuel and mixing it with the air in required proportion.

 # Function of carburator :- 1. Mix air and fuel.
2. Maintain Reserve petrol.
3. Supply correct mixture of air fuel.
4. Provide rich mixture starting for Ideal

Factor affecting carburation :-

- **engine speed :-** As the engine speed increases the time avaiable for making mixture by carburator decreases. therefore the design of carburator should be made by considering this factor.

- **volatility of the fuel :-** the complete vaporization could be achived by using high volatile fuels. therefore suitable evaporation characteristic of the fuel are necessary for efficient carburation.

Temperature of incoming air :- The temp. of incoming air has a large influence on carburation. As increase in temp.

Spiral

Teacher's Sign .....

to decrease in power out put of the engine design.

(4) Design of carburators:- The carburator design. have considerable effect on carburation. proper design ensures supply of desired composition of the mixture to the engine.

Air fuel Ratio:- The ratio in which air is mixed with fuel for the purpose of combustion. is called Air fuel Ratio. Air and fuel are mixed to form three different types of mixture.

(a) Chemically correct mixture.
(b) Rich mixture.
(c) Lean mixture.

(a) Chemically correct mixture:- is one in which there is just enough air for complete combustion of fuel.
Example. To burn 1 kg of octane (C_8H_{18}) completely (15:12) kg of air is required. Hence chimically correct Air fuel ratio 15·12:1 approximately 15:1.

(b) rich mixture:- A mixture is rich. its air then the correct ratio is called a rich mixture.

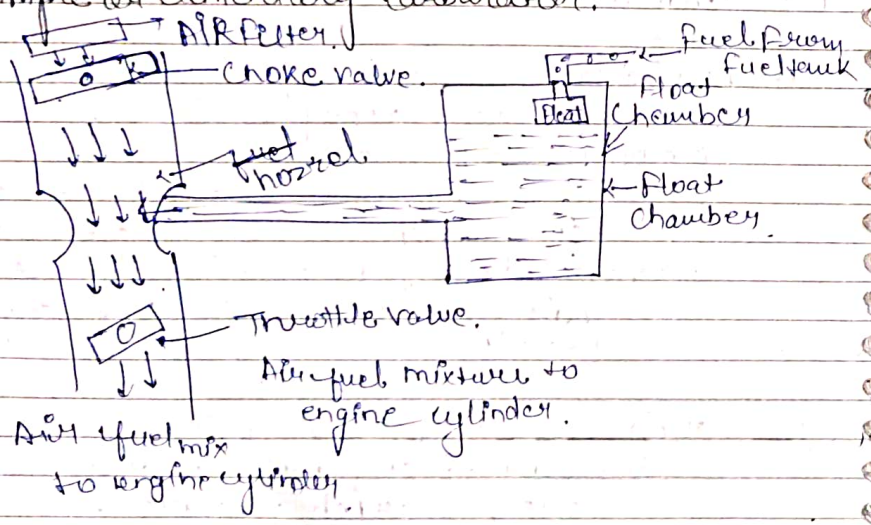
For example A/F ratio b/w 12:1 to 10:1.

Lean mixture:- A mixture which contain more air then the correct ratio is called lean mixture. For example. (A/F ratio b/w 12:1 and 10:1)

Mixture requirement at different conditions:- (Load and speed)

(i) A/F ratio
(ii) A/F ratio is Idealing.
(iii) A/F ratio for cruising - range loading
(iv) A/F ratio for maximum Power range.
(v) A/F ratio for acculation.
(vi) A/F ratio maximum economic of fuel.

A simple or elementary carburator.



Working:-
Simple carburator is used for mixing of air and fuel in proper ratio. It consist of two main parts the main body and float chamber. fuel from fuel tank enter in float chamber after passing through fuel filter.

The height of fuel is maintain in fuel filter by via float. when engine starts piston moves up and down and create suction in carburator.

The Air pass mix with fuel which is atomised by nozzel. that mixed air and fuel and enters during suction stroke.

Limitations:- Its fuel economi is very low working of simple carburator is depend upon atmospheric pressure. and it struggle to maintain a consistent air fuel ratio across different Applications:- during condition, reading to mixer that burn inefficiently. more fuel is used for

It is suitable for engine running at constant speed. it is also fitted on small portable petrol engines. for agriculture and horticulture sector.

Solex carburator:- It is a ideal carburator. for its easy starting and good performance it generally fitted in most of indian cars.

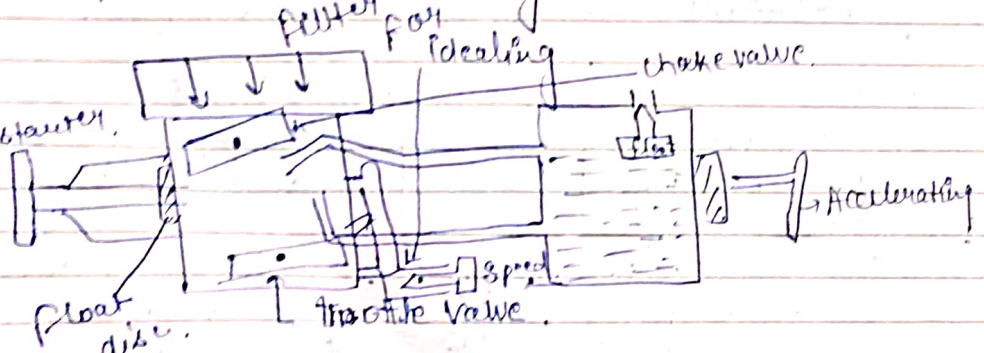
Various units of carburator are.
(1) starting
(2) Idle.
(3) Normal running.
(4) Accelerating.

(1.) Starting :— When the engin throttal valve remain close the vacuum created during the ~~suction~~ suction sucks air through atmosphere and fuel through tank and mix together for ignition to start ~~the~~ the engine.

(2.) Idle :— During Idle ~~throttle~~ throttle valve. normally close the mixture of air and fuel gas to the engine through Ideal orifice.

(3.) Normal Running :— ~~Normal running in HP~~ mixes by venturi use for suitable running of engine.

(4.) Acceleration :— During Acceleration Extra rich mixer is required for this purpose a pump is operated by a lever connected to spindal diaphragm connected to spindal push the rich mixer. Puto of fuel ~~the engine~~ into the cylinder which help in Accelating the Circuit.



Spiral

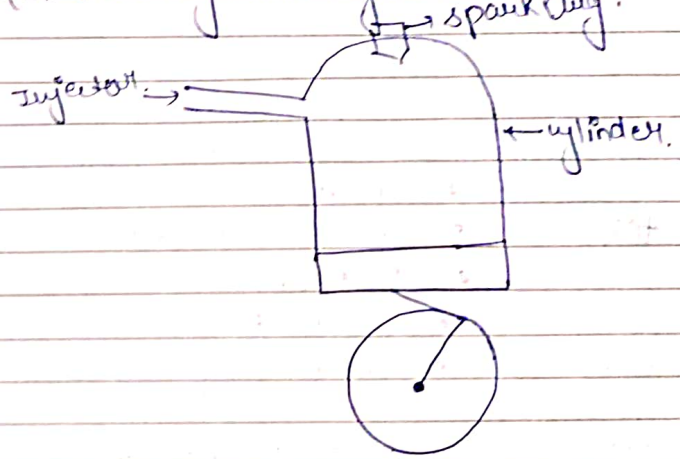
Teacher's Sign .....

Principle Disruption of Petrol Injection system :- (MPFI)

In MPFI system carburator is replace by fuel injectors it is of two types

(a) Port Injection system.
(b) Throttle injection system.

(a) Port Injection system :—



1. The injector is placed in the ~~tank~~ take manifold near the inlet port the ~~it~~ injector spray petrol into Air inside manifold.

(3.) fuel and air mix in uniform manner and mixer enter into the cylinder.

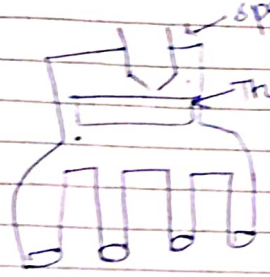
(b) Throttle injection system :—

(1.) This is similar to carburator body with throttle valve control.

Spiral

Teacher's Sign .....

(3) The screw is use to control air and fuel mixture.



Imp Battery Ignition system :-

(1) The essential component of BIS are.
- Battery
- Ignition switch
- Ammeter
- Ballast Registor.
- Ignition Coil.
- Condensor
- Contact breaker
- Distributor
- Rotor Arm.
- Spark Plug

(A) Battery :- It provide initial electric energy for ignition start.

(B) Ignition switch :- It is the medium to connect the battry supply to the primary winding.

(C) Ammeter :- It is used to measure the current

(D) Blast Registor :- is place in series with primary winding. to regulate the primary current and avoid damage to coil by over heating.

Ammeter

Primary

(5) Ignition coil :- It consist of two coils primary and secondary coil current Induced in secondary coil by mutual Induction of primary coil.

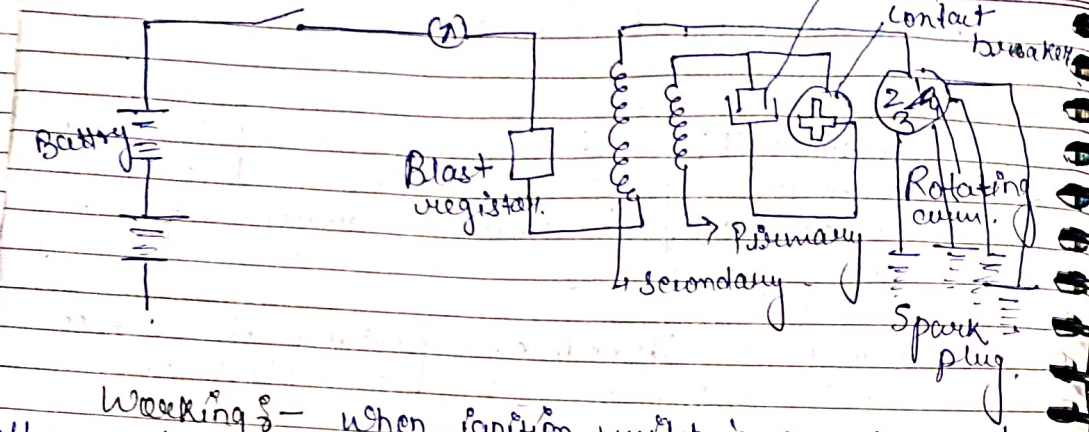
(6) Condensor :- It reduce sparking at a breaker point and thereby prolongs their life.

(7) Contact breaker :- The contact breaker is made up of Tungsten is the set of mechanical device to make break the primary circuit of ignition coil.

(8) Distributor :- It distribute step up voltage to spark plug (20,000 to 30000 Voltage).

(9) Rotor Arm :- The rotor Arm is fixed on the top of distributor and supply current different section.

(10) Spark plug :- The spark plug with an electrode about high potential discharge to generate Spark to ignite combustion engine.



Working :- When ignition switch is on, current flows from battery to the primary coil. the current flow through primary winding induced magnetic field in the secondary coil. When contact breaker open magnetic field collapsas which induced current or electromotive force. in secondary coil. the emf produced in secondary coil with high voltage upto 20000 volt) the distributor direct the high voltage to the proper spark plug. to jump the air gap which generate spark.

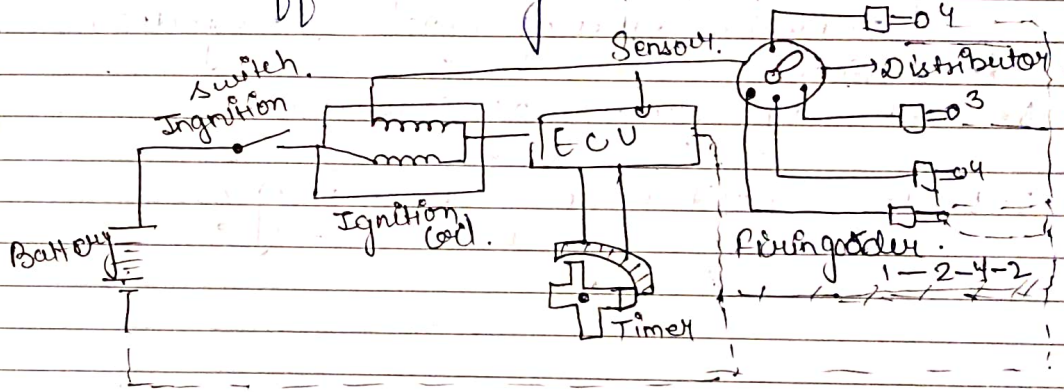
Electronic ignition system :- In the electronic ignition system a timer is use. In place of contact breaker. timer is of two types.

1. Pulse generator
2. hall switch effect.

Teacher's Sign .....

1. Pules generate :- It is use to generate and alternating voltage to supplying to electronic control unit to control the making and breaking of the current built up in the primary winding of the ignition coil.

2. hall effect switch :- this switch works on the principle that when a semiconductor chip of sillion or gramanium carry current is cross at right angle by a magnetic fail. Potential difference is produced at the H of the chip through hall effect. is very small in a metal.

