AUTOMOBILE ENGINEERING UNIT 1

BY

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Automobile engineering

Automobile stands for vehicle which can move by itself.

Self propelled vehicles…

Automobile differ from aeronautical and marine.

Power is produced by….transmitted….

History:

Requirements of an automobile:

1.It should develop power by itself.

2. Power control.

3. Power should be transmit to wheels.

4. Continue and discontinue power flow to wheels.

5. Torque should be control.

6. Directional control.

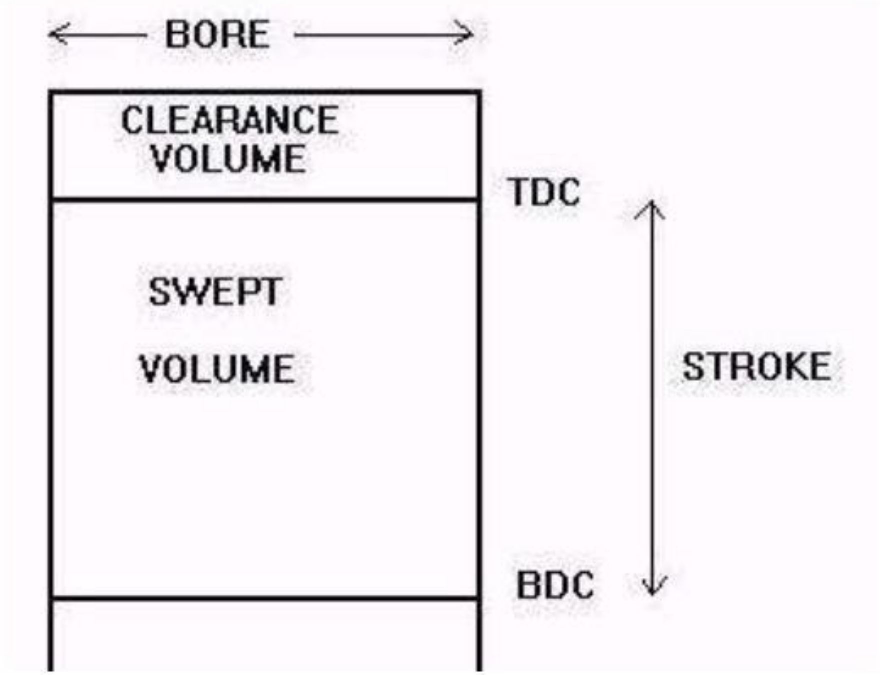
7.Should stop vehicle while it is running.

General classification:

1. Single unit vehicles.
2. Articulated vehicles.
3. Heavy tractor vehicles.

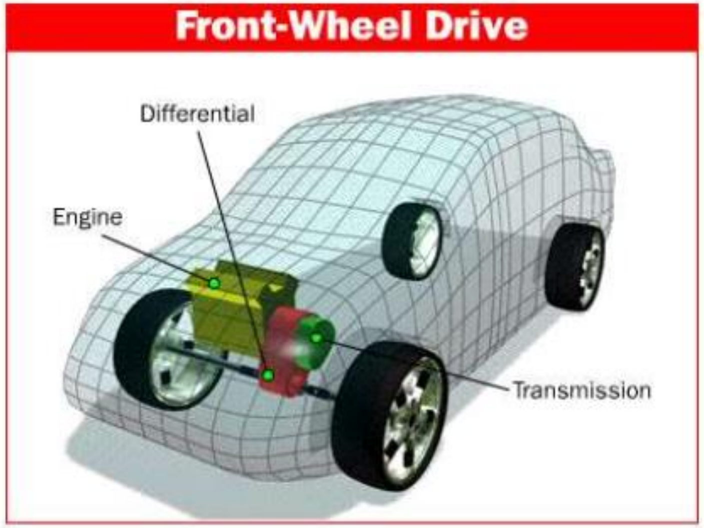
Types of automobiles:

1. With respect to purpose.
2. Weight of the vehicle.
3. Fuel used.
4. With respect to no of wheels.
5. Drive of the vehicle.
6. With respect to transmission.
7. Engine capacity.


BORE
CLEARANCE VOLUME
TDC
SWEPT VOLUME
STROKE
BDC

Different layout of a car

1) Front engine:



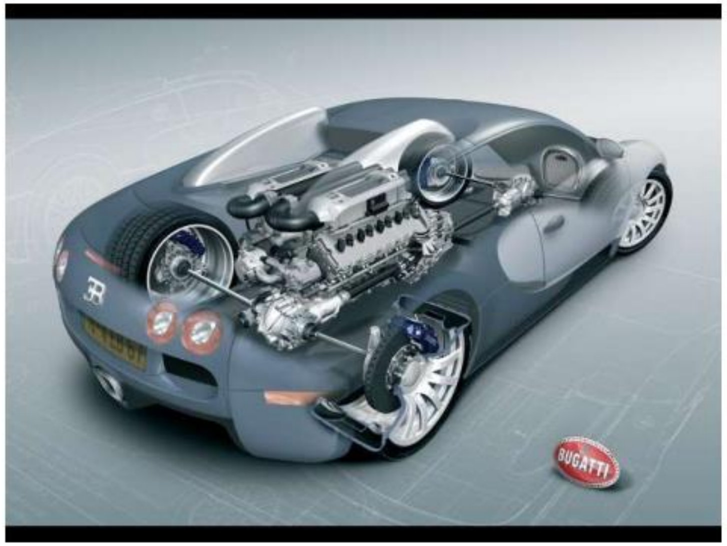
Protection, Cooling

2) Rear engine:

Rear engine….

- Clutch, gearbox and final drive
- Independent rear suspension system.
- Tail heavy.
- Handling will be difficult due to high speed.
- Large amount of space.
- Increase load will provide better grip on road.

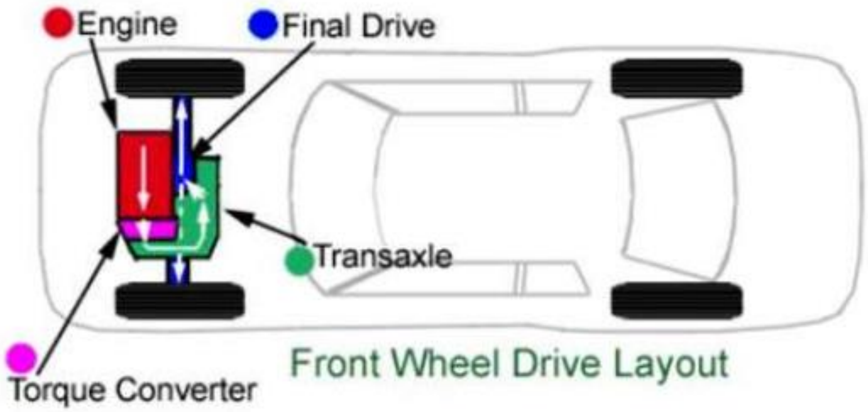
3) Central or Mid-Engine.



Central engine……

- Used in sports car.
- Location of engine provide excellent weight distribution.
- Good handling and maximum traction from driving wheels.
- Disadvantage in traditional cars.
- Two seat.

4) Front engine front wheel drive.



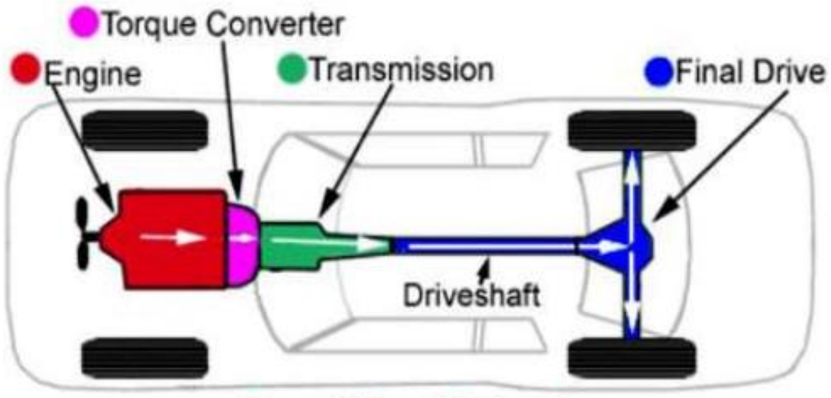
Advantages:

- Road holding is improved in wet and slippery conditions.
- Passenger and cargo spaces are good because no need of transmission shaft.
- Good road adhesion is obtained.
- Lower flat floor line is provided.
- Provide more comfortable.

Disadvantages:

- Acceleration is affected because the load transfer to rear of the vehicle.
- Complicated drive shafts are needed for CV
- Special universal joints and more complicated assembly required due to short distance of transmission.
- Possible for skidding under heavy brake.

5) Front engine Rear wheel drive.



Rear Wheel Drive Layout

Advantages:

- Reasonably balanced weight distribution between front and rear.
- A large luggage space is available.
- Control linkages such as coke, clutch and gear box are short and simple.
- Cooling by wind.

Disadvantages:

- Noise and vibration by universal joint and propeller shaft.
- Propeller shaft operation need floor tunnel clearance.
- When stuck in mud, tends to plough into ground.

6) Rear engine rear wheel drive:

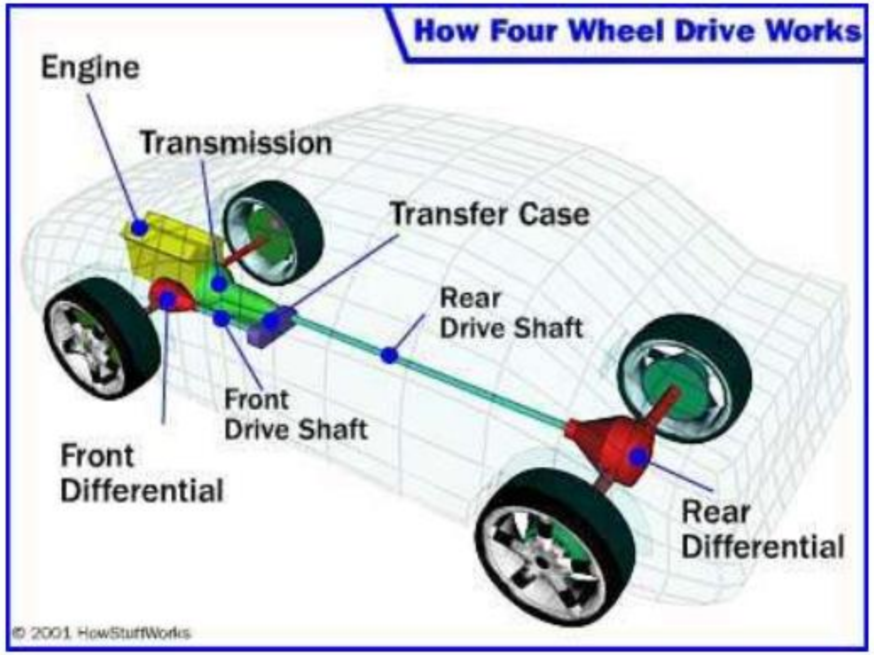
Advantages:

- Short line drive.
- Improved traction in rear wheels.
- Effective rear wheel braking.
- Absence of drive shaft give more floor space.
- Front of the vehicle can be designed for good visibility.
- This drive arrangement results a compact car.

Disadvantages:

- Vehicle affected by side winds at high speed.
- Difficult to accommodate the liquid cooling.
- Difficult to fix fuel tank in a safe zone.
- Space for luggage is reduced.
- Natural air cooling is not possible.
- Steering is difficult in slippery conditions.

7) Four wheel drive:



Advantages:

- Increased traction.
- Wear of tyres and other components are evenly shared.
- Easily recover when it struck in mud.