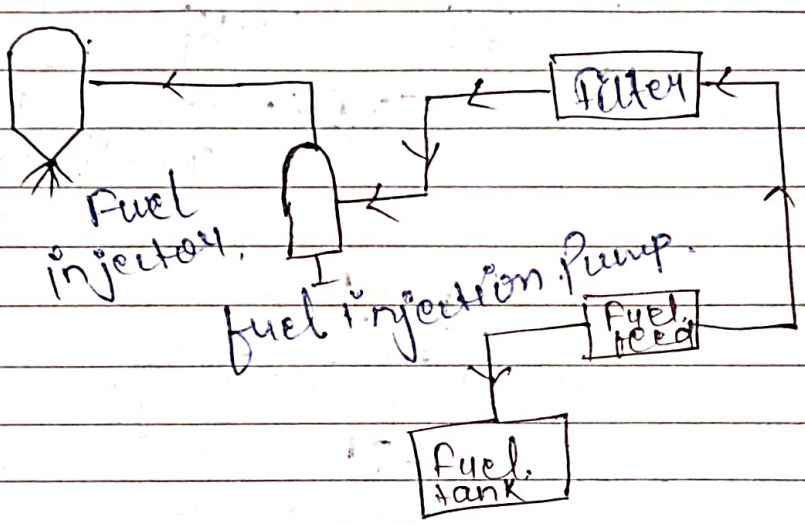


Chapter-3

Fuel Supply in diesel engine.

Components of fuel system :- / fuel injection system.

1. Fuel tank.
2. Fuel feed pump
3. Filter
4. Fuel injector pump
5. Fuel injector.



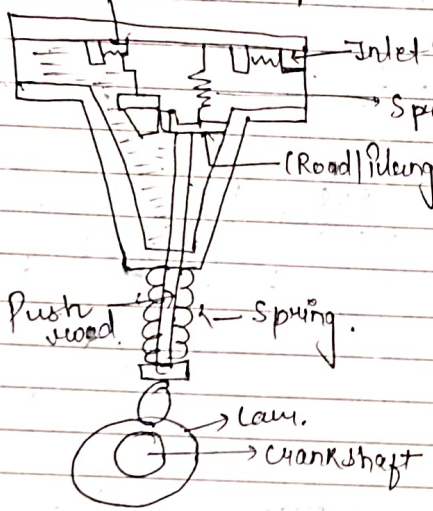
The fuel stored in fuel tank & fuel feed pump transferred the fuel to fuel injection pump via by a fuel filter. fuel injection pump forces the fuel under a very high pressure to fuel injector. fuel injector injects the fuel to the engine.

(1) Fuel tanks :- It is used to store the fuel. It may be placed at higher level or at a lower level.

(2) Fuel feed Pump :- The pump which supply fuel from fuel tank to fuel injection pump there are two types fuel feed pump are

- Plunger type feed pump
- Diaphragm type feed pump.

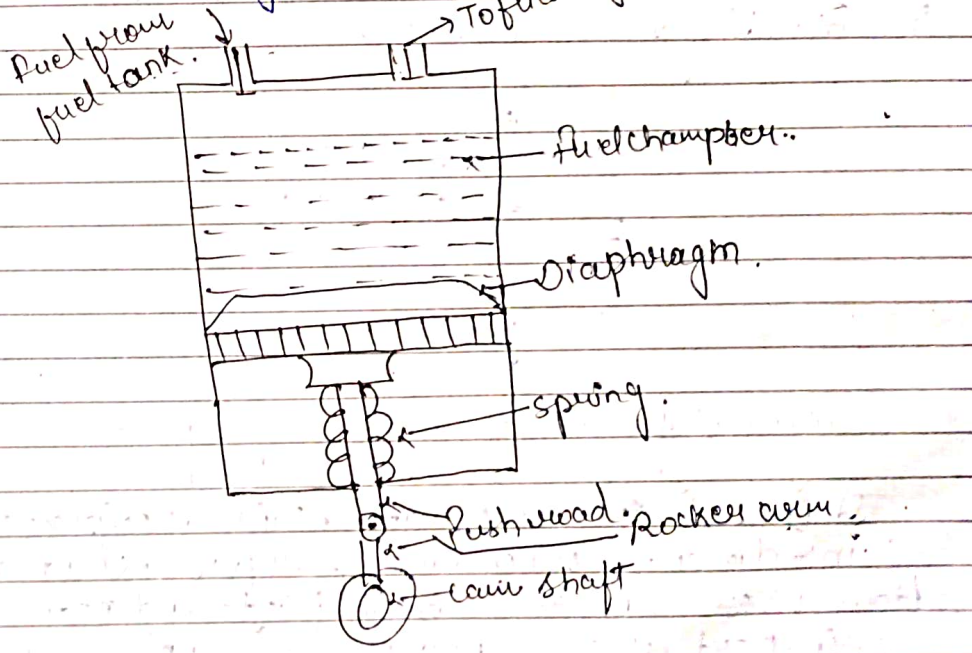
(a) Plunger type feed pump :-



When the cam moves away the spring along with plunger pushes downward and creates a vacuum in the chamber the downward movement of plunger opens the inlet valve and fuel is sucked from the fuel tank. Cam rotates and plunger moves upward direction and pressure developed in chamber closes inlet valve and open outlet valve which pushes the fuel in fuel injection pump through the filter.

(b) Diaphragm type feed pump :-

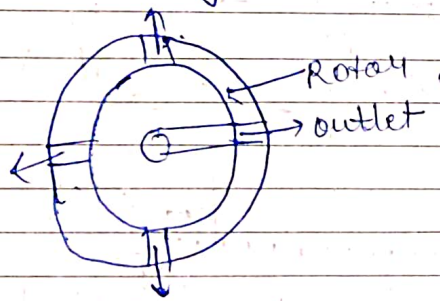
When the diaphragm pulls back against the tension of spring, vacuum is created in the chamber which opens the inlet valve and fuel enters inside the chamber. When diaphragm pushes forward inlet valve closes and outlet valve opens which transfer the fuel to the fuel injection pump through filter.



(5) Fuel injection pumps - The pump which supply quantity of fuel to the injector under a very high pressure at correct instant. It is of two type

(a) Distribution type.
(b) Plunger type

(a) Distribution type fuel injection pumps - The distribution type fuel injection pump is a rotary distributor type which pump and distribute the fuel at the correct moment this fuel injection pump is preffered in multicylinder engine.

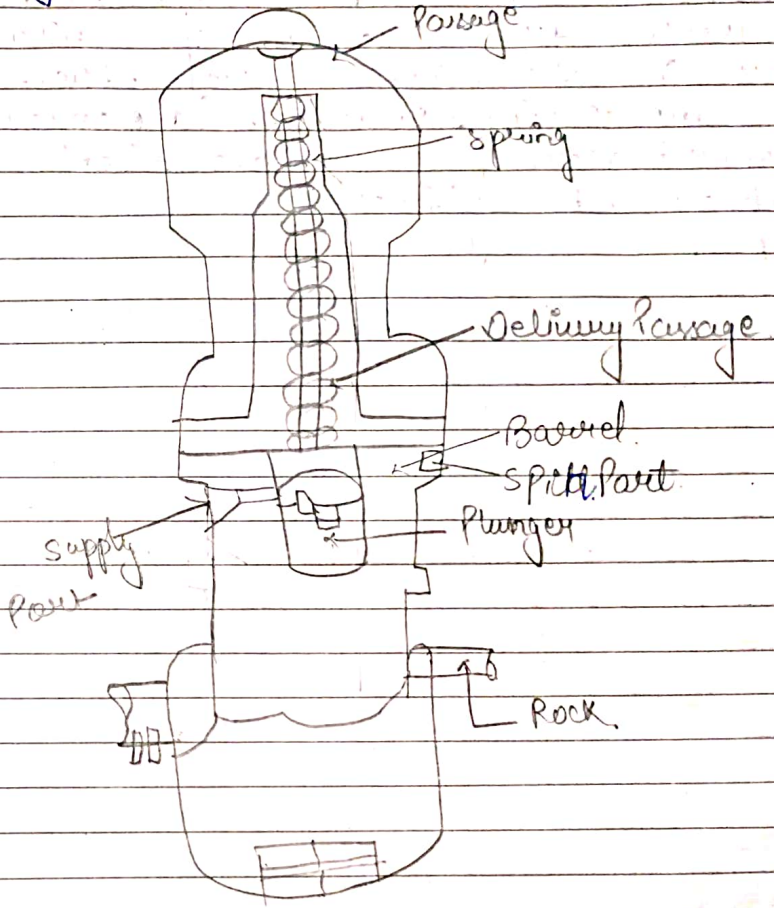


(b) Plunger type fuel injection pumps -

It consist of a plunger which reciprocate (up-down) when the plunger is at the bottom most stroke, both inlet and spin port are uncovered. fuel from fuel gallery into the barrel when plunger push up by cam and.

Teacher's Sign .....

Capet mechanism the plunger compresses the fuel to the high pressure and lift the delivery valve when the plunger move to its initial position the compress fuel transfered to the fuel injector.



Teacher's Sign .....

Fuel Filters:- Filters which clean the fuel from vapour or dirt, dust is known as fuel filter. it is of two type.

- Primary fuel filter
- secondary fuel filter.

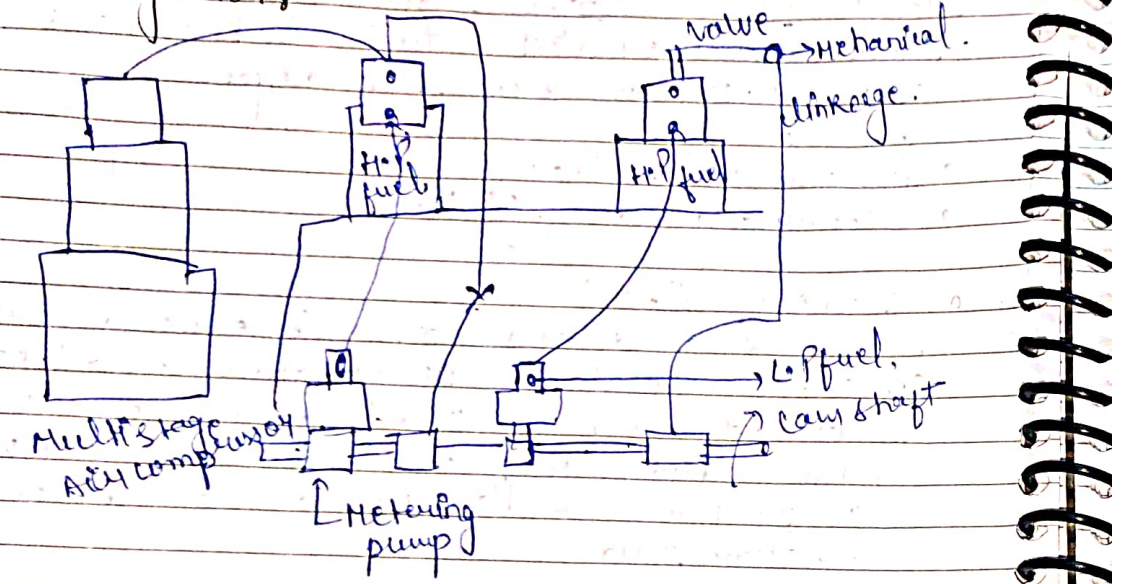
- Primary filter:- It consist of single bolw and center located perforated (small hole surrounded by a filter tube element. dust, dirt, impurite at the Bottom of the bolw and can be drained through drain plug.

- scondary filter:- It consist of two independent bolw bowl one having low filter and other is fitted with fine fuel from feed pump enter into the filter fuel filter from course filtration tra to the fine filter where fine particles ca be removed then the filtered fuel enter in fuel injection pump.

Types fuel injection system:-

There are two types of fuel injection
(1) Air injection
(2) solid injection

(1) Air injection :-



In this system the air is first compressed to very high pressure this compressed air is injected into the engine cylinder. and it carries the fuel with itself. the metered quantity is pump into the fuel valve with help of fuel pump given cam shaft. fuel valve is opened with the help of mechanical linkage operated by cam at which control the timing of fuel injection.

n the fuel valve is open. the blast air weeps the fuel along with it. and ell atomized fuel spray is supply to mbustion chamber.

Teacher's Sign .....

Advantages :-

1. It provides better atomization and distribution of fuel.
2. The fuel pump is required to developed only a small pressure.

Disadvantages :-

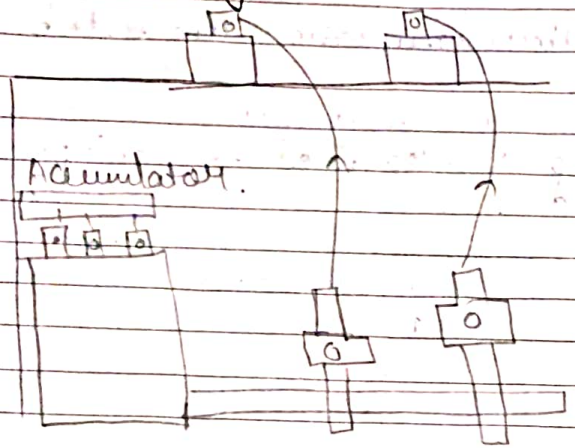
1. The fuel valve sealing requires considerable skill.
2. This system is complicated and expensive.

Solid injection :-

In this system the fuel low under high pressure is directly injected into the combustion chamber a fuel pump is used to delivery of fuel at high pressure this is also called as Air less injection Air less injection much superior to Air injection system. It can be classified as follows.

1. Individual pump
2. Nozzel system :-
3. Common rail system
4. Distributor system.

Common Rail System :-



Multicylinder high pressure pump

Metering and time element

In this system a high pressure fuel pump delivers fuel to an accumulator. The high pressure in the accumulator forces the fuel to each of the nozzel located in the cylinder. A mechanical rated valve allows the fuel to enter the proper cylinder through the nozzel.

Advantages :—

Simple construction, light in weight and cheap.

Only one pump is sufficient for multicylinder system.

W.→ Tillnow.