Disadvantages:

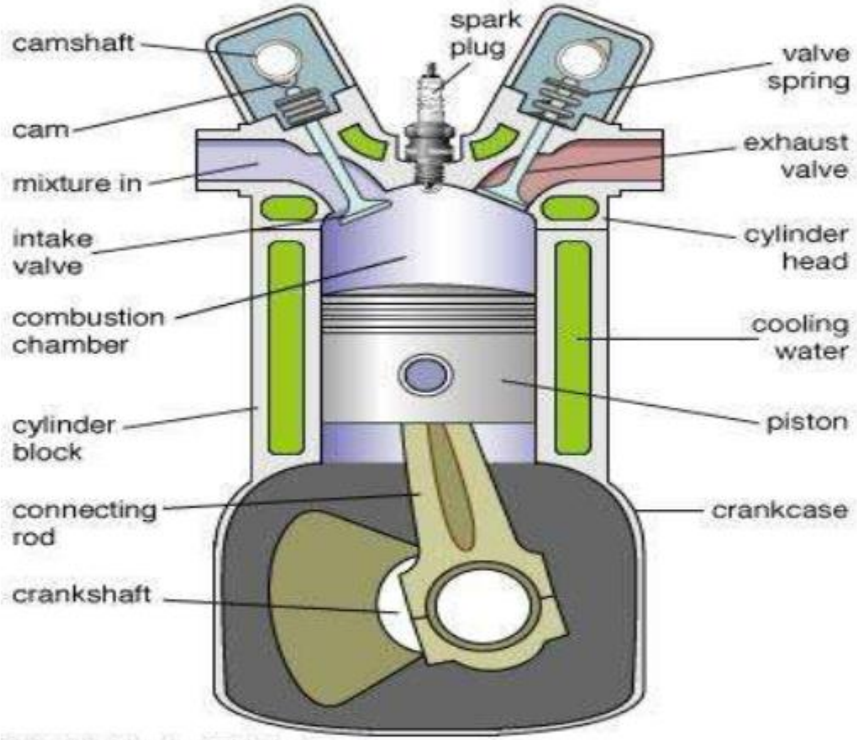
Increase weight, cost, fuel consumption, maintenance.

Difficult to accommodate ABS.

Engine components

Major components of engine are:

- Cylinder, Cylinder liner and cylinder head
- Crank case and oil pan
- Piston and piston rings
- Connecting rod
- Crank shaft and flywheel
- Valves and valve mechanism
- Lubrication system
- Cooling system



camshaft
spark plug
valve spring
cam
exhaust valve
mixture in
intake valve
cylinder head
combustion chamber
cooling water
piston
cylinder block
connecting rod
crankcase
crankshaft

Cylinder

Circular shaped container within which piston travels in reciprocating motion.

Combustion takes place.

Has to withstand high temperature and pressure

Cylinder liner

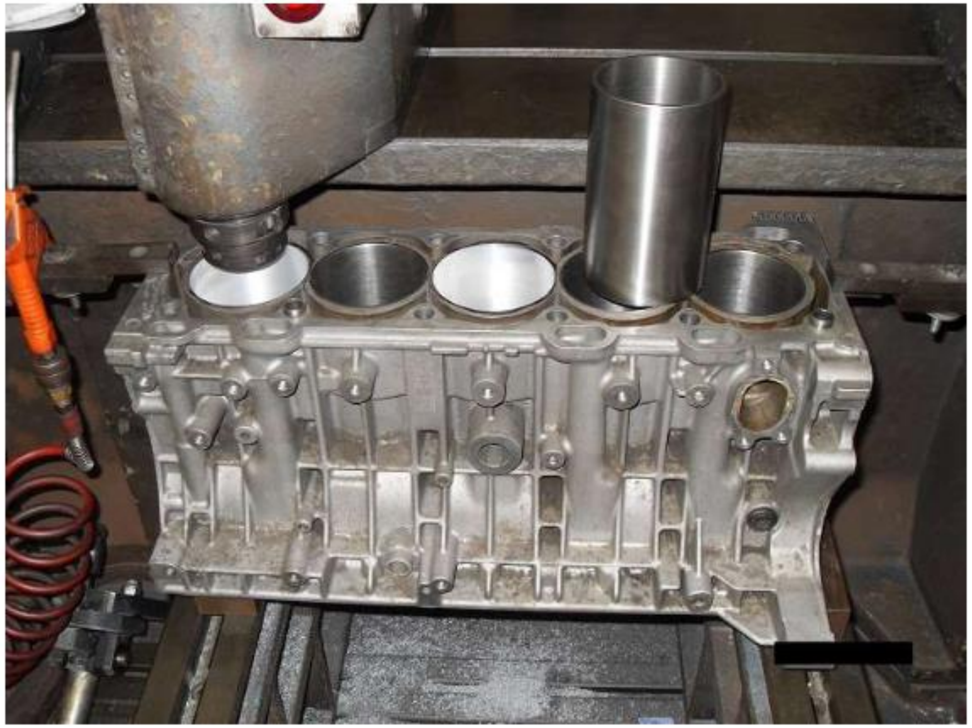
Inside the cylinder a replaceable liner is inserted which is known as cylinder liners.

1. Dry liner

Liner directly inserted into cylinder block. Cooling water not in contact with the dry liner.

2. Wet liner

Cooling water is in direct contact with the outer surface of the liner



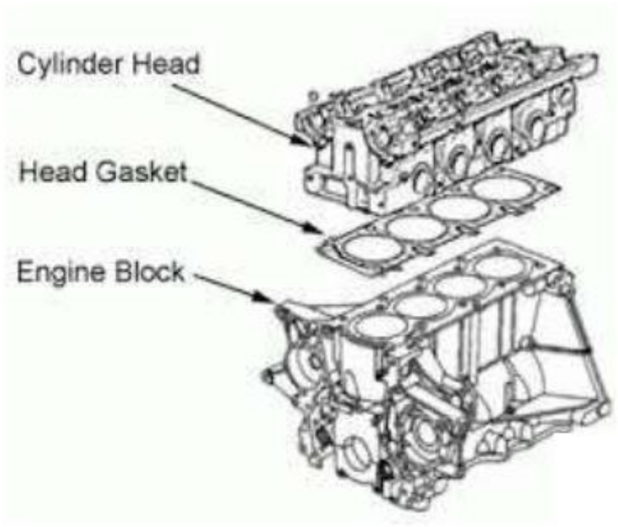
Cylinder head

Part is mounted on the cylinder is called cylinder head.

It contain inlet and exhaust ports and valve sets.

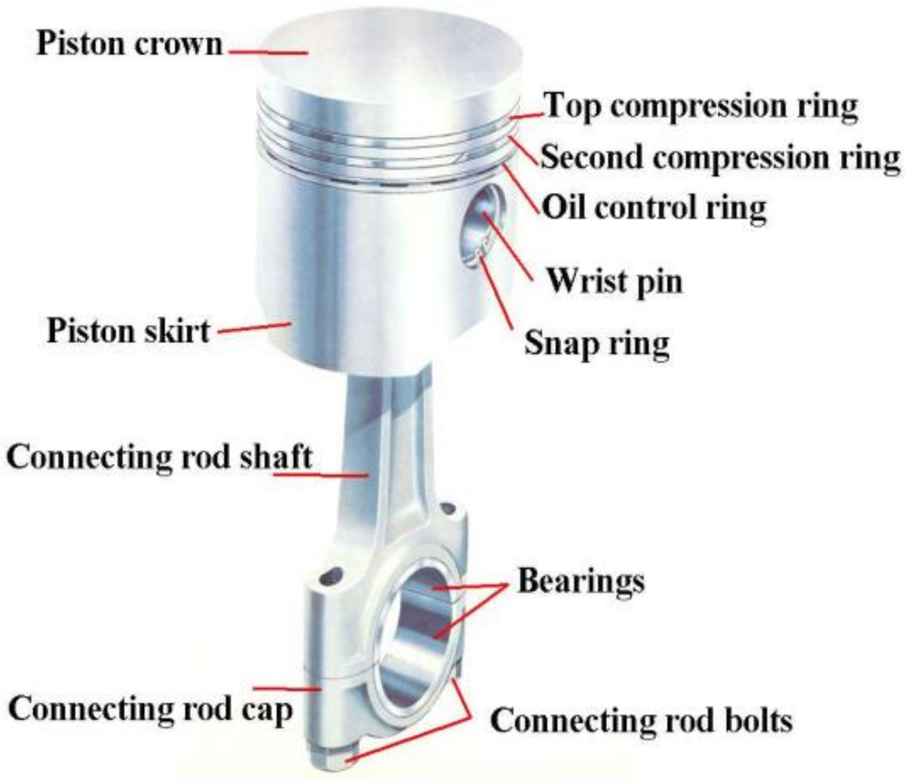
SI-engine, threaded hole for spark plug

CI-engine, hole for fuel injector


Cylinder Head
Head Gasket
Engine Block

Piston

- Main active part, has to close fit with the cylinder.
- Movement of the piston changes the volume in the cylinder and provide combustion space
- Moves only inside the cylinder in a reciprocating motion & produces the power for the engine

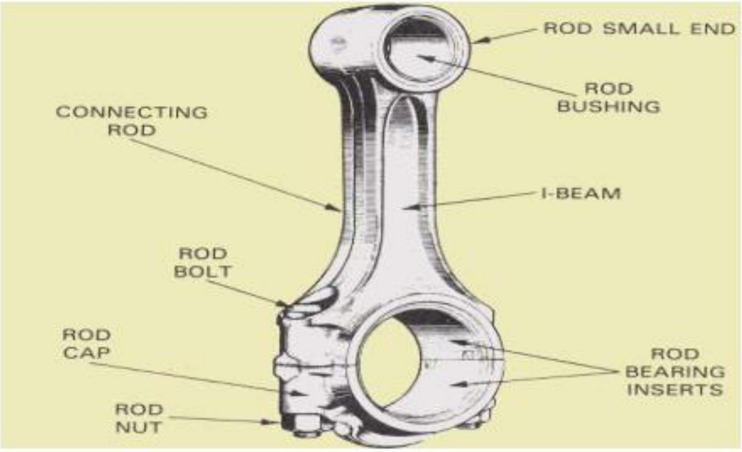

Piston crown
Top compression ring
Second compression ring
Oil control ring
Wrist pin
Snap ring
Piston skirt
Connecting rod shaft
Bearings
Connecting rod cap
Connecting rod bolts

Piston rings

- Circular rings fitted in the circumferential grooves of the piston.
- Special alloy steel-to retain elastic properties at high temperature.
- Upper ring-compression ring-tight gas seal
- Lower ring-oil ring- remove oil from the engine cylinder

Connecting rod

- The connecting rod is the connecting link between the piston and the crank shaft.
- By oscillating movement of the connecting rod reciprocating motion of piston converted into rotary motion of crank shaft.



Crankshaft

- It converts reciprocating motion of the piston into rotary motion.
- All other working parts are directly or indirectly connected coupled to it.

Fly wheel

Purpose: To store energy necessary to keep the engine crankshaft running during idle periods.

- Not necessary to receive to receive power impulse

Cam and Camshaft

- Camshaft contain cam depend upon no of cylinder (cylinder x 2) or (Valves=cam)
- Used to open or close the valve
- ½ N of crank used to operating the valve

Valves and valve mechanism

Valves-gate for opening and closing the inlet and outlet in cylinder.

Poppet and mushroom valve

Two type: 1. side valve mechanism

2. over head valve mechanism

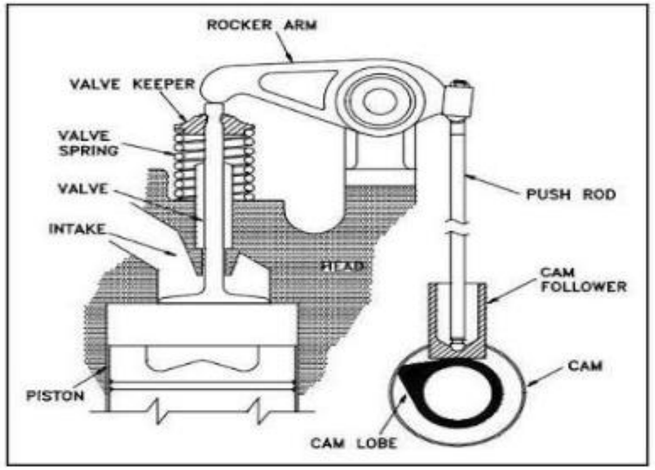
Side valve mechanism:

Mainly depend upon poppet adjustment, valve opening affected by lifting the valve of their seat

Over head mechanism:

Two additional parts: push rod and rocker arm

Valve mounted over the head of the engine



Crank case & Oil sump

- Crank case serves as a base of the engine. Cover called crank case sump is fixed on to the bottom of the crank case.
- The sump protects the engine from below.

Resistance to vehicle motion

- Involves the basic principles of newton's second law.

- Acceleration of an object is proportional to the net force exerted on it.

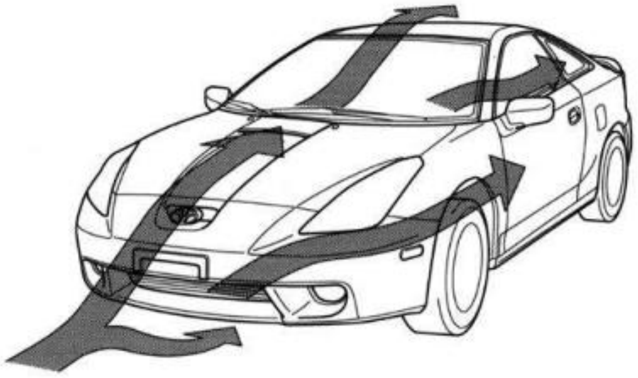
- Several forces acting on the vehicle and the net force acting on it governs the motion of the vehicle.

- Propulsion unit helps the vehicle to overcome the resisting force due to gravity, air and tire resistance.
- Acceleration of vehicle depends on
  - The power by propulsion unit
  - Road condition
  - Aerodynamics of the vehicle

  Resistance can be categorized as
  - Air resistance
  - Gradient resistance
  - Rolling resistance
  - Inertia force

I. Air resistance

Vehicle traveling in air at particular speed encounters a force resisting. This is known as ***aerodynamic.***



Aerodynamic drag depends upon:.,

- Size of the vehicle
- Shape of the vehicle
- Speed of the vehicle
- Wind velocity

II. Gradient Resistance

When vehicle goes in slope, its weights produces a components of force that is always directed downwards.

Slope - ϴ

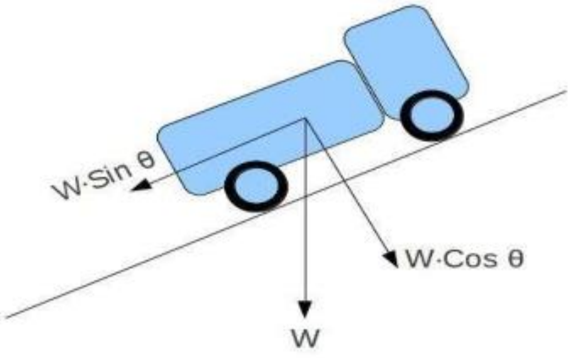
W has two components

One is perpendicular to

road surface **W cos ϴ**

Other one is along to

road surface **W sin ϴ**



III. Rolling resistance

When vehicle rolls tyres in contact with the road surface, it will make friction.

Rolling resistance is the sum of the following components:.,

Resistance from tyre deformation

Resistance due to tyre slip angle

Resistance due to bearing friction and residual braking.

Road rolling resistance

IV. Inertia force

In addition to the driving resistance inertia forces occur during acceleration and braking.

Total mass of the vehicle & inertia mass are the factors influencing the resistance to acceleration.

Moment of inertia of the drive elements of engine, clutch, gearbox, drive shaft including all the road wheels are reduced to the driving axle

Aerodynamics of automobile body

Aerodynamic is the behaviour of air in motion relative to the vehicle body.

Various aerodynamic forces acting

I. Drag force

II. Lift force

III. Cross wind force

Drag force

- Drag force is mainly known as air resistance

$$F_D = \frac{1}{2}\rho A C_D v^2$$

C_D – Drag coefficient

ρ – density of air

V – velocity of air

A – Projected area of the vehicle viewed from front

- Forward motion of the vehicle pushes air in front of it.
- This results in high air pressure in front of the vehicle, and creates a zone of low air pressure.
- High pressure zone in the front of the vehicle oppose its movement.
- Skin friction:., difference in speed b/w two air molecules produces friction
- Avoiding excessive projections like door handles, mirrors aerials help in reducing drag

Lift force

Aerodynamic lift force is the vertical component of the resultant force caused by the pressure distribution on the body.

$$F_L = \frac{1}{2} C_L \rho A U^2$$

Aerodynamic lift will tend to reduce the pressure b/w tyres and ground

Cross wind force

Cross wind force is acting in the lateral direction on the side of vehicle.

These forces acting at the centre of pressure instead of center of gravity, they cause various moments,

Pitching moment (My):

Caused by the drag force or lift force about Y axis. This moment makes the rear wheels lift off from the ground

Yawing moment (Mz):

Caused by the cross wind force Fy about Z axis

Rolling moment (Mx)

Caused by cross wind force about X axis

Chassis

To construct any automobile, chassis is the basic requirement.

A vehicle without body is called chassis,. carrying unit

Main components of chassis:

Frame   Suspension

Steering Mechanism

Engine, clutch and gear box

Radiator

Propeller shaft, Wheels, Differential unit

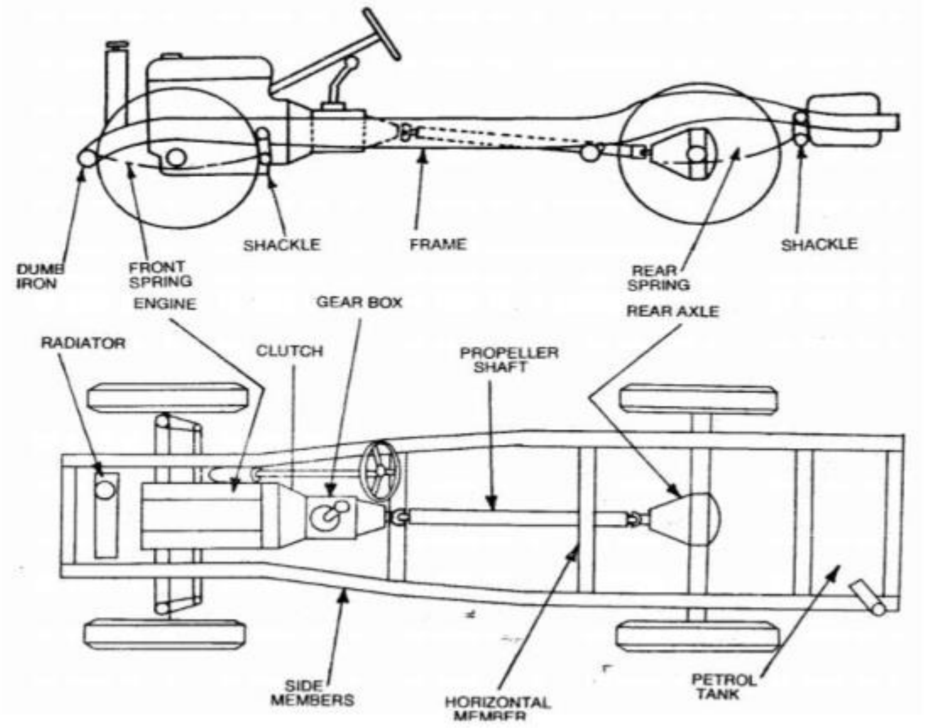
Universal unit, Brakes

Battery, fuel tank, electrical system and silencer.

Classification of chassis:

1) Full forward.
2) Semi-forward.
3) Bus chassis.
4) Engine at back.
5) Engine at centre.

Layout of chassis:



Components in chassis:

1.Frame:

- Foundation to carry engine and body of vehicle.
- Frames made by tubular, channel and U shaped section.
- Frame into chassis.
- Bends upward in shape at rear and tapered at the front.

2)Suspension system:

- Insulate the wheel and axles from the frame.
- Provide comfortable ride to passengers.
- Avoid the transmission of road effect to passengers.

3) Steering system:

- Used to accurately control the direction of a vehicle.
- Must be light and easy to operate.
- Rotary motion into angular turning.

4) Braking system:

- It bring the vehicle into rest or slow down.
- Energy conversion.

5) IC engine:

6) Clutch:

- Friction type uncoupling device.
- Single steel disc faced with suitable friction material.
- Take up the drive from engine and release whenever desired.

7) Gear box:

- Contain various types of gears which are constantly in mesh.
- Gear changes takes place by sliding the dogs.
- Function- To provide the variation to the torque applied by the engine to rear wheels.

8) Propeller shaft:

- **Transmit** power from the rear end of gear box to the final reduction gear.
- Hooke’s joint- small and limited angular displacement in rubber joints.

9) **Differential:**

- Carries power from propeller shaft to rear wheel axles.
- Different speed in rear wheels while in curve.
- It ensure the final output torque is equally distributed to rear wheels.

10) Universal joint:

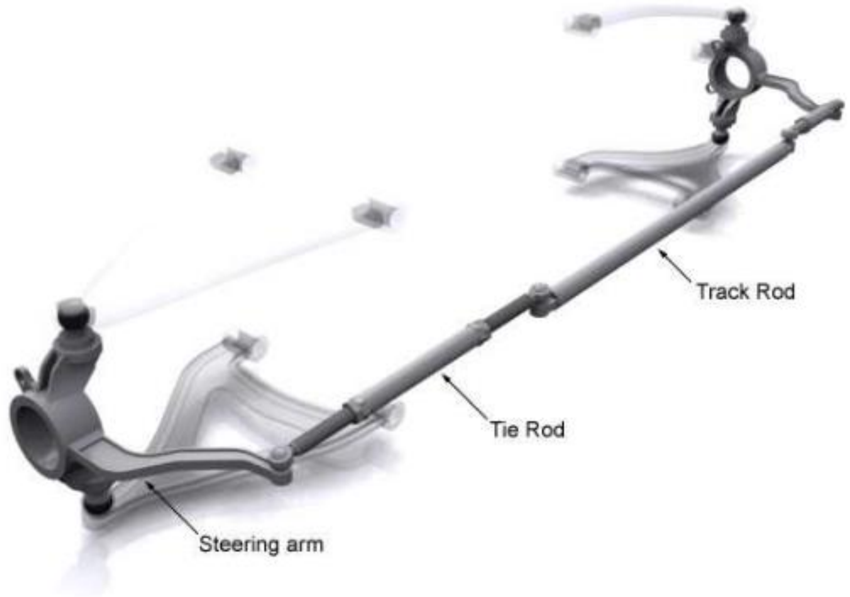
- Rear axle moves up and down by road condition.
- Permit turning of propeller shaft.

11) Springs:

- Fitted between frame and wheel to prevent moment of frame along with up and down moment of wheels.
- Spring is a reservoir of energy..stored by bending and release when it will resumes into its normal state.

12) Front axle:

- It used for steering front wheels about kingpin’s axle.
- Steering arms and track rod link, two stub axles are used.


Track Rod
Tie Rod
Steering arm

13) Rear axle:

- Rear axle is a tube such as shaft enclosing driving shaft with suitable bearings.
- It enlarged at centre for final gear drive.
- Change of direction from the line of propeller shaft to the axle shaft.
- Differential.
- Suspension system.

14) Battery:

15) Wheels:

FRAME

- Frame is the main part of chassis. All other parts of chassis mounted on the frame.

- At the front end engine is mounted. Frame is supported by wheel and tyre assembly.

- Some parts of steering system connected with frame and remaining to the body.

Importance of frame:

- To form base for mounting engine and transmission system.
- Should withstand the engine and transmission thrust and torque.
- Carry load.
- Accommodate suspension and other parts.

Requirements of a good frame:

- Must be strong, light.
- Withstand the blows, twists, vibrations and strains.

Frame construction:

- Frame sections are more important to make a good frame.

Three frame sections

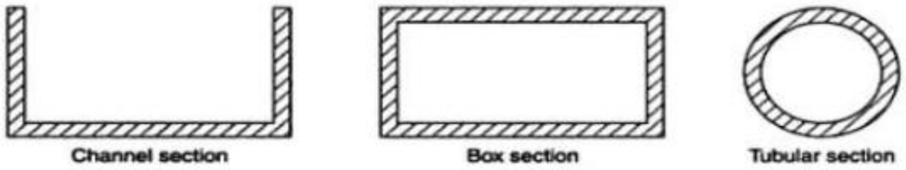
1) Channel
2) Tubular
3) Box

CONVENTIONAL FRAME

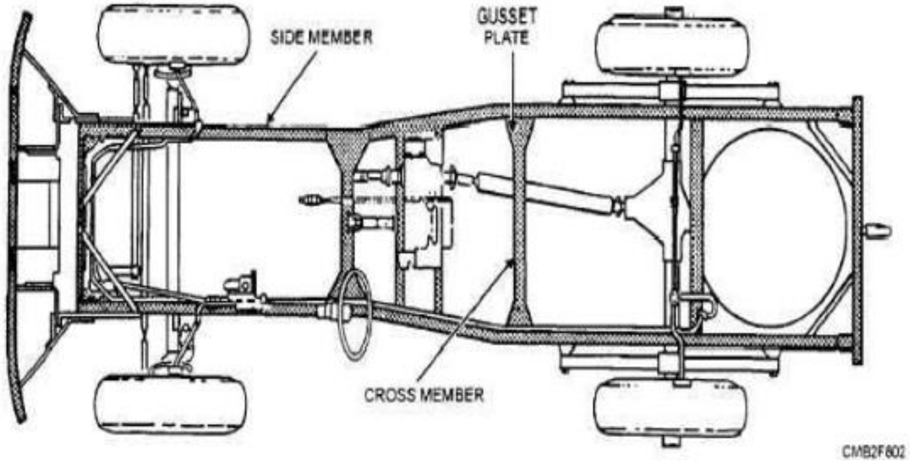
a.Channel Section - Good resistance to bending

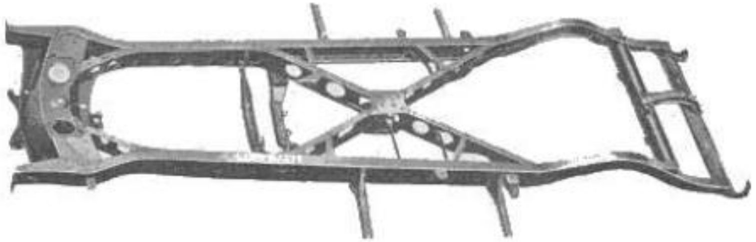
b. Tabular Section - Good resistance to Torsion

c. Box Section - Good resistance to both bending and Torsion



Steel sections used in chassis frame.