Dt.
Page

Disadvantage :-

1. Some time excess amount of fuel may be injected into cylinder may accurate design and work man-shaped are required.

Requirements of fuel injection system :-

1. The amounted of fuel injected per cycle should be as meter accurately.
2. For proper atomization.
3. For the control injection rate.
4. For uniform fuel distribution in all cylinders.
5. For the correct injection timing of fuel.

24/02/25.

Chapter-4 Cooling And Lubrication.

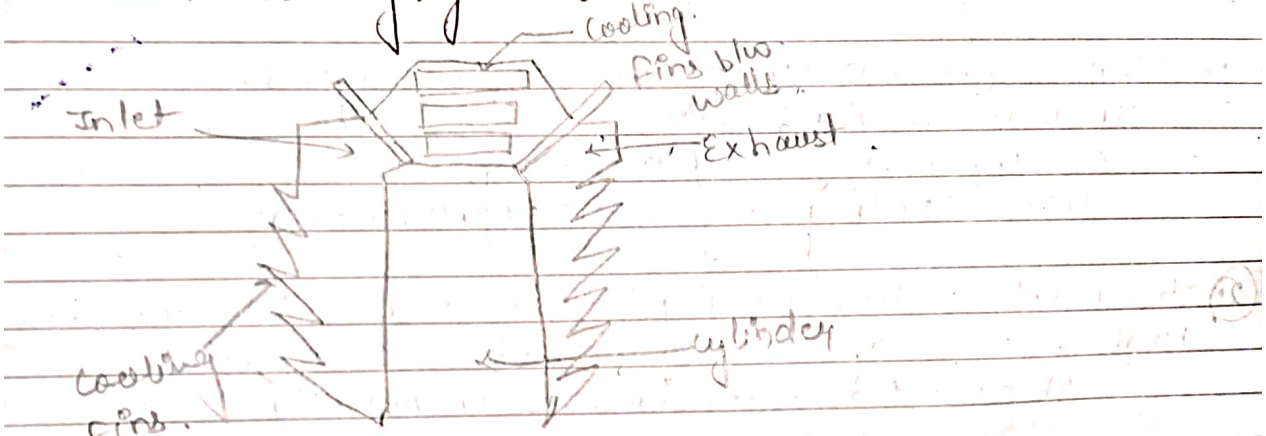
* Function of cooling systems:-

1. Maintenene the desired temperature of engine.
2. Increase efficency of engine..
3. Increase engine life
4. Increase power output.
5. Increase volume-metric effiency.

* Types of cooling system :-

1. Direct Air cooling or Air cooling. System
2. Indirect Water cooling or water cooling. system.

* Air cooling system:-



In this system, Heat after being conducted through the cylinder is directly dispite to the environment. fins are provided.

Teacher's Sign .....

For this work the heat dissipation depends upon.

1. Surface area of components in contact with air.
2. Rate of air flow
3. Temperature difference b/w component and air.
4. Conductivity of material.

* Advantages :-

1. Light in weight
2. Its can operate in cool climate.
3. Anti-freezing element not required.
4. Simple in design, and less costly.
5. problem of corrosion is less.

* Disadvantages :-

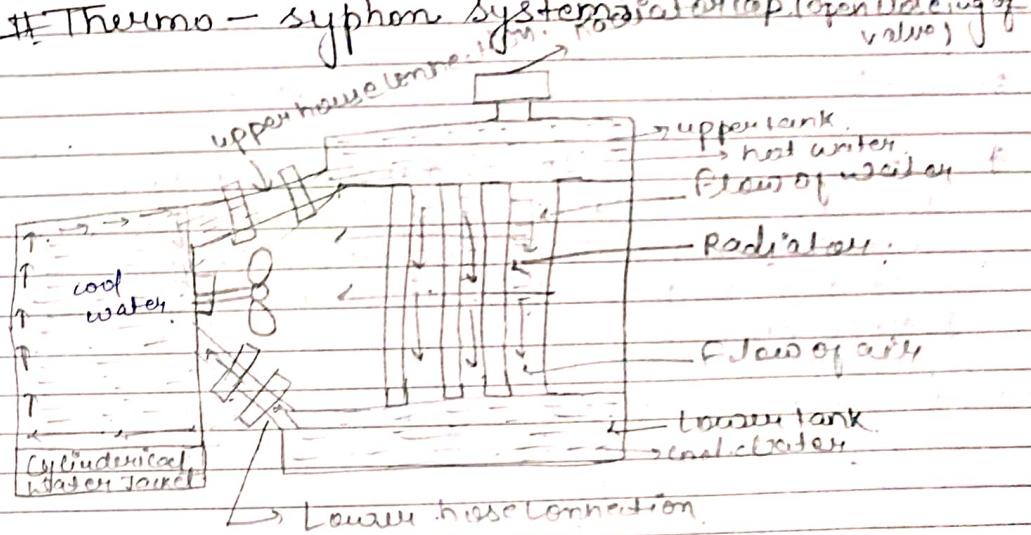
1. This system only use in small engins.
2. Uneven cooling is
3. less efficient in the cooling.
4. Air cooling engine are more noisy.

(2) Indirect water cooling :- In water cooling system heat is first transferred to water then it dissipate to the surrounding air.
In water cooling system water is circulated to water jacket around each combustion cylinder.

Various method of water cooling are :-

1. Direct or non return.
2. Thermo - syphon system.
3. Forced circulation Method.
4. Evaporated cooling Method.
5. Pressurised cooling Method.

Thermo - syphon system :-



In this system the circulation of water obtained due to the difference in density of hot and cold water. The top of the radiator is connected to the top of water jacket by a pipe bottom of the radiator to the bottom of water jacket water travels down the radiator across which air is passed to cool it.

The air flow can take place due to vechicle motion or a fan, can be provided for the purpose.

Limitations:-

1. The rate of circulation of water is slow in sufficient for cool, 2. It is not suitable for heavy duties engines.
3. It required bigger size radiator.

Radiators:- The radiator works by circulating coolant throught tubes and fins transferring heat to the surround ing air and maintaining the stable engine temperature.

→ The component which dessipate the heat from circulating water to the air is called Radiator.

→ It consist of three part upper tank central part & louder tank.

→ It is of two tube tubular radiator Cellular radiator.

Spiral

Teacher's Sign .....

Thermo State:- The valve used in cooling system to regulate the cooling system to regulate the engine temp by controlling the amount of cooling water flow through water jacket to radiator core.

→ A thermo state fitted in system, which initially prevents the circulation of water below a certain temp. so that the water heated up quickly.

function and types of coolant:-

1. The water is not suitable for high altitude applications since the water freezes at zero degree (C) to prevent freezing coolant are added in cooling water.

Define of coolant:-

→ coolant is a fluid use in the radiator to remove engine heat. the most common coolant are.

1. water Alcohol.
2. ethylene gycool.
3. Glycerine
4. Denaturant Alcohol.
5. Calcium and magnesium chloride.
6. Propylene gycool.
7. Mixture of Alcohol and glycerine.

Spiral

Teacher's Sign .....

Benefits of coolant :-

1. uniform cooling.
2. Better thermal efficiency.
3. Permit the use of high compression ratio.

Lubrication :-

It is a process of introducing a film/layer of lubricant to reduce friction between moving parts.

Functions :-

1. To reduce friction minimize wear and tear.
2. Reduce oxidation.
3. Reduce shocks and vibration.
4. To Reduce noise.
5. To carry away impurities.

Lubrication of Engine components :-

In engine there are many surfaces in contact with each other should be lubricated to reduced friction the components are piston cylinder, crank shaft and bearings.

3. Connecting rood.
4. Valves.
5. Valves gears.

Types of lubricants :-

1.) Solid :- Lubricants which are used after mixing with oil. they are in solid state for Example graphite, mica.

2.) Semi solid :- The lubrication such as grease which are neither in solid nor in liquid state they are used to lubricate water pump.

3.) Liquide lubricant :- The lubricants which are in liquide state known as liquide lubricants they are mainly classifiede as.

1. Animals oils obtained from fish etc.
2. vegetable oil obtained from vegetables. e.g mustard oil.
3. Mineral oil, are obtained from petroleum. chiefly.

Properties of lubricants :-

1.) viscosity :- The property of oil which measure its resistance to flow. A good lubricant should have optimum viscosity.

2.) Flash point :- The lowest temperature at which the lubricating oil will flash. A good lubricant should have

high Flash point (catch Spark)

3.) Fire point :- The lowest temperature at oil ignite a good lubricant should have high fire point.

4.) Volatility :- The property of oil which determine the tendency to evaporate when subjected to high temperature a good lubricant should have low volatility.

5.) Oiliness :- The property of oil to spread and stick on bearing surface.

6.) Emulsification :- The property of oil due to which it mix with water.

7.) Chemical stability :- The property of lubricanting oil to have a least tendency to form oxide.

8.) Adhesiveness :- The property of oil due to which oil particle stick with metal surface.

9.) Pour point :- The lowest temperature at which lubricating oil will flow under specific condition.

10.) Insoluble residue :- The property by which lubricant should not have.

any insouble residue.

LUBRICATION SYSTEM OF I.C ENGINE:-

The system of engine to supply and regulate the flow of lubricating oil.

* Lubricating system are classified as :-
  - Mist lubrication system.
  - Dry sump lubrication system.
  - Wet sump lubrication system.

* Mist lubrication system :- This lubrication system generally use in two stroke petrol engine, like, scooter, moped, motorcycle etc.

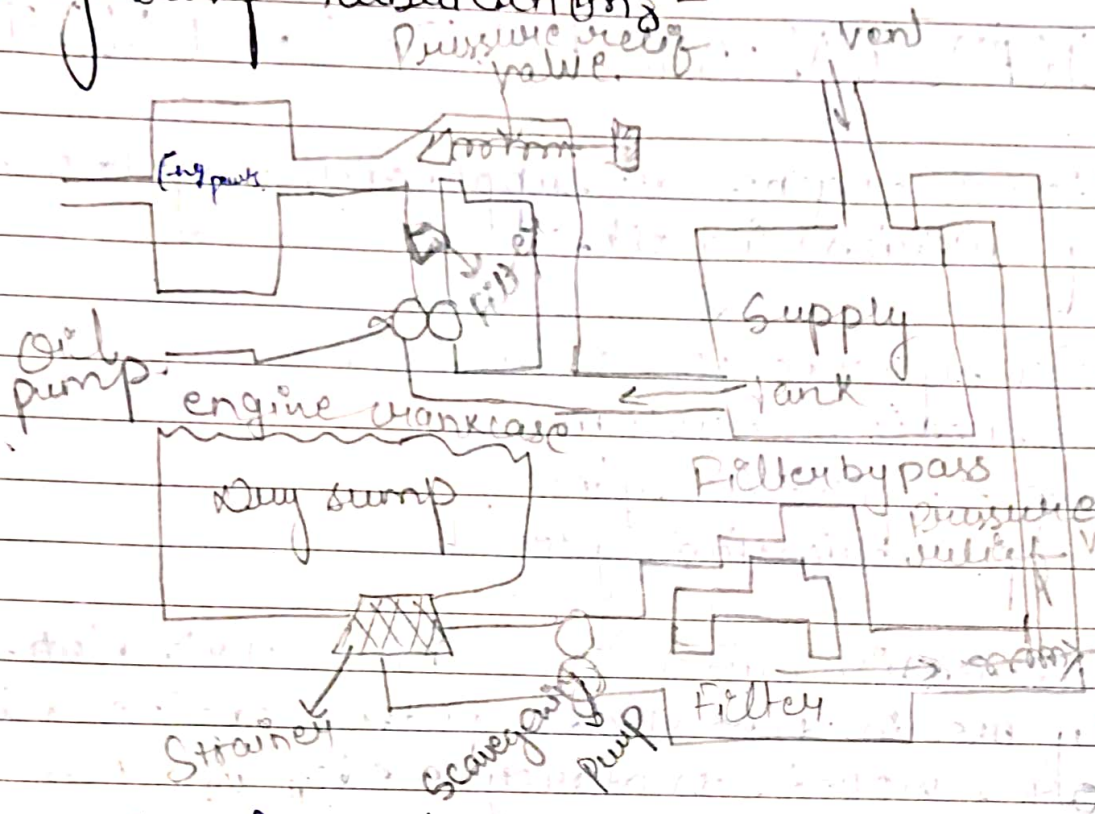
→ In such engine lubrication oil mixed with fuel in a ratio of 3% to 6%. When the fuel burns oil get vaporized and form mist. that mist lubricate the connecting rod and rest of the lubricating parts.

* Advantages :-
1.) Lubrication system is simple.
2.) It has low cost.
3.) It requires less maintanence.

Disadvantages :-
1.) It provide heavy exhaust smoke.
2.) Exhaust smoke deposite on piston ring, and other parts of engine which lowers the

Volumetric efficency.

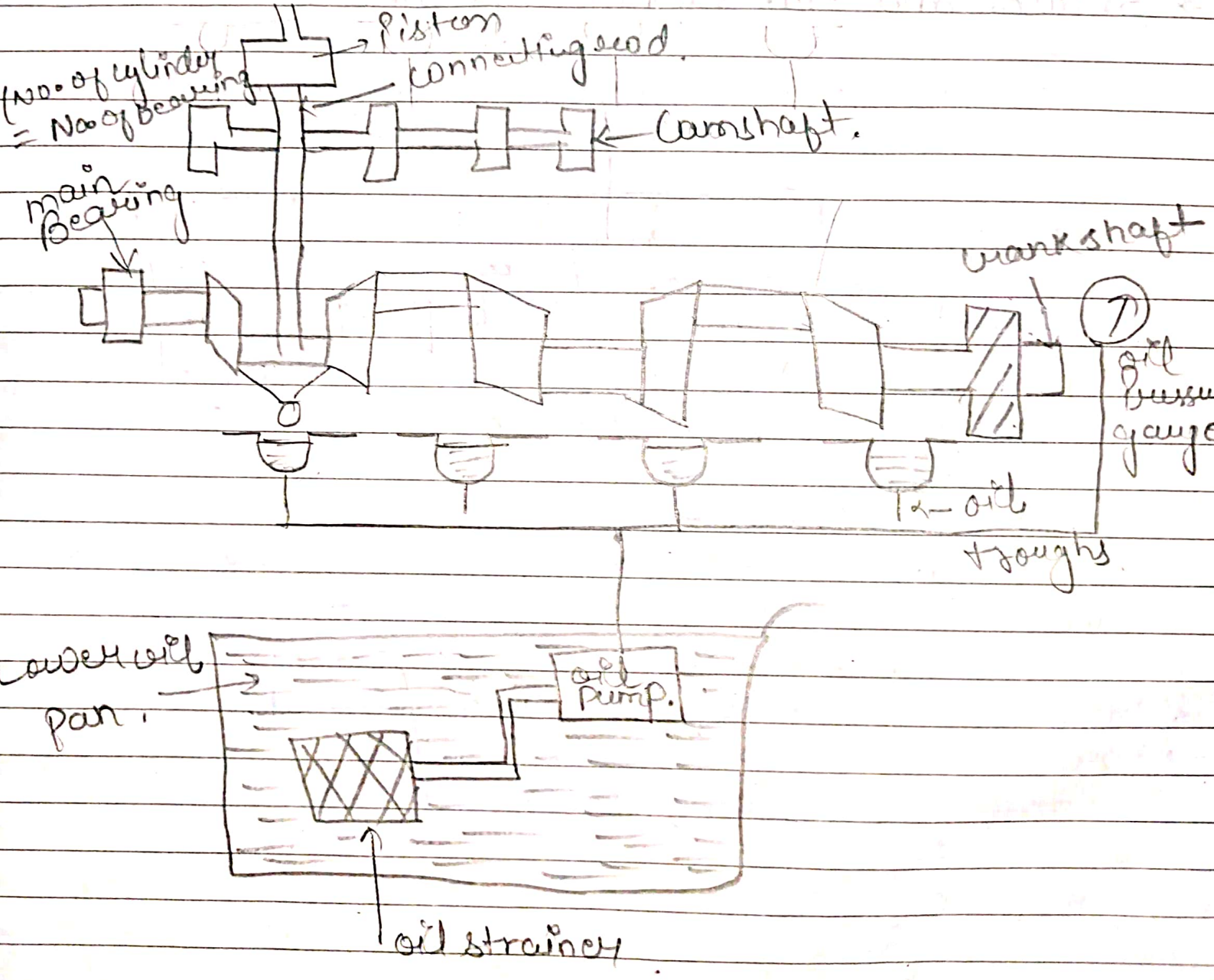
* Dry sump lubrications -



This system is used where vehicle changes its position continously like aircraft. In the lubricat oil is kept in supply tank from where oil is sucked by oil pump oil gets cooled by oil cooler lubricate the different parts of system oil gets stored then in a sump called Dry sump. after passing through strainer the oil by pump called scavenging pump take the oil dry sump and transferred to supply tank. after get fittered through pressure relief valve are also provided to the pump.

WETSUMPLUBRICATION is attached the bottom crankcase. When lubricating oil lubricate the different parts of Machine. Oil flow back to sump by the help of gravity. it is of three type.

1. Splash lubrication system.
2. Splash and Pressure system.
3. Pressure feed lubrication system.



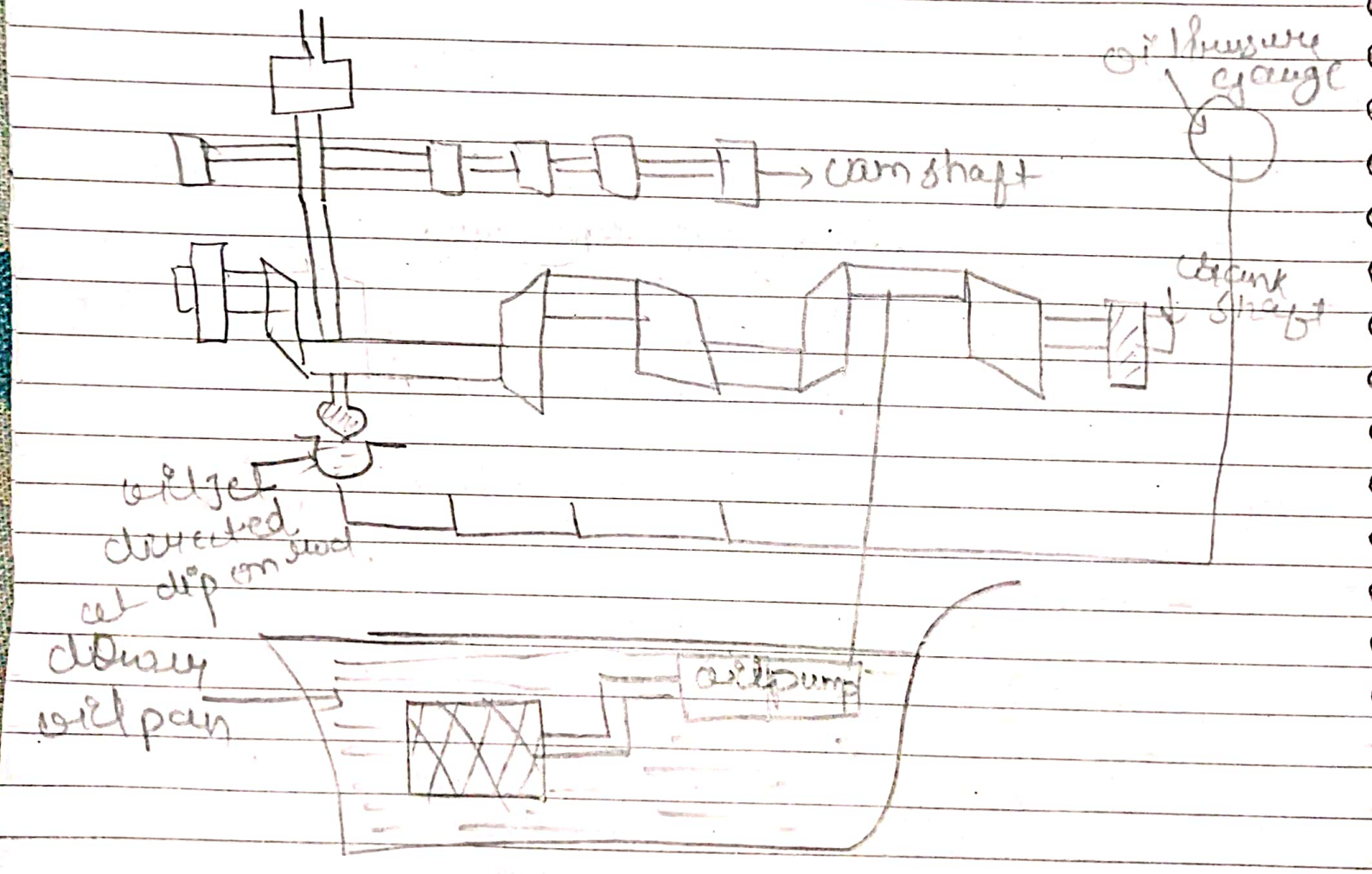
Spiral

Teacher's Sign .....

*Splash lubrication :-

The system in which the lubricating oil is splash by centrifugal force. Over different moving parts of engines is called splash lubrication System. the lubricating oil is stored in oil sump a 'dipper' is connected at the end of connecting rood which splashes the oil when engine starts.

*Splash and lubrication system :-



Teacher's Sign .....

It is modified splash system. in which lubrication is done by both splashing ~~and by~~ via pump in this system pump is provided which supply lubrica -nt oil on different parts of engines. all four stroke engine are lubricated by this system.

* Pressure fed lubrication system :-

In this system lubrication only done by the help of pump. the oil pump supply oil from the sump to bearing of crankshaft it also supplied lubricating oil to the different parts of engine piston. pin. gudgeon pin. etc.

Chapter - 5

Testing of I.C engine.

Engine powers - The flow of energy through the engine is expressed by three term's these are,

1) Indicated powers - The actual power provide inside the cylinder is called indicated power is is Expressed as I.P. I.P = F.P + B.P

2) Brake powers - The net power produced at the crank shaft of an engine is called the Brake power it is expressed as B.P. B.P = I.P - F.P

3) Frictional powers - The difference of indicated power and Brake power is called Frictional power it is expressed F.P.

∴ Efficency of I.C engine $\eta = \frac{\text{Output}}{\text{Input}}$.

(1) Mechanical efficency - It is ratio of Brake power to indicated power. It is represented as.

Teacher's Sign .....

$\eta_{Mech} = \frac{B.P}{I.P} = \frac{I.P - F.P}{I.P}$

$\eta = 1 - \frac{F.P}{I.P}$ or $\frac{\text{Friction Power}}{\text{Indicated Power}}$

Thermal efficency:- It is the relation that how efficient it is used it is of two types
it is {indicated thermal efficency}:- The ratio of heat equalivalent to workdone by the gass in cylinder to total heat energy supplied by the combustion of fuel. In the same time. is known as indicated thermal efficency.

$$I.T.E = \frac{I.P}{m_f \times C.V}$$

m_f = mass of fuel supplied.
C.V = Calorific value.

Key point
Calorific value:- The amount of heat energy released when ~~perfect~~ specific amount of fuel is completely burn.

(2) Breake thermal efficency:- It can be defined as ratio of the Breake power to the heat supplied by the fuel.

$$B.T.E = \frac{B.P}{m_f \times C.V}$$

m_f = mass of fuel supplied

Spiral

Teacher's Sign .....

CV = calorific value.

(3.) Relative efficiency :- It is the ratio of actual efficiency obtain from an engine to the theoretical efficiency of the engine cycle.

R.E = Actual brake thermal efficiency.
Air standard efficiency.

(4.) Volumetric efficiency :- The ratio of the actual volume of the charge taken into the engine cylinder during suction stroke to the swept volume.

V.E = Volume of charge admitted.
Swept Volume.

(5.) Air standard efficiency :- The ratio of heat converted into work to the heat input per cycle.

η_{air} = heat converted into work per cycle.
Heat input per cycle.

Method of finding I.P and B.P:—

- Indicated power:— The actual power produce inside the cylinder of the engine is known as indicated power of the engine.

$I.P = B.P + \text{engine losses}$

P_m = Indicate mean effective pressure

A = Area of cross section of Piston.

L = Length of stroke.

n = no. of working Strokes/min

Work done per stroke $= P_m A L$

Work done per minute $= P_m A L n$

$$I.P = \frac{P_m A L n}{60} \quad W$$

For 2 stroke engine $= n = N$

For 4 stroke engine $= n = \frac{N}{2}$

Brake Power:- The net power available at the crank shaft of an engine is called Brake power. For measurement of power out put dynometer are used.

1.) Absorbption dynometer.
2.) transmission dynometer.

Absorbption :— This dynometer absorb and measure the power out of the engine to which they are couple.

2) Transmission :— In transmission dynamometer the power is transmitted to the load. to the engine coupled after it is indicated.. some type of scale.