SIDE MEMBER
GUSSET PLATE
CROSS MEMBER
CMB2F602



Body mounting brackets

Types of frame:

- Conventional frame
- Semi integral frame
- Integral frame

1. Conventional frame:

- Known as non load carrying frame.
- Loads on the vehicle transferred to suspension.
- Total frame mounted on the wheel axle by means of springs.
- Rubber mountings between body and frame, this makes the body completely isolated from frame deflection.

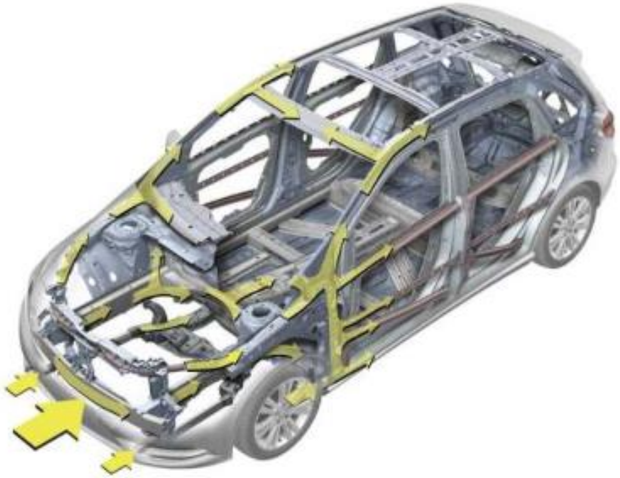
- Mainly used in heavy trucks.
- Has advantages of strong chassis of less weight.
- Easy to repair in comparison to the integral chassis.
- Cross section of frame usually channel, tubular or box type

Rubber mount

2.Semi integral frame:

- In the semi integral type, the body mounts are made of stiff material.
- The body structure has now become semi integral.
- Some of the load transferred to the body structure.
- The semi integral type permits case of styling changes and eliminate road noise when proper insulation are used.

3. Integral frame:



- Called as chassis-less.
- Used in passenger cars, suitable for mass production.
- No separate frame, all assembly units are attached to the body.
- Heavy side members are eliminated and cross members are combined with floor.
- Body of the vehicle give space for mounting engine, suspension and other units.
- Much weight reduction.

Materials for frame:

1. Aluminium alloy
2. Mild steel sheet
3. Carbon steel sheet
4. Nickel alloy steel sheet

Defects in frame:

Defects in frames and body generally occur due to the impact on rough road and impact with other objects or vehicle. The following kind of defects may occur:,

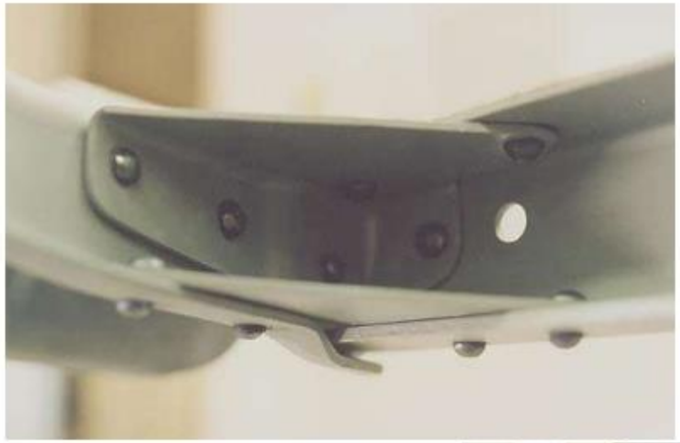
1. Misalignment in horizontal and vertical frame.
2. Twisting of main frame and sub-frame.
3. Buckled main frame and sub-frame.
4. Bent side members
5. Broken or loose gusset plates and rivets.

Frame repair and alignment:

Although the chassis frame is strong enough, it does not require any care. But if the vehicle is carelessly driven on rough road or if it is heavily load, some defects occur in the frame.

1. Loose rivets:

   Due to rough driving and heavy loads, the chassis rivets become loose. So the frame members also becomes loose and creates noise.



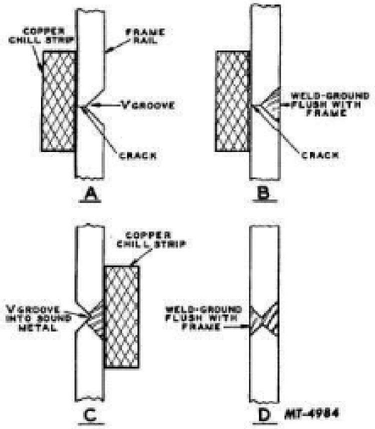

While replacing the loose rivets,

1. Rivet head is cut by drill or gas torch not by chisel.
2. If the hole size is increased, then the oversize rivet is used for tight fit.
3. Before fitting the new rivet, the hole is carefully cleaned.
4. The new rivet is properly heated and fitted by a riveting hammer.
5. The loose rivet should be welded or it should be replaced.

Cracks:

Cracks may also occur in the chassis frame. Chalk solution is made in water and pasted it on the frame where the crack is suspected. Holes are drilled one on each side of the crack if the arrangement for repairing is not available.

V groove



Bend:

If the frame bends due to the accident, it is adjusted by heating the deflected member and straightening by a jack.

Classification based on number of cylinders:

1. Single cylinder engine:

- Has one cylinder, mostly used in light motor vehicle. Maximum cylinder size 250-300cc.
- Popular due to few parts to manufacture and maintain.
- Requires heavy construction for more power.

Reason for using single cylinder in two wheelers:

i) Compact in size

ii) Power developed is enough to carry two passenger load.

iii) Vehicle In lighter weight, so it give high acceleration.

2. Multi cylinder engines:

Multi cylinder engine has two, three, four, six, eight cylinders which arranged in many ways.

Reason for using multi cylinder:

i) Multi cylinder engine develops more power required to propel the commercial vehicle.

ii) Vibration is less due to balancing of the crank.

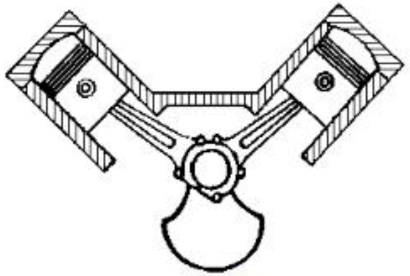
iii) Swept volume of the engine is high and also surface volume ratio is increased. It results a greater power output and better cooling.

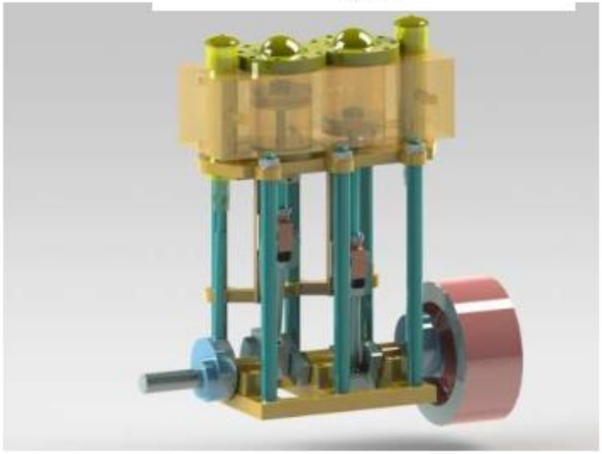
iv) Diesel engine normally run at higher compression ratio of 18:1. At this high compression ratio, the thermal efficiency is high.

Classification based on arrangement of cylinders:

- horizontal engine- push forward the vehicle.
- Fuel economy is high.
- Crankcase cannot used for storing lubrication oil.
- There will be excessive wear at the lower side of the piston and cylinder liner. The weight of the piston is carried by the cylinder liner.
- Consumption of lubricating oil is more.

- Two cylinder engine can be arranged





- The size range varies from 500-1000 cc for twin cylinder engine.
- In v-type engine cylinders are arranged at an angle of 60˚ or 90˚ to each other. This arrangement is more compact and economical than inline type.
- In Opposed cylinder arrangement, the cylinders are arranged horizontally opposite to each other.

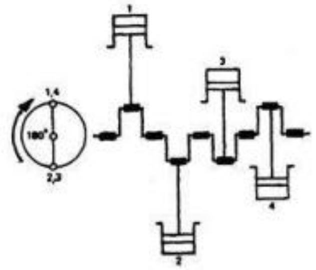
- Cylinders are arranged vertically in-line with the crankpins arranged at 120˚ intervals around the shaft.
- It only confined with two stroke engine.
- The crankcase is divided into three compartments.
- Each sealed off section of the crank case is provided to one of the cylinders.

Four cylinder engine:

- Four cylinder engines are widely used in small, lightweight and fuel efficient cars.
- 180˚ crankshaft arrangement is always used.
- Balancing of four cylinder engine is not good, but the torque is much uniform
- Piston 1 and 2 moving in opposite to the direction of piston 2 and 3.

Four cylinder inline engine

- In opposed four cylinder engines, the cylinders are arranged horizontally in pairs on each side of a flat four crankshaft.
- In this engine, one power stroke is occurred in every 180˚ of crankshaft rotation.
- This arrangement is called as flat four.

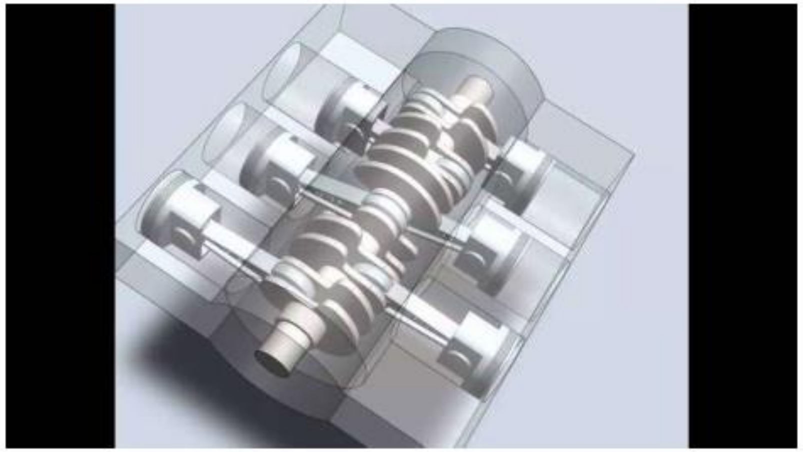


- V four engine have cylinders arranged in two rows of two cylinders each.
- Two rows are set at an angle 60˚ each other.
- Firing order is 1,3,4,2

Five cylinder:

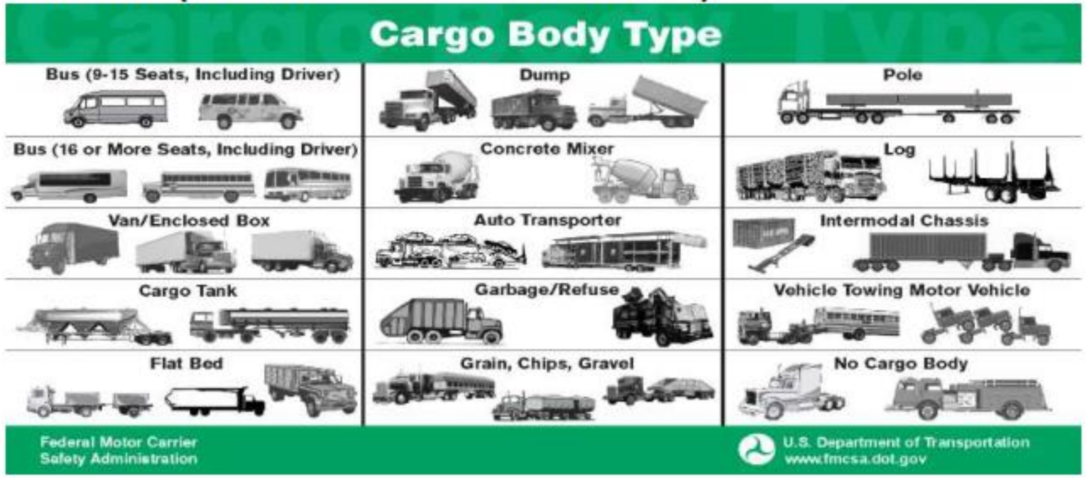
- Most of the modern and high powered cars are employing with six cylinder engine.
- Generally inline engine built with 120˚ crank shafts.
- Possible firing order is 1-5-3-6-2-4- and 1-4-2-6-3-5.
- Six cylinder V-engines are very important engine which are built to have a bank of three cylinders at v to each other.

- Opposed six cylinder engine are also available. The cylinders are placed in each side of two rows but they are opposite to each other.



Automobile body

Body is the super structure for all vehicles. Either be constructed separately and bolted to the chassis or manufactured integral with the chassis (Frameless construction).



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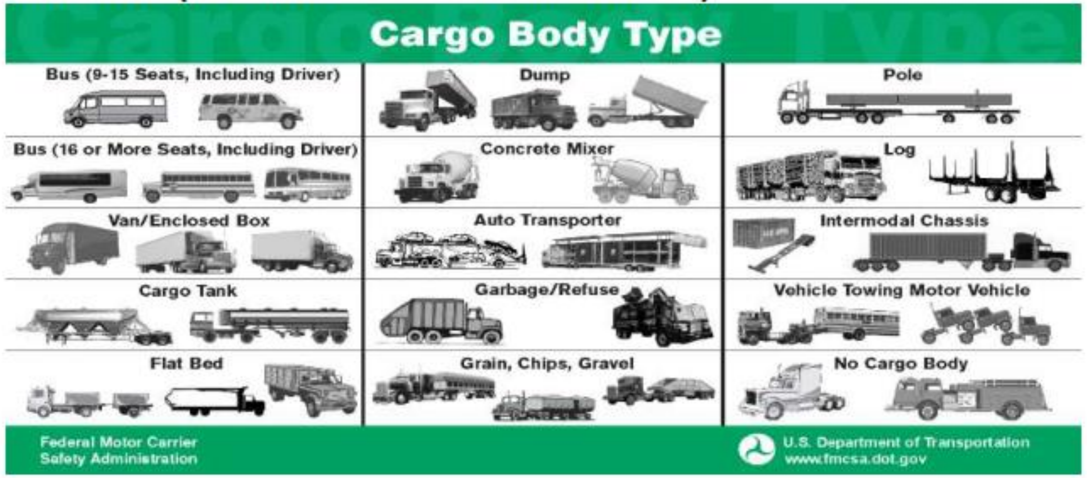
Body is the super structure for all vehicles. Either be constructed separately and bolted to the chassis or manufactured integral with the chassis (Frameless construction).



Importance of vehicle body design aspects

- Body contribute 40% of total W in car, 60% in buses, so reduction in body weight is important.
- Body weight have the impact on fuel economy
- Positive pressure on the front of the vehicle should be minimized, and it should be deflected smoothly.
- Main consumer appeal of style should also be considered.

Requirements of vehicle body:

1. It must be strong enough to withstand all types of forces acting on the vehicle.
2. Stresses induced in the body should be distributed evenly to all portions.
3. Weight of the vehicle should be minimum.
4. It must provide space for passengers and luggage.
5. It should have good access to the engine and suspension elements.
6. It should create minimum vibration during running.
7. Easy to manufacture and minimum cost.
8. Minimum drag, good shape and colour.

Components of vehicle body

- **Structure**- All load carrying elements are defined as the body structure.
- **Finish**- The finished group includes all unstressed units such as bonnet, lid, bumper.
- **Equipment**- Equipment group includes seats, heating system and doors.

- All steel sections are made by dies separately and welded to other sections for forming the steel bodies.
- Each panel is designed to give enough strength.
- Car body have two types of panels.

  1. Outer panel (shape)
  2. Inner panel (Reinforce)
- Inner panels provide mounting locations for various trim panels and connecting assemblies

- Initially the floor of the car body is assembled and then pillars, rails and panels are welded.
- Floor made by 3 parts,: front, centre and rear section.
- Box shaped rocker panels are fixed to sides of the floor.
- Centre pillar supports the rear doors and hinges of front door. It support the roof rails.
- Roof rails and centre pillars are usually in box section, it give maximum strength to body.

- Roof panel is welded to the top side rails.
- Rear window and front windshield frames are attached to the roof panel by spot welding.
- Engine compartment is formed by assembling different sheet metal panels.
- Radiator support is provided to support the radiator by means of bolts.

- Engine hood is manufactured as like truck lid.
- It has inner and outer panels.
- Inner panel acts as the reinforcement to the engine hood, it provide mounting locations for the hood lock and hinges.
- Outer panel gives the shape of the body, hood is attached to the car body by means of hinges

- Seat – folding back and bucket. Rails
- Front doors are hinged on front pillars, rear doors are hinged with center pillar.
- Rubber weather strips are bonded around doors.
- Special glass used in auto to prevents the passenger in case of any accident. Does not make sharp edges when broken.
- Bumpers are provided at the front and rear end to protect the vehicle from light impact.
- Materials for body construction.

- Wind screen and window panels are made by hard glass.
- Laminated safety glass and tempered glass.
- In laminated safety glass two layers of glass bonded together with the help of another inner layer of vinyl transparent plastic under heat and pressure.
- The tempered safety glass is made from a single piece of heat treated glass.
- It cut to the required shape and then heat treated until it becomes soft.
- Then it is treated with cold air to the outer surface.
- It becomes five times harder than ordinary glass.
- Used for side or rear windows.


Mirrors
Hoods
Tailgates
Trunk Lids
Header &
Nose Panels
Tail
Lights
Radiator
Supports
Step
Bumpers
Grilles
A/C
Condensers
Bumpers
Headlights
Fenders
Radiators
Doors

Comparison of SI Engine and CI Engine

SI	CI
Air fuel mixture from carburettor	Air is only from atom
Spark plug is required	Fuel injector
Compression ratio varies from 6 to 8	Compression ratio 12 to 18
Operated by Otto or constant volume cycle	Operated by diesel or constant pressure cycle
Starting is easy due to low compression ratio	Starting is little difficult
Running cost is high	Running cost is low
Initial cost is low	Initial cost is high
Maintenance cost is less because of few parts	Maintenance cost is more because of more number of parts.
Thermal efficiency is low	Thermal efficiency is considerably high
Used for high speed application	Used for low speed operations

Comparison of two stroke and four stroke engines:

Two stroke / advantages	Four stroke / disadvantages
A cycle is completed in 2 strokes or one revolution of the crank shaft.	A cycle is completed in 4 strokes.
For the same power developed the two stroke engine is much lighter.	For the same power developed the four stroke engine is bulky, heavier.
Turning moment is more uniform,: lighter flywheel.	Turning moment is not uniform,: heavier flywheel.
Contain ports are operated by piston itself.	Contain valve which is operated by separate mechanism
Initial cost is low-less complicated mechanisms	Initial cost is high-complicated mechanisms
Mechanical efficiency is more.	Mechanical efficiency is low.

Two stroke/ disadvantages	Four stroke/ advantages
Thermal efficiency is low	Thermal efficiency is high
Volumetric efficiency is low	Volumetric efficiency is high
Greater cooling and lubrication are required	Lesser cooling and lubrication are required
Overall efficiency is less	Overall efficiency is more
Greater rate of wear and tear	Lesser rate of wear and tear
It is used in light vehicles only	Used in heavy vehicles
Exhaust is noisier	Exhaust is more uniform and hence noiseless operation
Specific fuel consumption is more because of escaping with exhaust gases	Specific fuel consumption is less because of separate exhaust stroke.
Less compression ratio	More compression ratio

Valve timing diagram-four stroke cycle SI engine

IVO -- Inlet valve open

IVC – Inlet valve close

IS – Ignition start

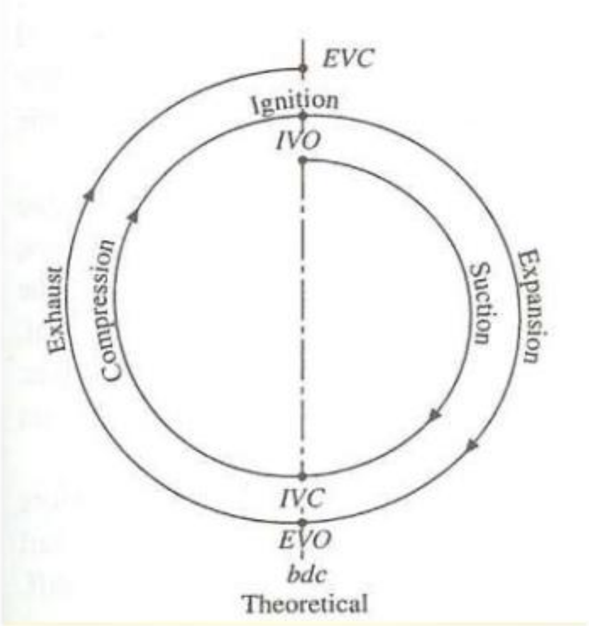
EVO – Exhaust valve open

EVC – Exhaust valve close

TDC – Top dead center

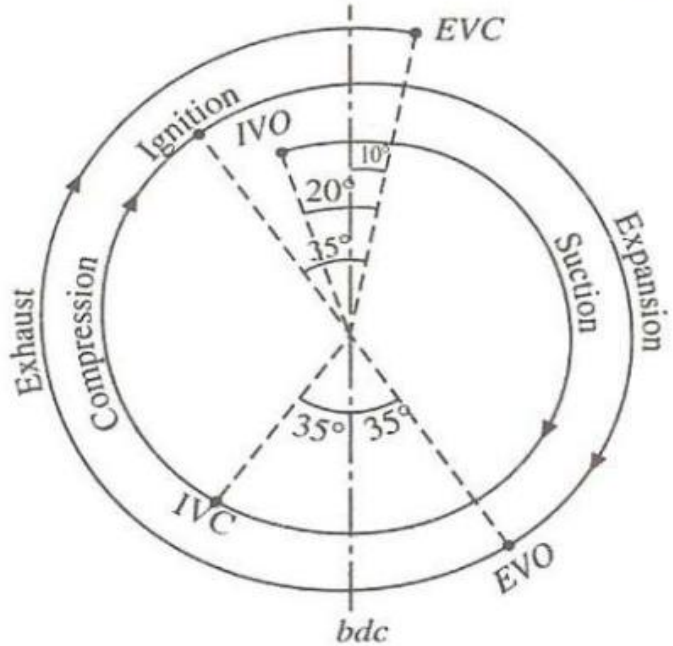
BDC – Bottom dead center

Theoretical valve timing diagram:

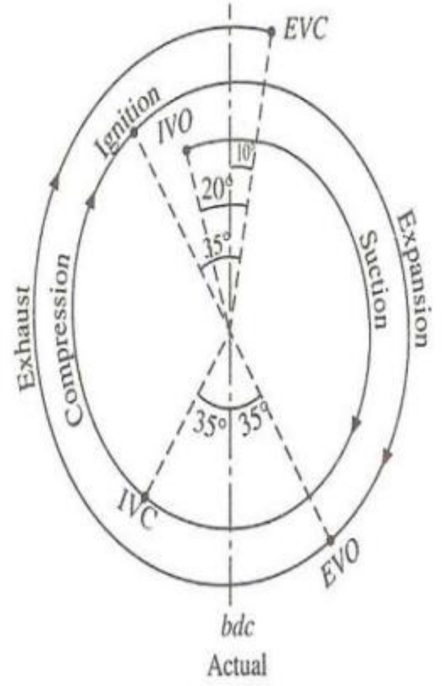


Inlet and exhaust valves open and close at both dead centers, all processes are sharply completed at TDC or BDC

Actual valve timing diagram:

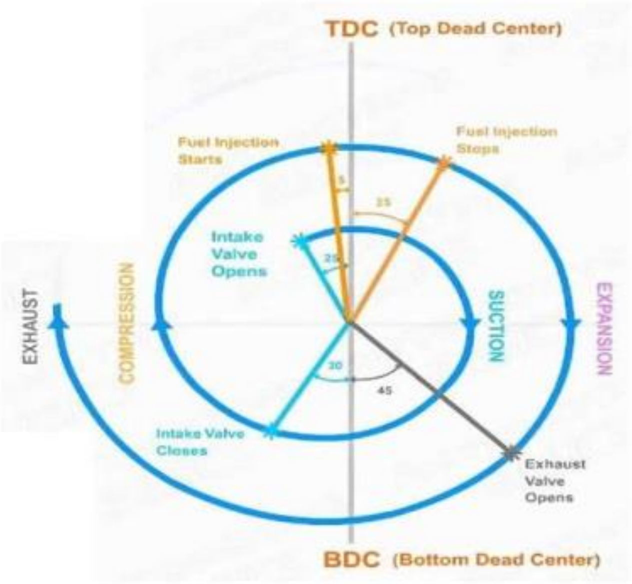


Actual

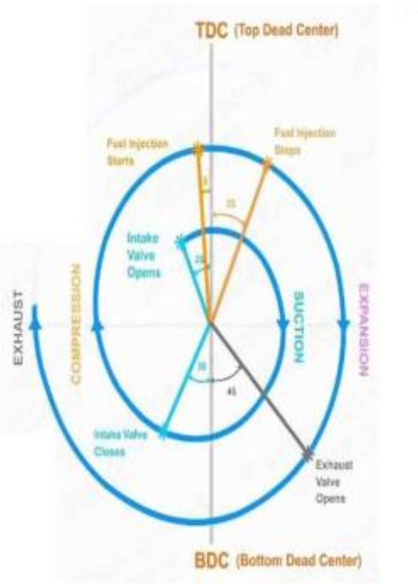


- Inlet valve opens 10-30° before TDC.
- Air fuel mixture is sucked into the cylinder till the inlet valve closed.
- IVC at 30-40° after BDC.
- Spark produced 20-40° before TDC.
- EVO 30-60°before BDC.
- EVC 8-20°after TDC.
- Valve overlap period.