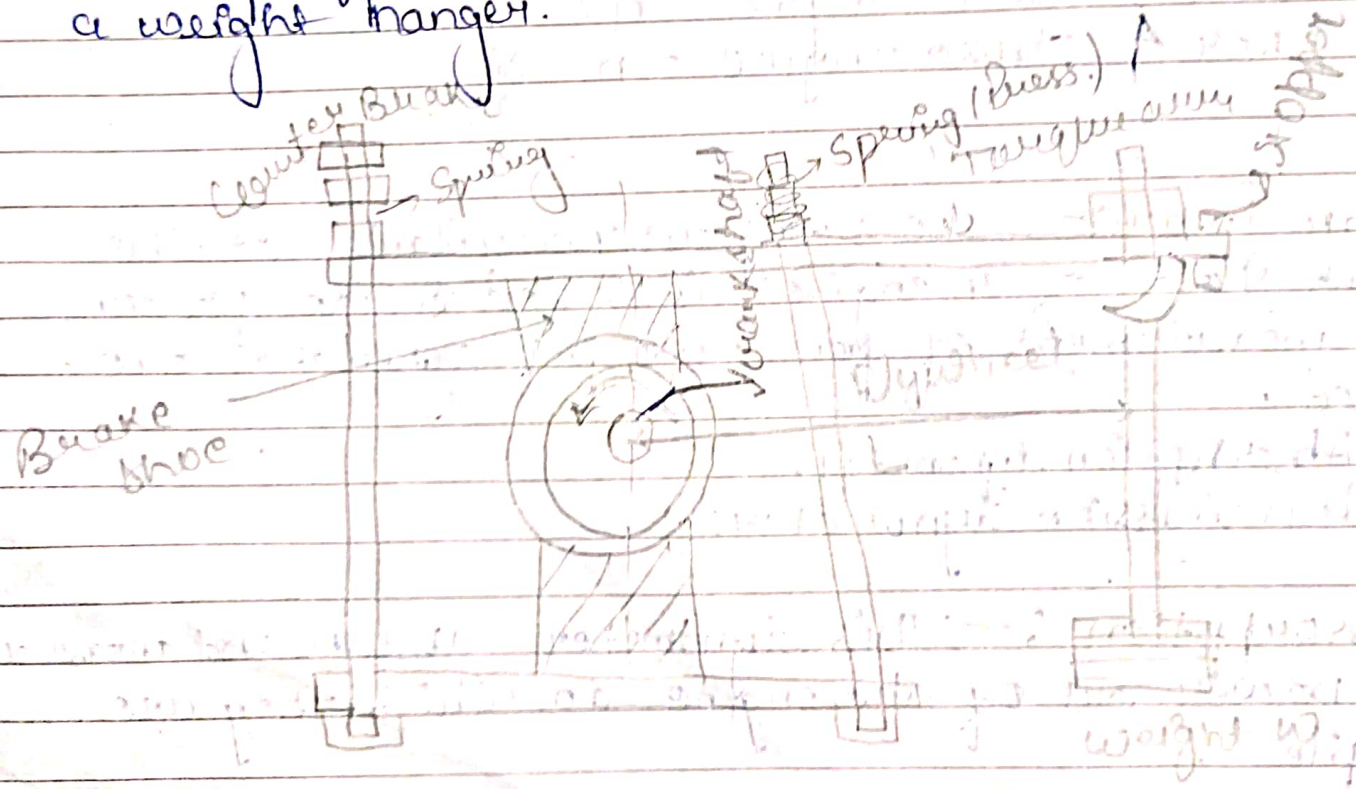
Work done per revolution = $2\pi RXT$

" " minute. = $\frac{2\pi RTN}{60}$

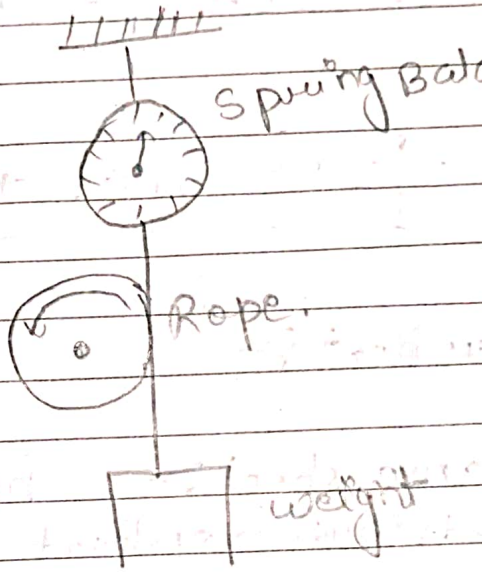
N = number of revolution per minute.

T = Torque. (WXL)

1) Prony Brake :— It consist of Brake shoes which are clamped on the fly wheel. with the bolt, the pressure of flywheel. can be adjusted by means of nuts. A load bar extents from the top of the Brake at the end is attached. a weight hanger.



2) Rope Brakes :- It consist of No. of turns of Rope wound around the rotating drum attached to the output shaft of the engine. one side of the rope is connected to the spring balance and other to a loading device the power absorbed is due to friction b/w the rope and the drum (circular flywheel) the drum therefore requires pulley



MORSE TEST :- the Method of finding indicated power of each cylinder in a multicylinder engine is called morse test.

Now, consider 4 cylinder having indicated power I_1 I_2, I_3, I_4 respectively and friction power f_1, f_2, f_3, f_4 respectively.

Total Brake power is given as

(Brake power) $B = (I_1 + I_2 + I_3 + I_4) - (f_1 + f_2 + f_3 + f_4)$ — (1)

when cylinder 1 is cut off then $I_1 = 0$ Friction

Spiral

Teacher's Sign .....

losses remain same in all cylinders.

$$BP_1 = (0 + I_2 + I_3 + I_4) + (f_1 + f_2 + f_3 + f_4) \quad (2)$$

Subtracting eq^n (2) from eq^n (1)

$$I_1 = B - BP$$

$$I_2 = B - BP_2$$

$$I_3 = B - BP_3$$

$$I_4 = B - BP_4$$

$$\text{Total} = I_1 + I_2 + I_3 + I_4 = (B - BP) + (B - BP_2) + (B - BP_3) + (B - BP_4).$$

$$\text{Total} = \boxed{IP = I_1 + I_2 + I_3 + I_4.}$$

~~# Heat produce heat :-~~

Heat Balance sheet :- The sheet which shows the distribution of heat supplied to engine is known as heat balance sheet. ~~show the distribution~~

(a) Heat supplied in fuel :-

$$Q = mC_v$$

Where m = mass of fuel.

C_v = calorific value.

(b) Heat rejected to cooling water :-

$$Q = m_w (C_w (T_o - T_i).$$

Where $\dot{m}_w$ = mass of cooling water.
C_w = Specific heat of cooling.
(inlet) T_i = Inlet temp. of water.
(outlet) T_o = outlet temp. of water.

(c) Heat carried by exhaust gases :-

$$Q = \dot{m}_g C_g (T_g - T_a)$$

Where, $\dot{m}_g$ = mass of exhaust gas.
C_g = specific heat of exhaust gas
T_g = Temp. of exhaust gas
T_a = Ambient Temp.

Pollutants in S.I and C.I. engines :-

Air pollution can be defined as an addition of any material to our atmosphere which will have a harmful effect on our planet.

Pollutant	Major source	Harmful effect
(1.) CO Carbon monoxide.	Automobile - 43%. Power generation - 7%	Enter the circ of oxygen in blood causes poisonin effect.
(2.) HC Hydrocarbon	unburnt hydrocarbon Automobile - 57% Petroleum refining - 43%	(2.) HC (Hydro ~~on~~ irritation is respiratory organs.

Spiral

Teacher's Sign .....

3.) Nox (oxides of Nitrogen)	Automobile - 39%. factories, Power generation. Petroleum refining - 61%.	Irritates the eyes nose, throat headache and lungs damage.
4.) SO_2 (Sulphur dioxide)	Automobile (diesel) - 1%. Factories - 99%.	Irritate respiratory system and causes inflamation of wind pipe.

Emission of Pollutants from S.I. engines :-

Emission from exhaust :- When complete combustion of gasoline take place the exhaust gas. Gas contain CO_2 and water vapours.

$$2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O.$$

1.) Carbon monoxide :- (CO).
It produce by incomplete combustion of gasoline.

2.) Hydrocarbon (HC) :- Unburnt hydrocarbon emission are result of incomplete combustion which are emitted through exhaust.

3.) Oxides of Nitrogen :- (NOx) are produced when O_2 and N_2 of atmospheric pressure are combine inside combustion chamber at temp above 1100°C

Teacher's Sign .....

Emission of pollutants form diesel engine.

1. CO - carbon moxide :- Its concentration is quite less (2%) as compared to petrol engine (5%).

2.) Hydrocarbon (HC) :- Presence of carbon particle in the exhaust gases is the cause of black smoke in diesel engine.

3.) oxide of Nitrogen :- (NOx) As high temp. reaches due to complete combustion in very high amount.

Methods of controlling pollution in engines

- combustion of chamber optimization.
- Improve air intake system.
- optimize compression ratio.
- optimization of fuel system.
- use of Alternate fuel like electricity and biodiesel.

Alternate fuels :-

- Natural gas :- It is the mixture of hydro-carbons like methane (CH_4) with low (CO) emission.

- Hydrogen :- It is the cleanest fuel which produce water vapour after combusti

Spiral

Teacher's Sign .....

It burns 10 times faster than ordinary fuel.

- Electricity :- It is use in form of batteries.
- biodiesel :- They are Renewable fuel that can be manufactured by vegetable oil, animal fat and recycle. Restaurant grease.

Q-4. Emission Norms :- are the maximum prescribed level of Co, HC, and Nox, set up by the government which the vehicle is permitted to emit from its exhaust while running.

Bharat Stage → Pollution Control Norms.
the emission norms are the burn. ministry of environment. the emission norms are enforced in vehicle as.

1. Motor cycle and three wheeler. — Co 4.5%.
2. Car :- Co 3%.
3. diesel engine 65% HSU
4.

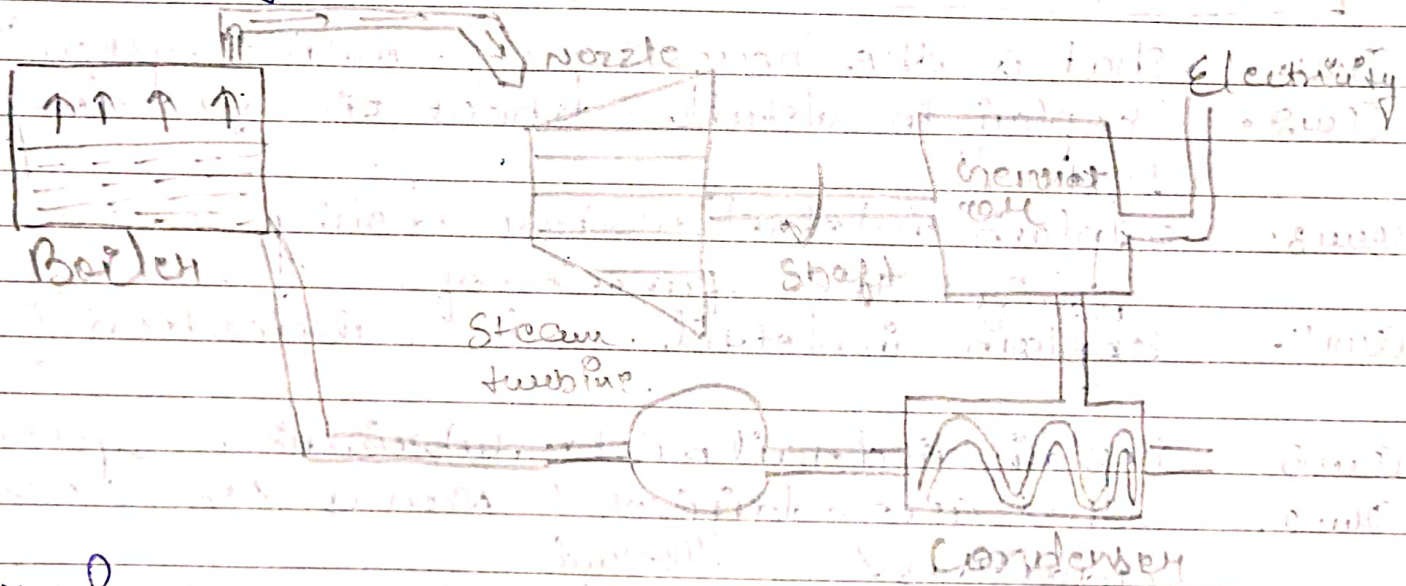
Standards	Reference	year
1. BS-I	EURO - I	2000
2. BS-II	EURO - II	2001 - 2005
3. BS - III	EURO - III	2005 - 2010
4. BS - IV	EURO - IV	2010 - 2017
5. BS - VI	EURO - VI	2018 - till now

Chapter-6
Steam Turbine and Steam Condensers

* **Steam turbines** — It is a rotary machine which convert heat energy of steam into mechanical energy

* **Function of steam turbines** —
1. Steam turbine used heat energy of steam and transform into kinetic energy through nozzle and kinetic energy converted into mechanical energy.

The steam turbines are mainly use for power generation in thermal plants.



* **Parts of a steam** — (Turbine)

1. Turbine Rotar —

It carries the blades are made up of special steel Alloys.

(2.) Stators :- In which the rotor rotates and Nozzle are encased.

(3.) Nozzle :- The function of the steam Nozzle is produced a jet of high velocity steam which directed on the balades of turbine.

(4.) Casing :- It consist of turbine rotor and blades it control the movement of steam from the blades to the condense

CLASSIFICATION OF STEAM TURBIN

* According to the mode of steam action.
  - Impulse turbine.
  - Reaction turbine
  - Combination of both.

* According to direction of flow of steam.
  - Axial flow
  - Tangential flow
  - Radial flow.
  - Mixed flow.

* According to the Exhaust condition.
  - Condensing turbine.
  - Non-condensing turbine.

* Acc to No. of stages
  - single stage
  - Multistage.

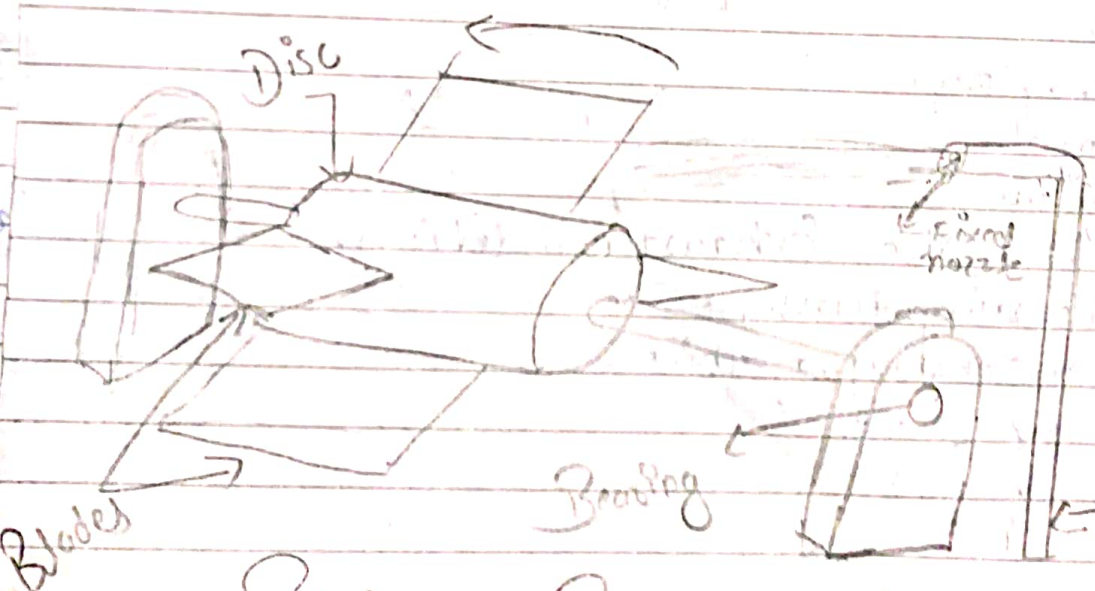
* According to the steam Pressures-
- high Pressure.
- Medium Pressure
- Low Pressure

Advantages of steam turbines—

1.) efficiency is high.
2.) Steam consumption is low.
3.) It produced high speed.
4.) It has no moving parts so there is no vibration.
5.) It has very less friction losses.
6.) It requires very nickel amount of lubrication.

IMPULES TURBINE :-

the turbine that is driven by high velocity of steam from a nozzle directed on the vanes attached to a wheel. the resulting Impules spin continue. Next page.



Spiral Principle of Impulse Turbine

Teacher's Sign .....

from a nozzle directed on the vanes attached to a wheel the resulting impulse spins the turbine. and removes Kinetic energy from the fluid flow.

*. Construction :- the main parts of impulse turbine a rotor nozzle, blades, and, casing.

*working :-

First of all. steam is supplied through nozzle. From the nozzle it leaves with a very high velocity. the velocity of steam increase and the pressure remains constant in the moving blades the Kinetic energy is used. In producing work on the shaft. It rotates turbine at a very high speed. the power transmit into the generator. and produces electricity.

#Difference blw impulse turbine and reaction turbine

Impulse turbine	Reaction turbine
(1) It is suitable small capacity power generation.	(1) Suitable for medium and high capacity power generation.
(2) less space is required per unit power.	(2) More space is require
(3) Total pressure drope occurs only on nozzle.	(3) pressure drope continous occurs both in fixed and moving blades.
(4) the steam velocity is very high therefore, Speed of turbine is very high.	(4) steam velocity is low therefore speed of turbine is also low.
(5) The power is obtain due to Impulsive force of steam.	(5) The power is obtained due to Impulsive force as well as due to reactio of the steam cleaning blades.

Spiral

Teacher's Sign .....

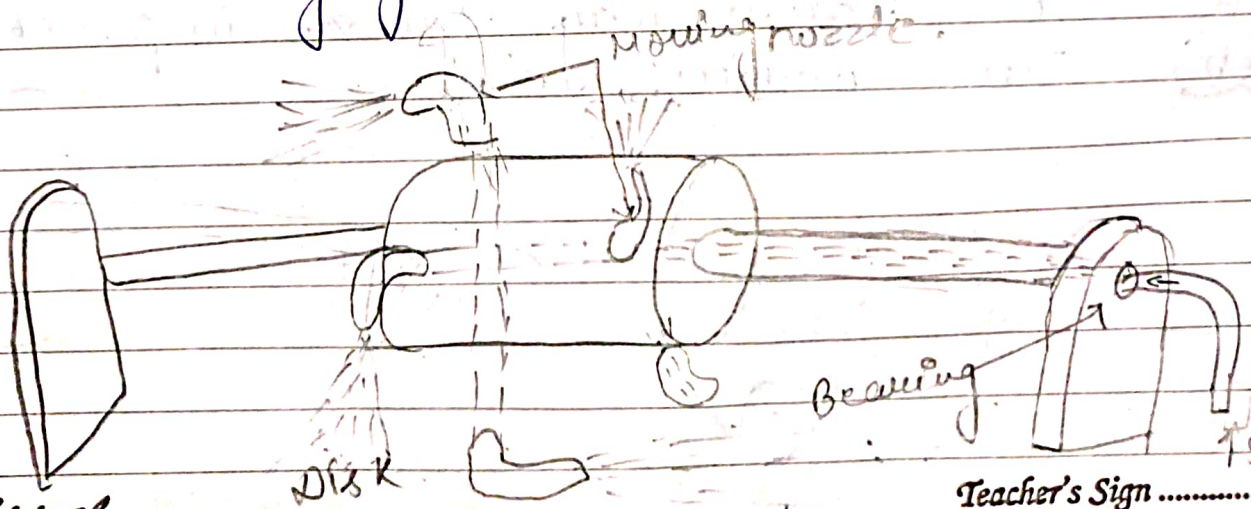
Reaction turbines - A turbine in which the pressure of steam decreases while passing through nozzled. is called reaction turbine.

→ Reaction turbin work on Newton third law of motion.

Construction - It consist of rows of moving. blades mounted on the drum. (diagram)

→ In reaction turbine fixed blades acts as nozzle in which velocity of sp steam is increased and pressure decrease.

Working - The steam enters the turbines. under pressure through guide vanes a reaction turbine allows pressure energy to decrease gradually across the moving blades. the steam coming out from nozzle exerting a reactive force on blades which causes rotation of the turbine converts the fluid energy into rotational mechanical energy which is used to drive a generator for electricity generation.



Teacher's Sign .....

Governing of steam turbine :—

The method of maintaining the speed of turbine constant irrespective of variations of load on turbine various method of governing are.

1. throttle governing.
2. Nozzle control governing.
3. By-pass governing.

* Throttle governing :- When load on the turbine decreases it speed increases. the centrifugal force on the flyball increase and its sleeves outward due to this lever arm actuates so the steam can pass inside. this throttling tends to restored the original speed.

then load on turbine increase its speed decreases and hence centrifugal force decreases therefore flyball moves inside and allow wall to open up and permit more steam to enter the turbine this tends to increase the turbine steam.

* Nozzle control governing :- In this arrangement N_1, N_2, N_3 . V_1, V_2, V_3 are valves under full loads conditions all valves are open to admit maximum amount of steam to the nozzle as load on turbine decrease its speed increase and supply of steam to nozzle to cut of one by one due to decrease in steam supply turbine

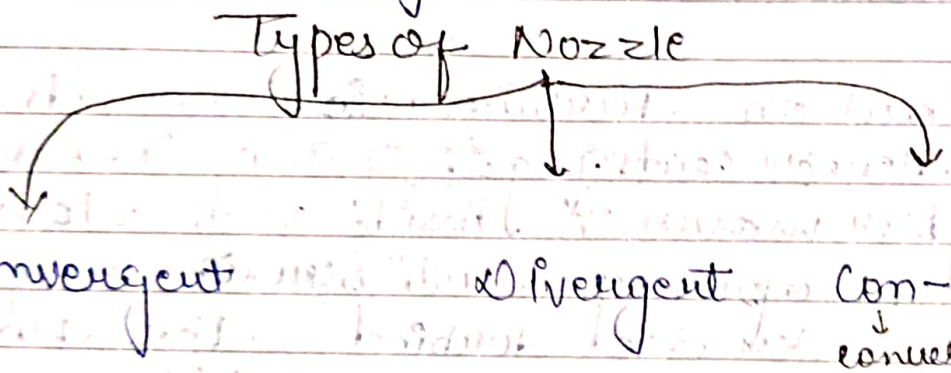
Spiral

Teacher's Sign .....

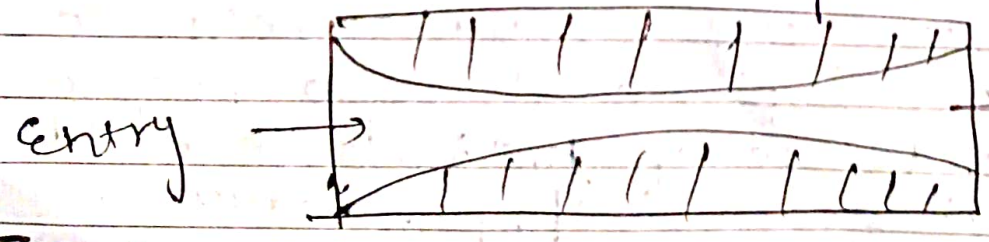
Speed tends to fall back of its original value

By pass Governing :- When suddenly load increases on the turbine the additional steam is required. this additional steam could not pass through the previous installed nozzle and no additional nozzle is available therefore, By pass regulation allows required steam to reach By pass valve open And steam is By pass through. louder lower Stages.
→ out to the turbine

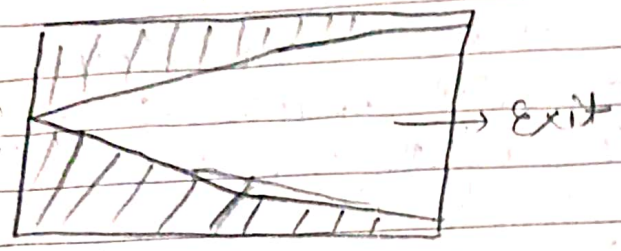
Steam Nozzle :- It is a device use in steam turbines to convert heat energy of steam into Kinetic energy.



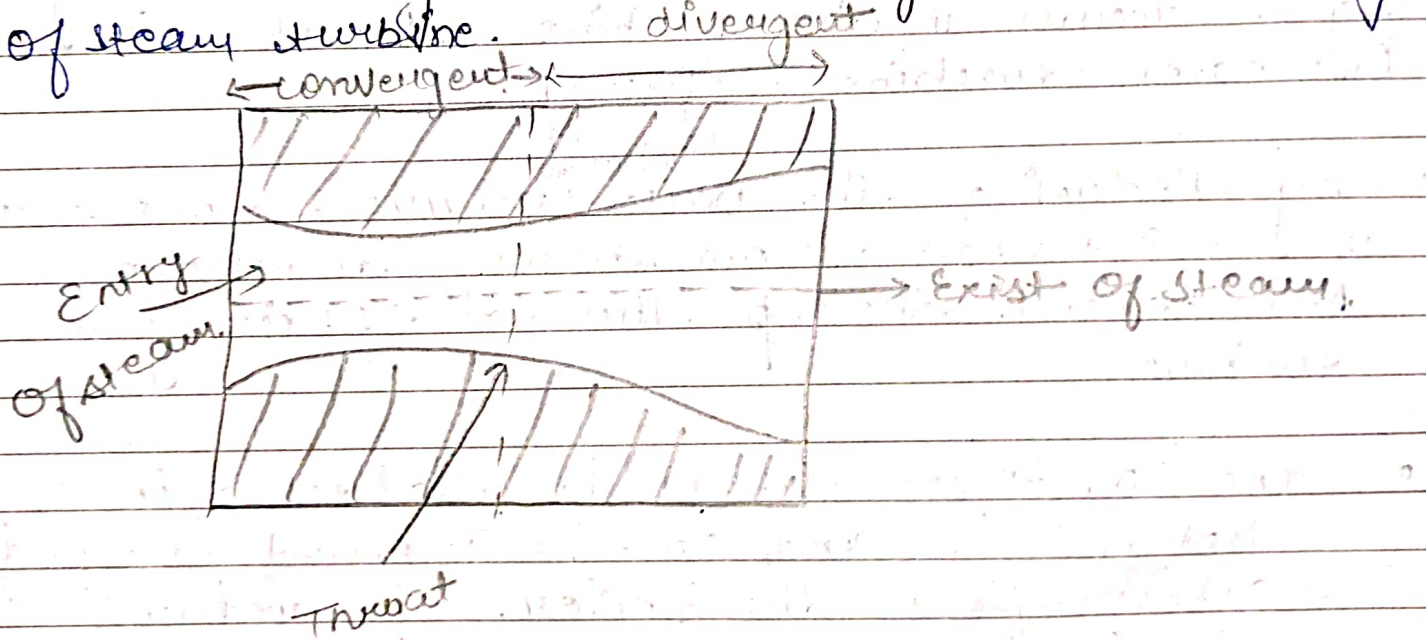
1. Convergent :- When cross-section area of nozzle decreases continously from enterance to exist is called convergent nozzle.
It is use when the back pressure is equal or more than critical pressure ratio.



(2.) Divergent :- In this the cross-sectional area of the nozzle increases continously from Entrance to exist this nozzle is use where back pressure is less than critical pressure.



(3.) Convergent and divergent nozzles :- It has mainly three parts convergent section throug throat and divergent section. A nozzle which converges to throat and then diverges after wards is known as convergent and divergent nozzle. this type of nozzle is widely used this days in various types of steam turbine.



Applications of steam Nozzle :-

- Use to produce high velocity jet of steam.
- use to feed water into boiler
- use to remove air from steam condenser.
- use to measure flow of steam.

Steam condenser :- It is a closed vessel which convert steam back into water to maintain a continous water supply.

function of steam condenser :-

- It maintain very low back pressure by creating a vacuum in the turbine exhaust it increases turbine efficiency.
- By Reducing the Back Pressure more energy is extended from steam thereore. enhanced the thermal efficiency of turbine.
- the condenses water is collected in a hot well and can be reused as feed water for the boiler. It reduced the need for fresh water minimise treatment cost.

Element of a condensing part's -

1) Condenser's - It is closed vessel in which steam is condensed.

2) condensing pump's - To extract condensed steam from condenser and feed to the hot well.

3) Boiler feed pump's - It is use to pump the condensate from the hot well to the boiler.

3) cooling water pump's - To circulate the cooling water through the condenser.

4) Hot well's - A sunk b/w the condenser and the boiler which receives condensate water.

5) Air extraction pump's - It is used to remove air from condenser

6) Cooling tower's - For cooling the dicharged water from condenser.

Classification of condensor's -

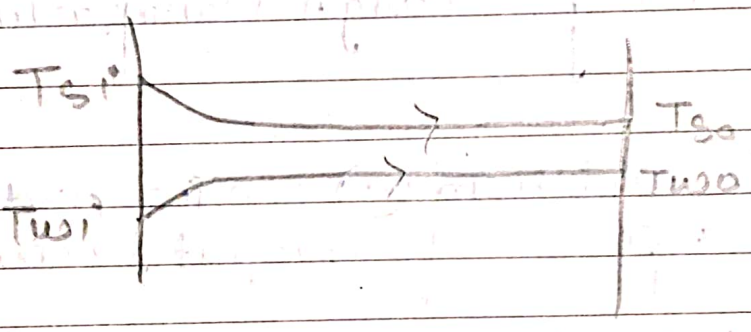
There are two type of condensor.