Valve timing diagram for a four stroke CI engine:



Valve timing diagram for four-stroke diesel engine



Valve timing diagram for four-stroke diesel engine

- IVO 10-25° before TDC.
- IVC 25-50°after BDC.
- FIS 5 to 10° before TDC.
- FIC 25° after TDC.
- EVO 30 to 50° before BDC.
- EVC 10 to 15° after TDC.
- Overlap period.

AUTOMOBILE ENGINEERING UNIT 2

BY

V VIGNESHWARAN, M.TECH, AP

Carburetor

Carburetor is a device used for atomizing and vaporizing the fuel and mixing with the air in varying proportions to suit for changing conditions the operating conditions of engines.

Vaporizing – change stage

Atomizing – Breaking up of the liquid into small particles

Carburetor is supposed to supply the fuel air mixture in correct proportion under different conditions of temperature, speed and load on engine.

Relatively rich mixture 12:1

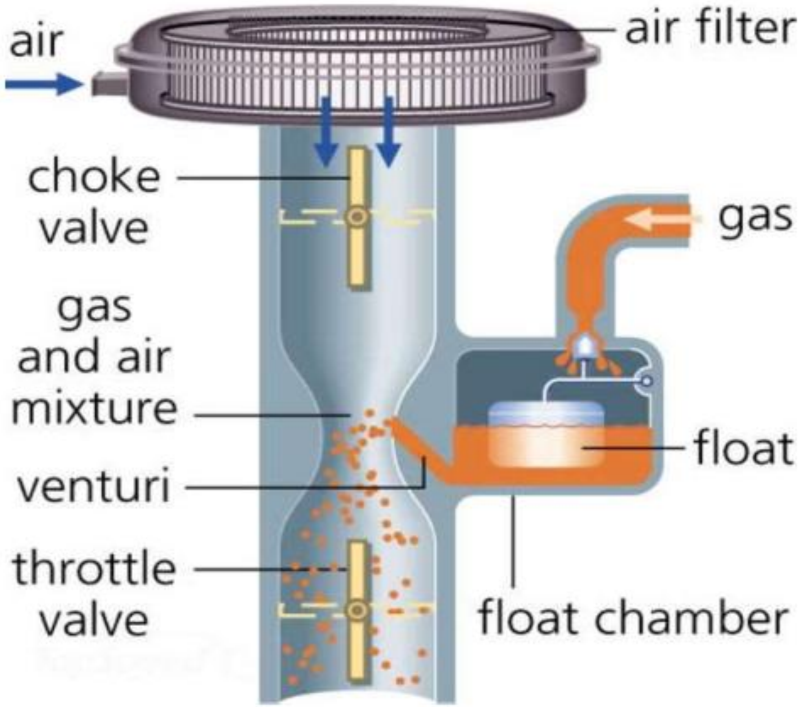
Leaner mixture 16:1 in leveled roads

Extreme rich mixture 9:1

Function of carburetor

- Prepares a mixture of petrol and air in correct proportions.
- Maintain small reserve of petrol in the float chamber.
- Atomizes and vapourizes the fuel.
- It supplies a fine spray of petrol.
- It measure the conditions of engine operations and supplies the proper quantity and proportions of air and fuel.

Simple carburetor



- Air flows into the top of the carburetor from the car's air intake.
- When the engine is first started, the choke can be set so it almost blocks the top of the pipe to reduce the amount of air coming in to make rich mixture.
- In the center of the tube, the air is forced through a narrow kink called a venturi. This makes it speed up and causes its pressure to drop.
- The drop in air pressure creates suction on the fuel pipe, drawing in fuel.

- The throttle is a valve that swivels to open or close the pipe. When the throttle is open, more air and fuel flows to the cylinders so the engine produces more power.
- The mixture of air and fuel flows down into the cylinders.
- Fuel is supplied from a mini-fuel tank called the float-feed chamber.
- As the fuel level falls, a float in the chamber falls and opens a valve at the top.
- When the valve opens, more fuel flows in to replenish the chamber from the main gas tank. This makes the float rise and close the valve again.

Solex carburetor

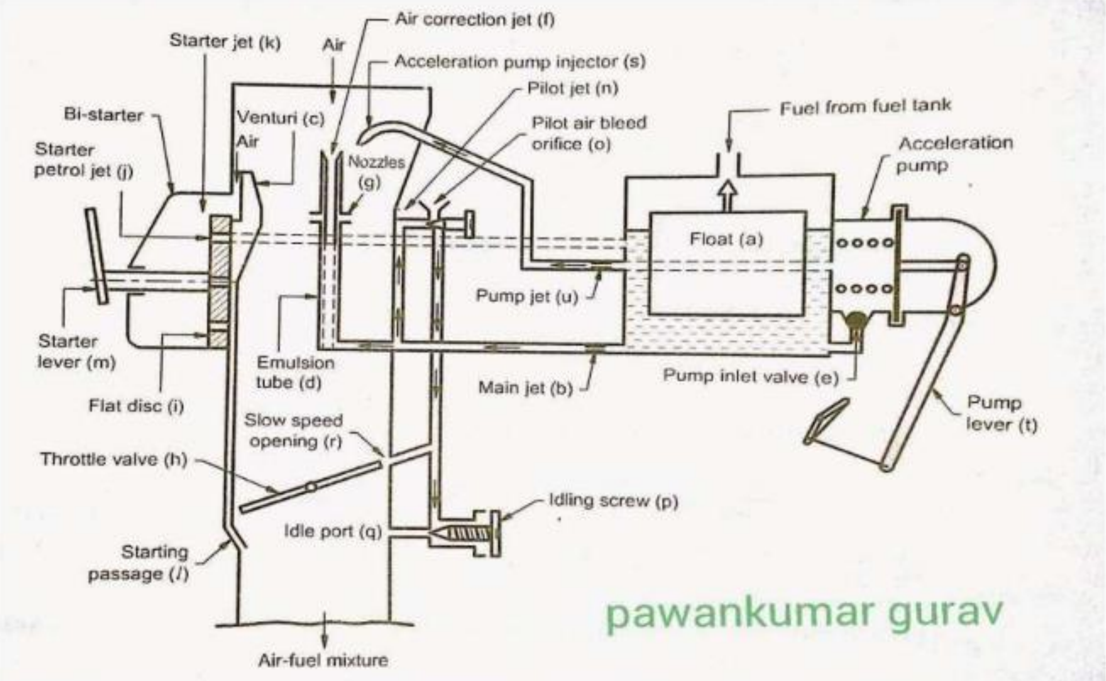


Fig. 2.9.1 : Solex carburettor

- In automobile engineering, Fiat cars are most popular brand in India due to its very easy start in cold conditions.
- This easy start is obtained by Solex Carburetor which is a down draft type carburettor and has special provisions to supply, richer mixture at starting of engine and weaken it gradually till the engine reaches its normal running speed.
- Solex carburetor are available in many designs and all have following work circuits,

01) Solex Carburetor Starting Circuit:

- The throttle valve remains in closed position during starting. The petrol is supplied to the starter petrol jet through first passage from the float chamber and the air through the starter air jet for starting operation.
- Starting Valve which have different sizes hole, is made from flat disc. The position of various holes can be adjusted in front of starter petrol jet by starter lever and then air is mixed coming from starter air jet .
- This air-fuel mixture, passes through another holes of starter valve, in a passage of the carburetor, below the throttle valve.

02) Normal Running Circuit:

- At normal running speed, starting circuit is closed and throttle valve is opened.
- The normal running circuit consists of main jet which receives the petrol through second passage, from the float chamber
- air is drawn through the venturi where the petrol mixes up with it forming a suitable mixture for the normal running of the engine.
- In this case, only throttle valve, governed the air-fuel ratio.

03) Solex Carburetor Accelerating Circuit

- The engine requires an extra rich mixture, during acceleration period.
- To obtain extra rich mixture, the fuel is pumped under pressure into the main air passage or in the venturi through an injector.
- Diaphragm pump is used to create pressure, which is actuated by a lever connected to the accelerator.
- The pump sucks the petrol from the float chamber through the pump valve and forces it through third passage into the main passage through an injector above the venturi of the carburetor.

04) Solex Carburetor Idling and Slow Running Circuit:

- During the idling operation, the throttle valve is kept closed and the engine receives the mixture through a port opening below the throttle valve.
- Area can be varied by an idle adjusting screw according to the need of the engine.
- The petrol is supplied to a pilot petrol jet from the main jet fuel circuit through fourth passage and the air from a pilot air jet .
- The petrol and air thus supplied mix up in the idle passage and go to a port situated below the throttle valve from where the mixture is sucked by engine.
- During the slow ***running***, the engine draws the mixture from the idle passage through a hole situated above the throttle valve when the throttle valve is partially opened.

S.U Carburetor

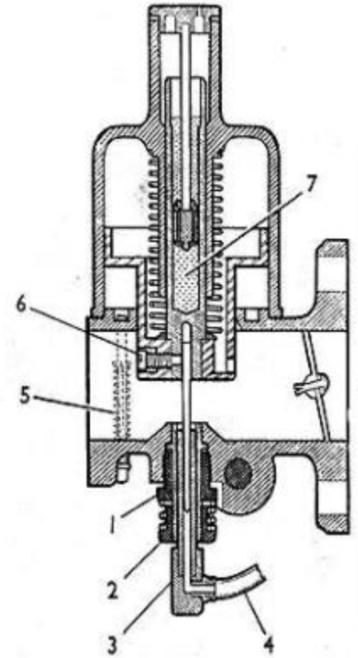
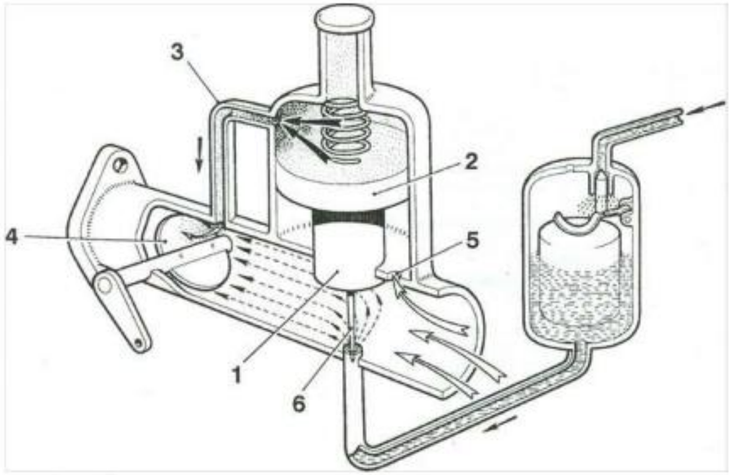


Fig. 3.3 SECTION VIEW OF THE HS4 CARBURETTER.
1 Jet locking nut. 2 Jet adjusting nut. 3 Jet head. 4 Feed tube from float chamber. 5 Piston lifting pin. 6 Needle securing screw. 7 Oil damper reservior.