1) Jet condensor

2) Surface condensor

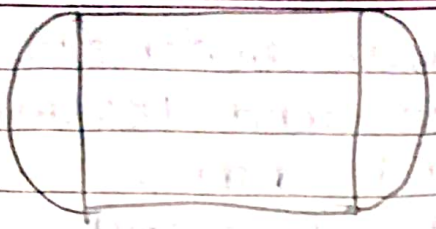
(1) Jet condenser :- It is a condenser in which steam is to be condence and cooling water comes in direct contact with steam It can be sub divided into two parts
1.) parallel flow Jet condenser.
2.) Counter flow Jet condenser.

parallel flow Jet condenser :-
A parallel flow jet condenser both exhaust steam and cooling which enter at the top of condenser and then flow downward direction. The condencate of water collect at the bottom.



Counter flow Jet Condenser :- In counter flow water is steam flow in opposite direction the cooling water after entering the condenser at the top is pass through the series of

(2) Surface condenser :- The exhaust steam and water don't come into direct contact the steam passes over the outer surface of tube through which a supply of cooling water is maintained.



Classification of surface condensers —

1.) Down flow type.
2.) Central flow type.
3.) Regenerative flow type
4.) Evaporated flow type
5.) Inverted flow type

Jet condenser	Surface condenser
(1.) Low manufacturing cost	(1.) High manufacturing cost.
(2.) Cooling water and steam are mixed up	(2.) Cooling water and steam are not mixed up
(3.) Condensing plant is simple.	(3.) Condensing plant is complicated.
(4.) Maintainence cost is low.	(4.) Maintainence cost is high.
(5.) More power is required for water pumping.	(5.) less power is required.

Dt. Page

Q. Difference b/w Impulse and Reaction turbine :-

Impulse	Reaction:
(1) In impulse turbine steam expand in nozzle where as pressure remain same in blade passage	(1) Steam expand partially in nozzle and expansion takes place in rotor blades.
(2) Blade efficiency is less.	(2) Blade efficiency is more.
(3) the pressure on both side of blades is same	(3) the pressure on both side of blades differ.
(4) Impluse blades are symmetric	(4) Reaction blades are Asymmetric.
(5) Steam velocity in an impluse is high	(5) Steam velocity in an Reaction turbine is not so high.

Spiral

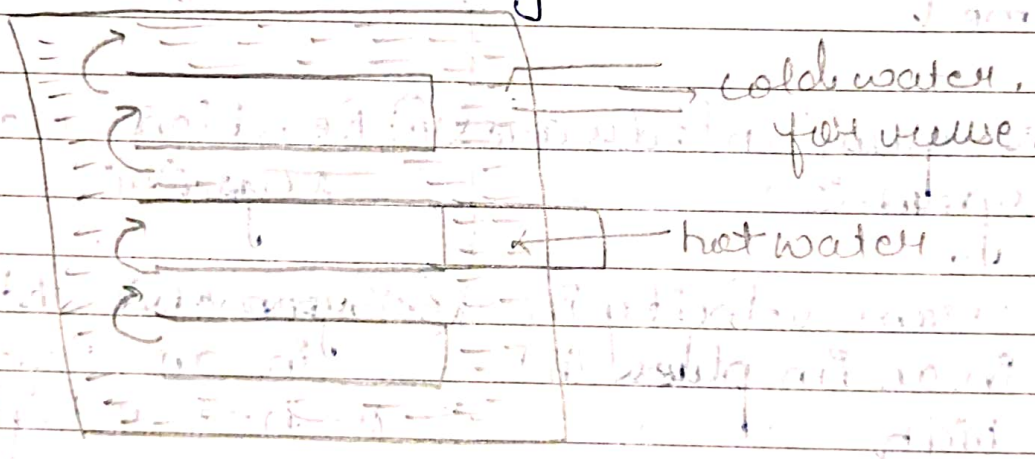
Teacher's Sign .....

Cooling pond :- the simplest method of removing heat from cooling water in a open pond. It is called cooling pond.

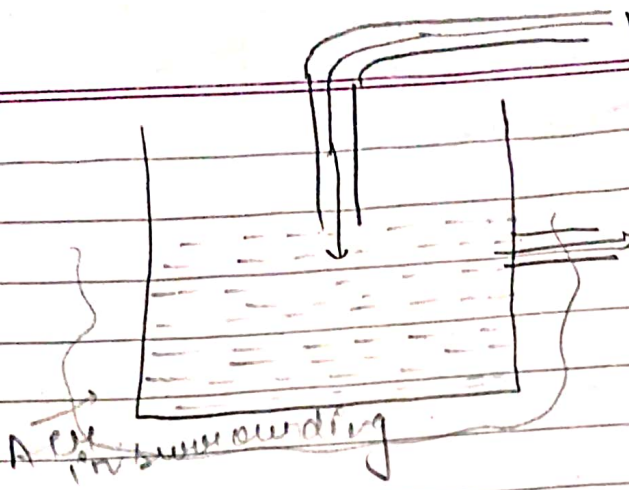
Types of cooling ponds :-

1. Non Direct flow type
2. Directed flow type.

1. Direct flow type :- In this type tank is divided into no. of channels by baffles. flow of hot water direct contact with baffles several times and cold water moved out to reuse again.



2. Non-Direct flow type :- The principle of Non-Directed flow type hot water from condenser enters the through and after flowing through trough it is discharge as cold water.



Cooling tower :- They are the component of condenser which are installed at roof of the power plant in oder to cool

Types of cooling Towers :-

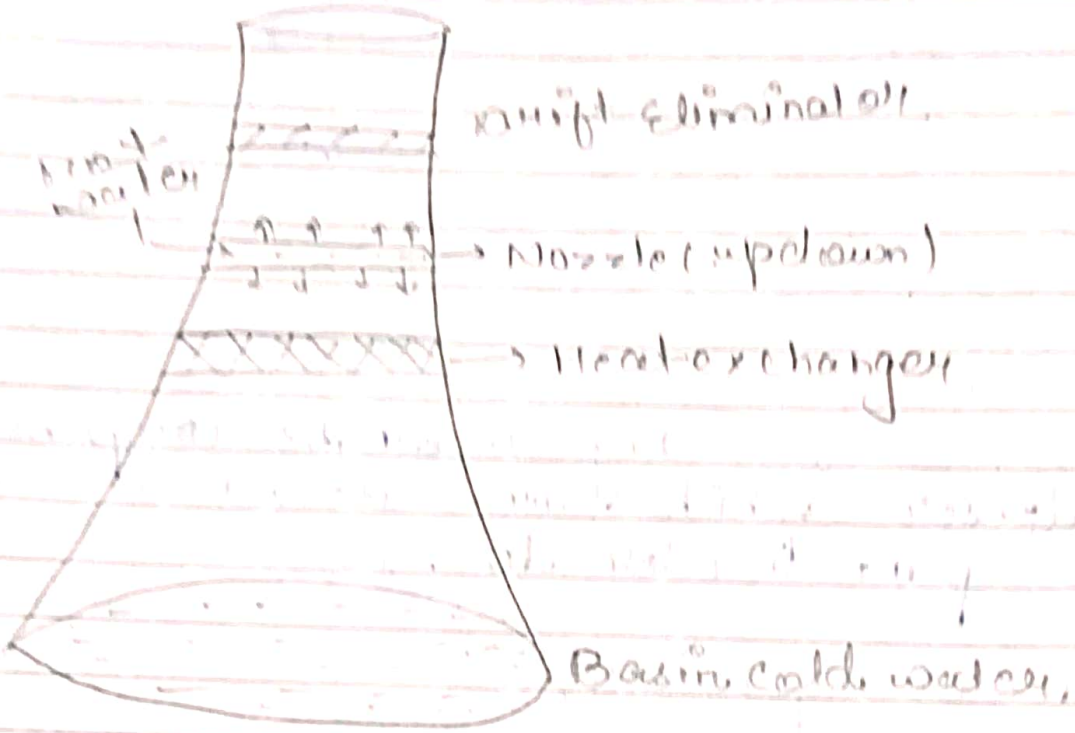
1. Natural Draft cooling tower.
2. Mechanical Draft Cooling tower

(1.) Natural Draft :- It is type of cooling tower in which hot water from condenser pump to the top where it spray down the hot water gives heat to the air which circulate through tower.

(2.) Mechanical Draft :- It may be be defin as forced Draft type in which fan and blower forces the air flow through tower in which hot water spray in down-ward direction.

PYQs

Ans.



Cooling tower

PYQs. Chapter-6

Que 1. Explain Steam Nozzle and its types.

Que 2. Explain the Nozzle control governing of steam turbine.

Que 3. Compare Jet condenser and surface condensers.

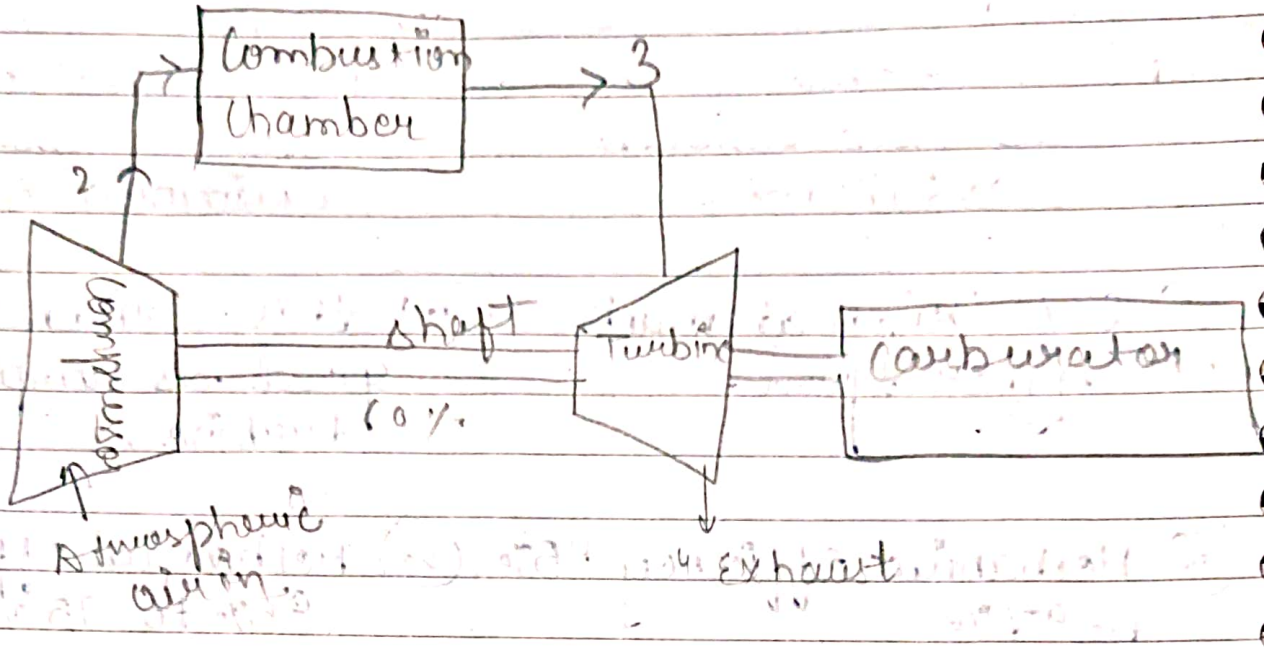
Que 4. Explain the difference b/w Impulse and Reaction turbine.

Que 5. What is governing? Explain various method of governing of steam turbine?

Chapter-7
Gas Turbines and Jet Propulsion.

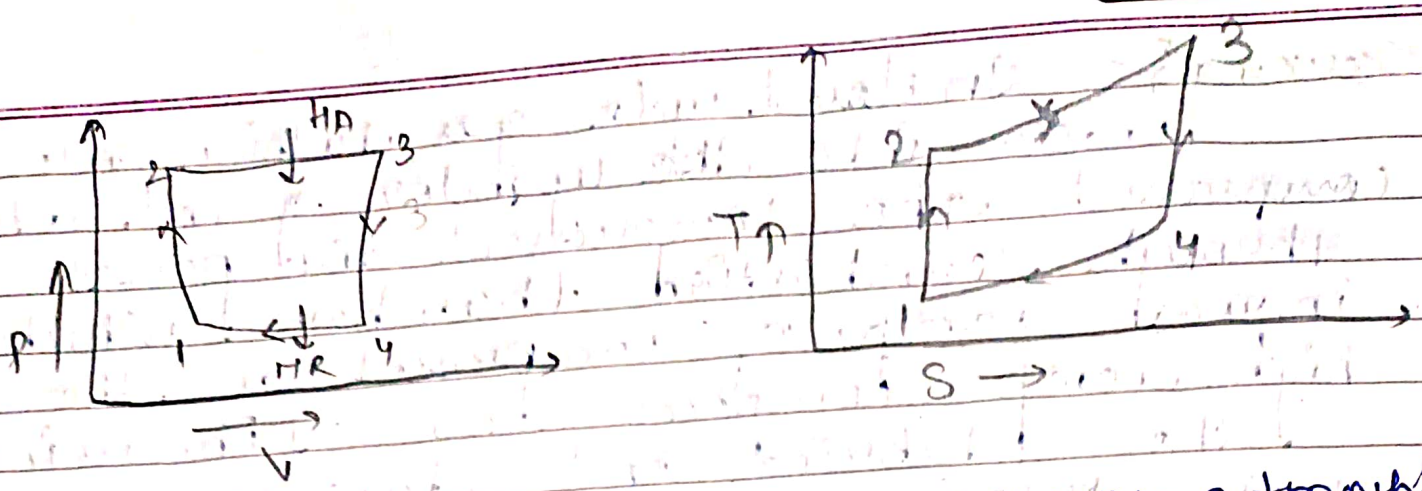
Gas turbine.	Reciprocating I.C engine.
(1) It is driven at much higher speed.	(1) It is driven at lower speed as compared to gas turbine.
(2) Mechanical efficiency 95% to 97%	(2) Mechanical efficiency is 85% to 95%.
(3) Cheap and easily available fuel such as oil, gas, biogas are used.	(3) specified fuel is used.
(4) Large power is pro-duced.	(4) Less power is produ as compare to gas turbin
(5) It requires no cooling water	(5) It requires coolin water.
(6) No flywheel is required.	(6) flywheel is requi -ed.

Open cycle gas turbine :-



Working :- It consist of combustion chamber turbine and genrator when air drawn into the compresser from atmosphere it get compressed and its pressure increases. compresed air enters into combustion chamber. Where its temperature increases high temperatu compressed gas enters into the turbine and rotate the turbine which produced work. turbine is directly connected to genrator which convert the mechanical energy into electrical engergy.

Teacher's Sign .....



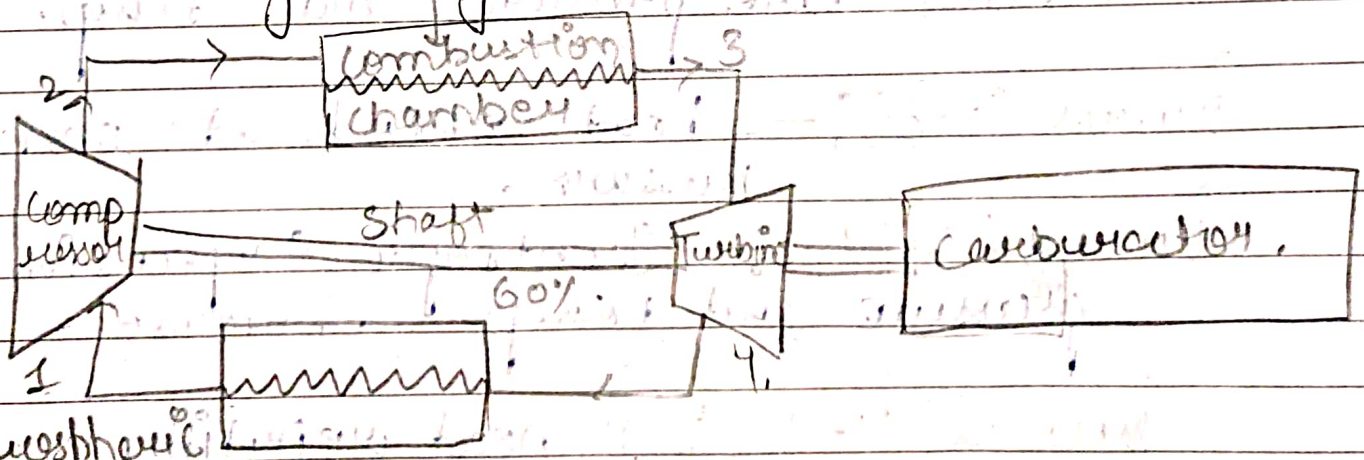
1.) Process (1-2) :- Isentropic compression atmospheric air get compressed from P_1 to P_2

2.) Process (2-3) :- Heat added at constant pressure the temp of gas raises from T_2 to T_3.

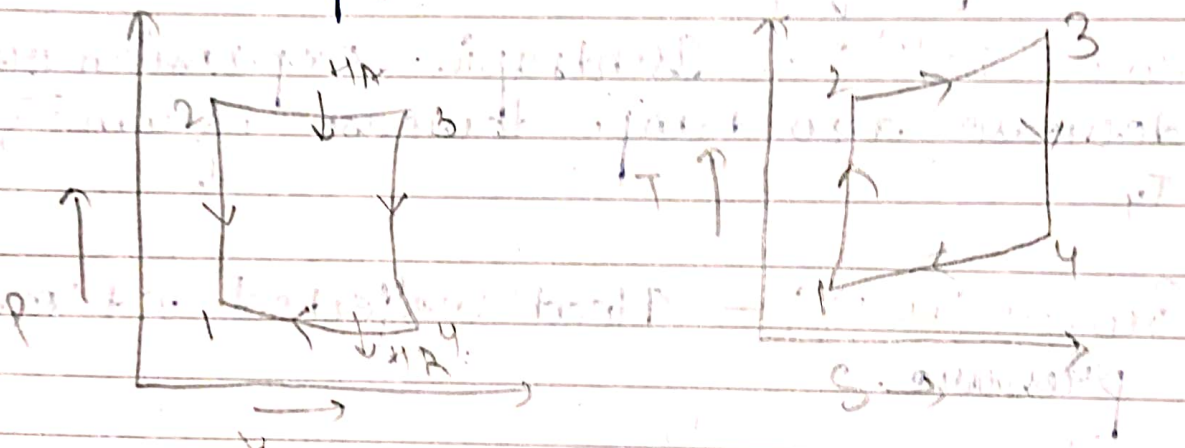
3.) Process (3-4) :- Isentropic expansion pressure decrease also temp. decrease from T_3 to T_4

4.) Process (4-1) :- Heat rejected at constant pressure.

Closed cycle gas turbine :-



Working :- In closed cycle gas turbine air enters into the cylinder 1 and get compressed the compressed air passed through combustion chamber which increase temp. of compressed gas the high temp. compressed air enters into the turbine and turbine shaft start rotating which helps to generator electricity through generator the exhaust gas enters into the cooler where temp. decreases and air again use in compressed.



Process :- (Isentropic compression)
Process (1-2) where pressure and temp. increase

Process (2-3) :- heat added at constant pressure.

Process (3-4) :- Isentropic expansion where pressure and temp. increase.

Process (4-1) :- heat rejection at constant pressure.

Teacher's Sign .....

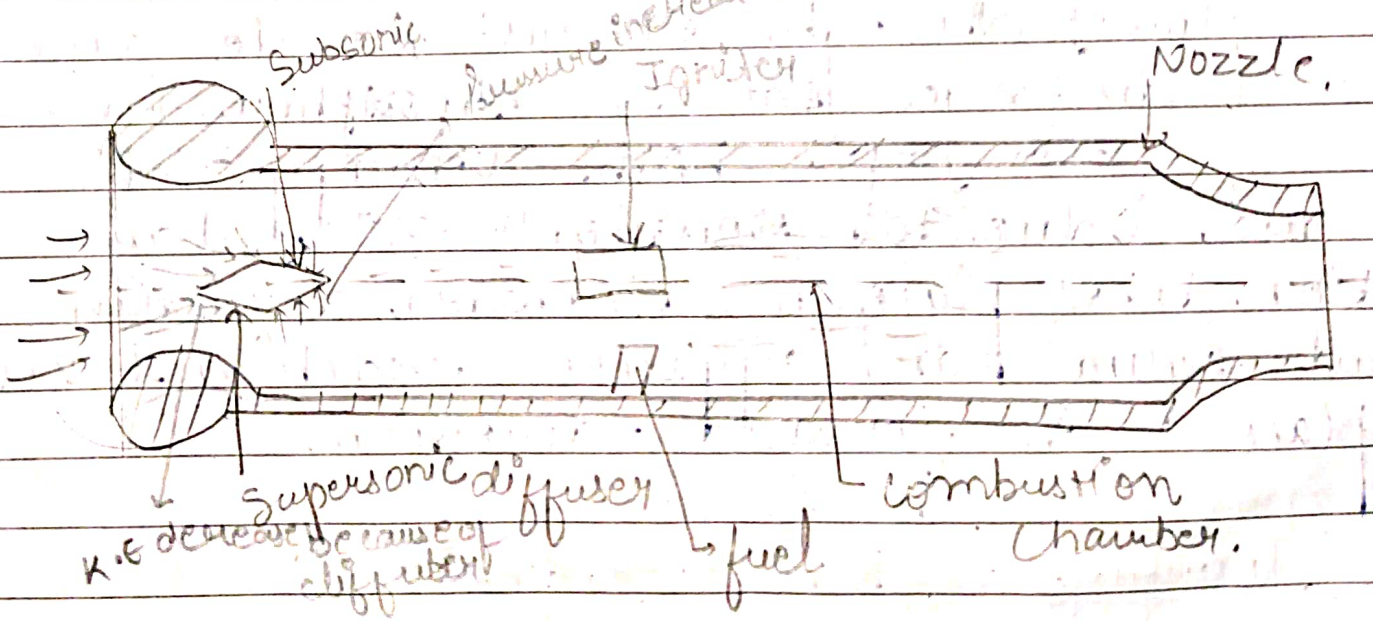
Applications :-

1. Power generation.
2. Aviation and marine engines / fields.
3. Military Application.
4. In steel oil and chemical industry.
5. Turbo charging of ~~po~~ diesel power plant.

limitation of gas turbines :-

1. Rotor speed is high
2. Overall efficiency is low.
3. life of the unit is short
4. They are not started.
5. It makes more noise.

RAM JET ENGINES :-



Teacher's Sign .....

It is very simple in construction it has no compressor and turbine. It consist of three main components

1. Diffuser
2. Combustion chamber.
3. Exhaust Nozzle.

Diffuser has two parts → supersonic
→ subsonic

→ As air flow with supersonic velocity in supersonic diffuser air get decelerated to sonic velocity which give raise in pressure in air as air enters in subsonic diffuser. its velocity get reduced and air get compressed. A high temp. air reaches in combustion chamber where fuel get burned and raise of temp. upto 2000°c takes place.

→ A hot gases form in combustion chamber flow through exhaust nozzle and discharge to Atmosphere in form of high velocity Jet. and due to Newton's 3rd law action takes place in backward direction and equal and opposite reaction takes place in forward direction.

Advantages of Ram Jet Engines -

1. light in weight
2. No moving parts
3. wide variety of fuel are used.

Teacher's Sign .....

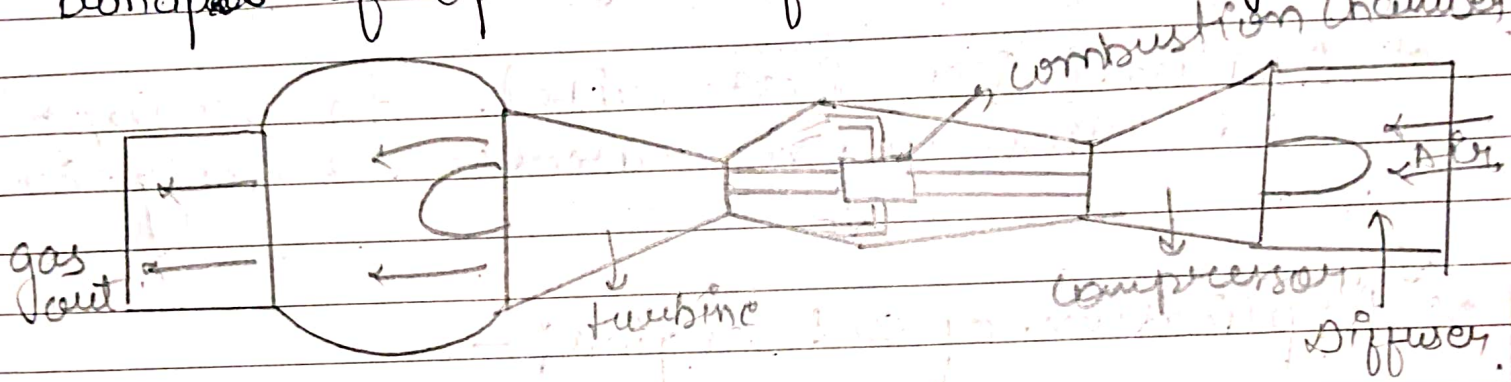
Disadvantages :-

1. It can't start own its own some other device is used
2. to accelerate to retain flight (velocity)
3. designing of diffuser is difficult.

Applications :-

1. Ram Jet are use for supersonic flight.
2. ~~Ram Jet engine are use~~.

* Principle of operation of Turbo-Jet Engines :



Air enters the engine through diffuser with a velocity equal to air craft and pressure of air raises above atmospheric pressure. after that air get compressed by compressor compressed air enters into the combustion chamber. where liquid fuel under pressure is spray. then the product of combustion enters into turbine developed power and drive the product of combustion expanded by diffuser and discharge through through nozzle with a high velocity so according to Newton third law of motion thrust

Teacher's Sign .....

J is provided in backward direction which gives forward motion.

* Advantages :-
  - very less engine vibration.
  - Smaller frontal area.
  - rate of climb is high.

* Disadvantages :-
  - More noisy.
  - Material used are very Expensive.
  - less efficient.

* Applications - Best suited to aircraft travelling at near-sonic velocity (800 km/h).

* Application of Jet engines (Jup) -
  - Aircraft propulsion.
  - Missile and Rocket.
  - Jet power boat and ship
  - gas turbine power plant.
  - Industrial uses like oil and gas industries.

* Supercharger :- It process of supply air/fuel mix to the engine at the pressure above atmospheric pressure. When engine is use super charging. It developed high pressure which increase the charge density as well as

weight density as power is proportional to weight of charge per minute. so super charging gives more power. that is upto 40% increase in power.

Types super charging :-

- By engine driven compressor
- Independently driven compressor
- By electric motor compressor
- By exhaust gas or Turbo charger.

Turbo charger :- In petrol engine about 35 to 40% fuel energy goes waste in form of exhaust gases. a turbo charger employed a compressor.

As super charger and turbine use to generated power and drive compressor.