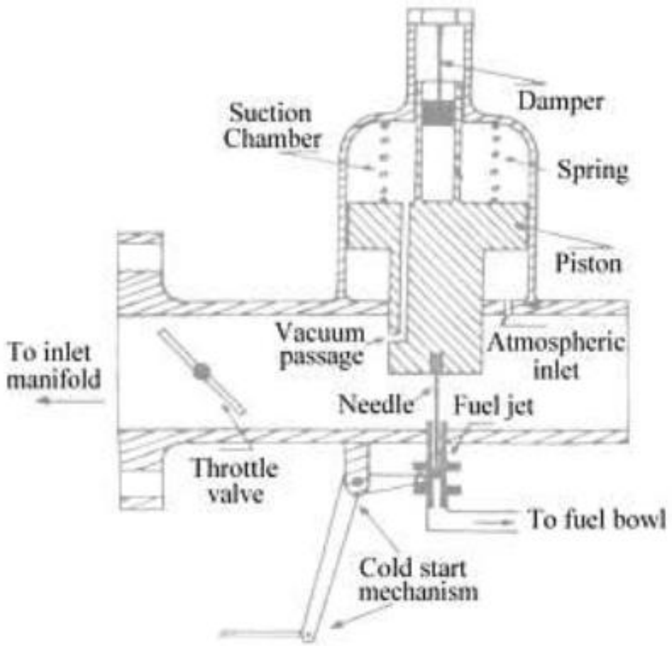

Damper
Suction Chamber
Spring
Piston
Vacuum passage
Atmospheric inlet
To inlet manifold
Needle
Fuel jet
Throttle valve
To fuel bowl
Cold start mechanism

DIAGRAM No. 1

- Orifice area is varied to meet the varying demand of carburetor.
- Contain only one fuel jet in which a tapered needle slides up and down.
- Needle fitted with the piston which moves up and down due to the pressure b/w engine suction and atmosphere pressure.
- Up and down moment of the needle define the fuel flow.
- Damper plunger placed in the hollow piston rod.

- Oil with suitable viscosity is filled in piston rod.
- It regulate the rate of lift and allow the piston fall freely.
- No necessity of acceleration pump. No idling or slow running circuit.
- Adjusting nut is provided to adjust the mixture strength.
- When engine suction is increased, the pressure difference b/w upper and lower sides of the disc will increased.

- It causes the disc to move up, fuel flows out.
- Engine in stationary, pressure difference is same which results piston move down to its lowest position and close the jet.
- Starting purpose jet operating lever is used. Lever controlled by a knop.
- Knop pulled – jet moves down, fuel flows.
- Knop pushed – jet return to its original position.

Carter carburetor

- It consist of the following circuits:
    1. Float circuit.
    2. starting circuit.
    3. Idle and low speed circuit.
    4. Part throttle circuit.
    5. Full throttle circuit.
    6. Acceleration circuit.

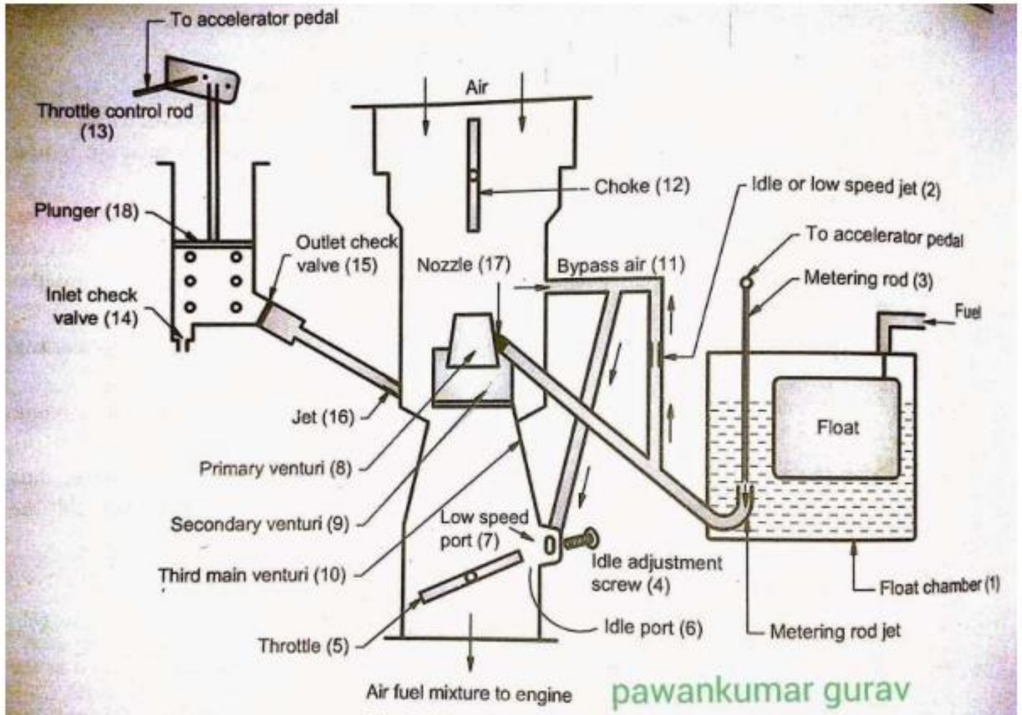


Fig. 2.9.2 : Carter carburettor

Construction:

- Petrol enters the float chamber
- Air from top, chock valve open during normal running.
- Have three venturi.
  - Smallest venturi, above the float chamber
  - Two venturi are below the fuel level and one is below other.

- The mixture from the primary venturi enters through the secondary venturi and it finally leads to main venturi.

- Multiple venturi result the better formation of the mixture at very low speed causing steady and smooth operation at very low and also at very high speeds

- Float circuit.
- Starting circuit.
- Idle and low speed running.

Throttle valve is almost closed, the whole of the engine suction is applied to the idle port. Petrol drawn through the idle feed jet and air through first bypass and a rich mixture is supplied.

In low speed operations, throttle valve is opened.

- Part throttle circuit.

The throttle valve is opened further for increasing the speed. The fuel is delivered by the main nozzle only.

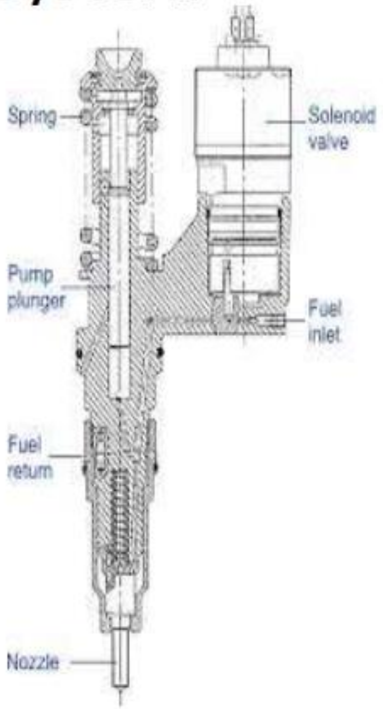
- Full throttle circuit.

Throttle valve is fully opened, higher rate of fuel flow required. It achieved by metering rod.

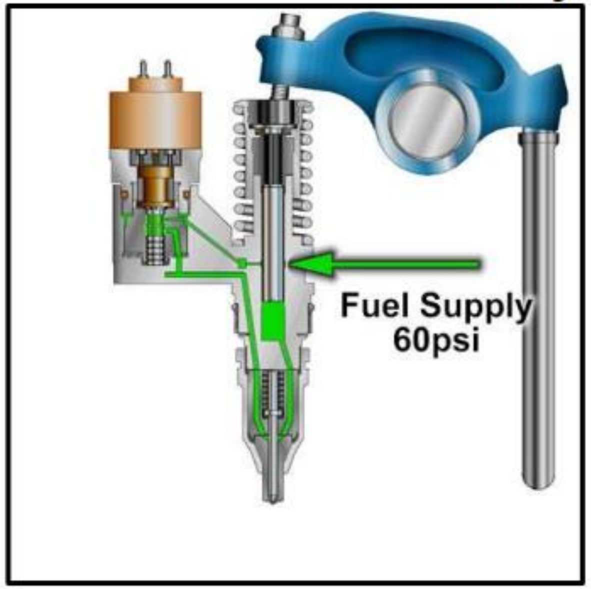
- Accelerating pump circuit.

Unit injection system

- Filling phase.
- Spill phase.
- Injection phase.
- Pressure reduction phase.

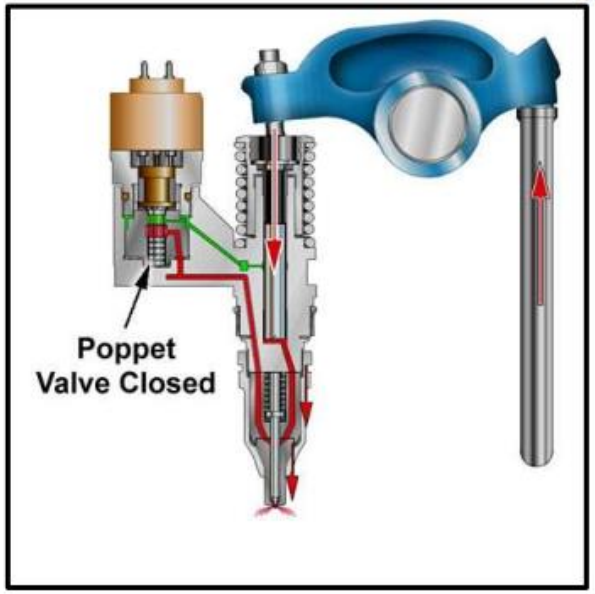


EUI - Injector Fill



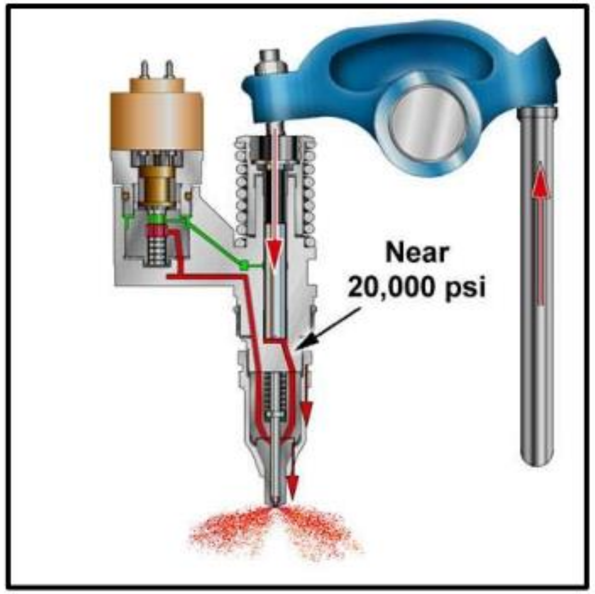
- Without pressure from the rocker arm, a spring keeps the plunger retracted
- Fuel flows into the injector through the fill / spill port, past the solenoid valve and into the barrel

EUI - Injection



- On a signal from the ECM, the solenoid closes the fuel valve
- Pressure elevates at the tip to the 5,500 psi needed to unseat the valve
- Injection begins

EUI - Injection



- Fuel continues to inject until the ECM signals the solenoid to open the valve

- Injection timing and duration is controlled by the ECM

Fill phase:

Plunger on the way up- draws fuel from the supply duct into the chamber. Fuel line is open as long as solenoid de-energized.

Spill phase:

Plunger on the down, as long as solenoid remains open and fuel flows into the return duct.

Injection phase;

Plunger still on the way down, solenoid is closed- fuel compressed by the plunger until the pressure exceeds specific opening pressure. Then the injector needle lift up-combustion chamber.

Pressure reduction phase:

Plunger still on the way down, ECU energizes solenoid- fuel delivered into return duct. Pressure drop in the injection nozzle.

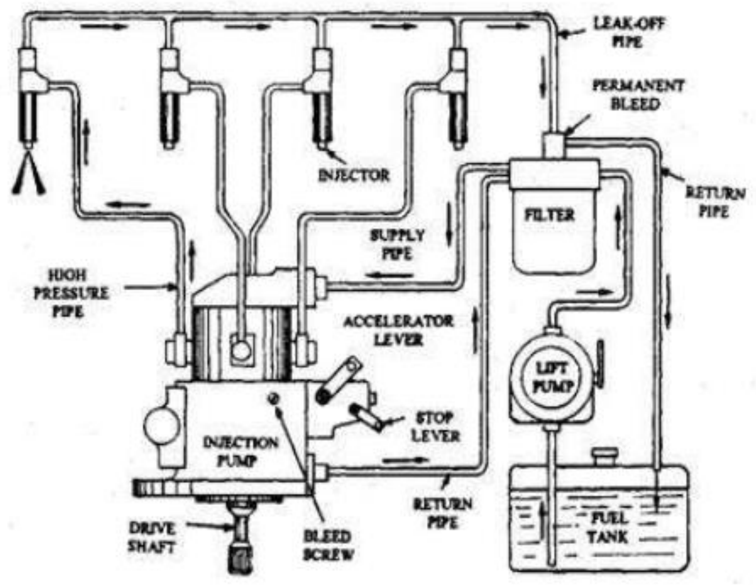
Advantages:

- High performance for clean and powerful engines.
- Balanced engine power against low consumption and low engine emission.
- High degree of efficiency.
- Low noise due to direct assembly in the engine block.
- High injection pressure-2200 bar.

Disadvantage:

- Separate unit is required for each cylinder.
- Close tolerance - high cost.

Rotary Distributor system



Rotary Distributor system

- Pump which pressurizes the fuel also meters the fuel and times the injection.
- Fuel is distributed to cylinders in a correct firing order.
- Rotating distributor – correct timing.
- Poppet valve used to admit the fuel to nozzle.
- Distributor pumps metering the injected quantity.
- Electronically controlled solenoid actuator.

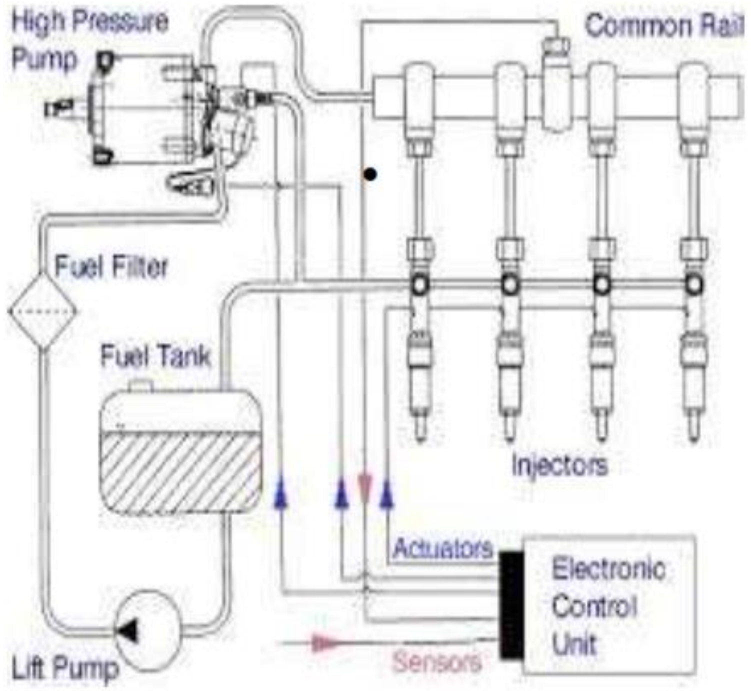
Advantage:

- Simple construction, low initial cost, easy maintenance

Disadvantages:

- Low durability, suitable for small bore engines.

Common rail direct injection system



Various components:

- ➢ High pressure fuel pump.
- ➢ Common fuel rail.
- ➢ Injectors.
- ➢ Engine control unit.

Advantage:

- Initial cost low.
- Superior pick up.
- Low noise and vibration.
- Higher mileage.
- Emissions are low.
- Fuel consumption is less.

Disadvantages:

- Complicated design.
- Production cost is high.
- High degree of engine maintenance.

Petrol injection system for SI engine:

Modern carburetors- limitation

- In multi cylinder engines – difficult for a single carburetor to supply uniform quality and quantity.
- Venturi throat of the carburetor restrict the air flow to the engine. Low velocity- less efficient atomization.
- Carburetor have many parts. After wear – less efficiently.

Differ petrol injection and diesel injection.

In diesel injection fuel injected at the end of the compression stroke. But in petrol we can inject at any time of the suction stroke.

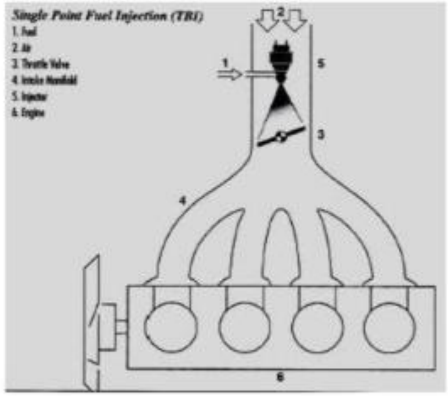
Types of Petrol injection system:

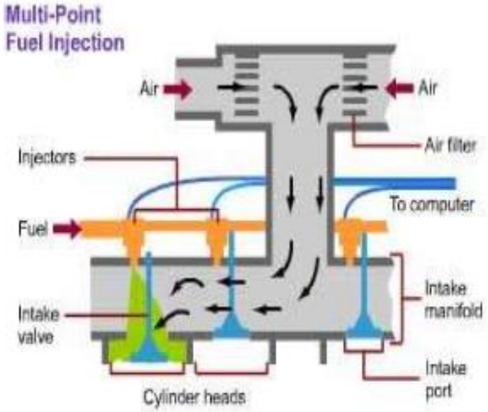
1. Multi point injection system.

Port injection system, injection valve for each engine cylinder. Injection valve is placed near the intake valve. It allow more time for mixing of air and petrol.

2. Single point fuel injection system.

Throttle body injection system, injection valve positioned slightly above each throat. Injection valve sprays fuel just before the throttle valve.


Single Point Fuel Injection (TBI)


Multi-Point
Fuel Injection
Air
Air
Air filter
Injectors
To computer
Fuel
Intake
manifold
Intake
valve
Intake
port
Cylinder heads

Working of electronically controlled gasoline injection system

It consist of four units:

1. **Fuel delivery system.**

   Electrically driven pump, filter to pressure line. End of the pressure line pressure regulator is placed. Regulator is connected to the intake manifold. Pressure kept constant, so that the quantity of fuel is injected is dependent only on the injection open time.

2. **Air induction system:**

   Air from atmosphere flows initially through air filter and then through air flow sensor. This sensor generates a voltage signal which is dependent on the amount of air flow.

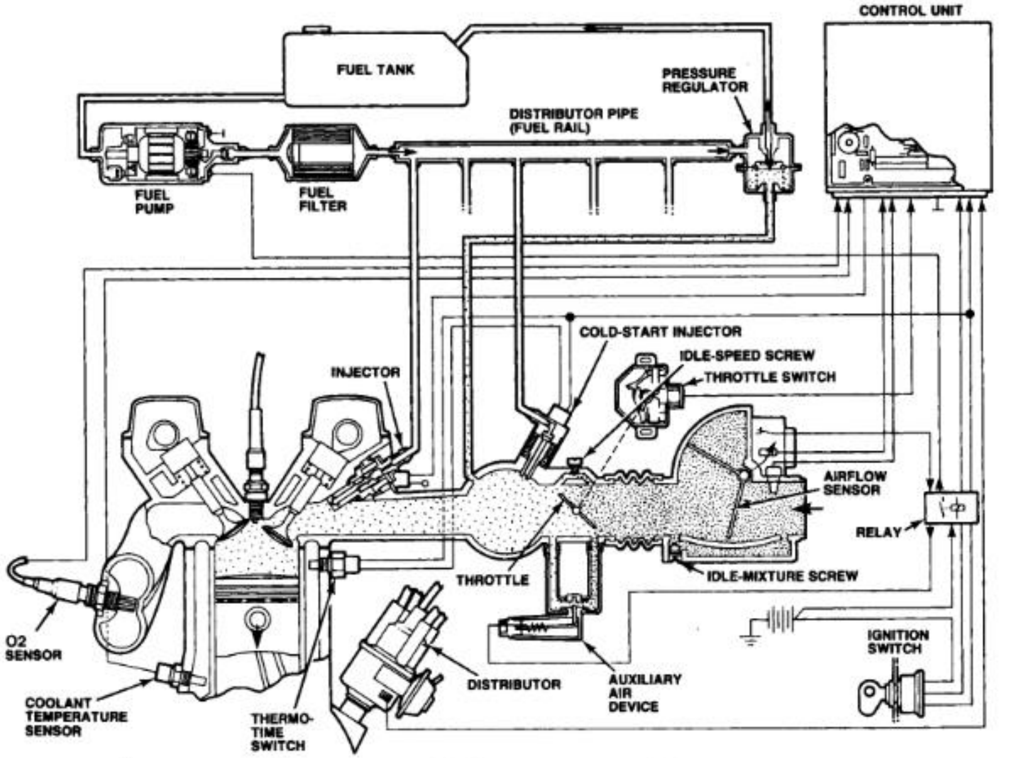


Figure 17-14. The Bosch L-Jetronic system has been used on various Japanese, European, and domestic vehicles. (Bosch)

3. **Sensors and air flow control system:**

Air flow sensor, intake air temperature sensor, Exhaust gas oxygen sensor, manifold absolute pressure sensor, Speed/crankshaft sensor, engine temperature sensor, crankshaft position sensor.

Cold start valve, auxiliary air valve, throttle valve.

4. **ECU:**

Heart of fuel injection, controls the amount of fuel injected by sensor. This unit computes air fuel ratio required for the best performance of the engine during each engine cycle and send signal to the injection valve. Fuel injected is varied by varying the injector opening time only.

Advantages:

- High quality fuel distribution is obtained.
- Increases the volumetric efficiency hence it increases power and torque.
- Design of manifold is simple.
- Exhaust emission are less due to precise air fuel ratio.
- Better starting and acceleration.

Disadvantages:

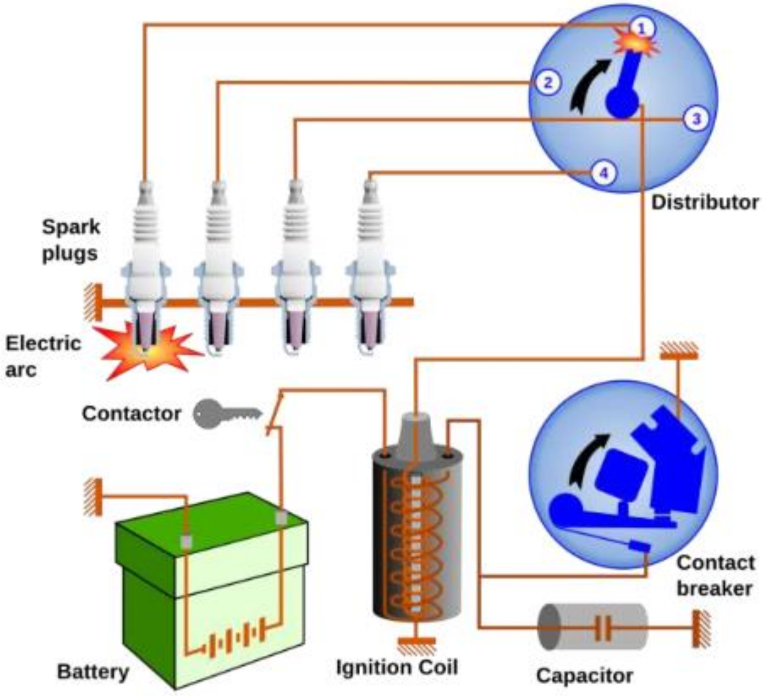
- Initial cost is very high because od precise and complicated components.
- More complicated mechanism.
- More noise is generated.
- Weight and space requirement are more.

Ignition system

- Spark ignition is mostly used in gas engines, Petrol engines working on Otto cycle.
- Fuel air mixture is ignited by a high tension electric spark.

  1. Battery ignition system.
  2. Magneto ignition system.
  3. Electric ignition system.
  4. Transistorized ignition system.

Battery ignition system



Battery ignition system Construction

Main parts:.,

Battery, Ignition switch

Induction coil, condenser

Distributor

One terminal of battery grounded, another one is connected to the primary winding through switch.

Other primary terminal connected to the contact point of the circuit breaker

Breaker points are held on contact by a spring system expect when forced by a cam

- Ignition coil consists of primary and secondary windings.
- Primary winding consists of thick wire with less number of turns. 200-300 turns…
- Secondary winding located inside the primary winding consists of 21000 turns of thin enameled wire.
- The condenser connected across the contact breaker.
- The distributor distributes the high voltage to the spark plugs.

- Spark plug is fitted on the combustion chamber. It produce spark to ignite the fuel-air mixture.
- Rotor of the distributor and contact breaker cam are driven by the engine.
- Primary circuit- Battery, primary coil, condenser, contact breaker.
- Secondary circuit- Secondary coil, distributor and spark plugs.

When the contact points are closed.:

- The current flows from the battery to the contact breaker points through the switch and primary winding.
- This current builds up a magnetic field in the primary winding of the ignition coil.
- When the primary current is at the highest peak, the contact breaker points will be opened by the cam.

When the contact breaker points are opened.:

- The magnetic field set up in the primary winding is suddenly collapsed.
- A high voltage is generated in the secondary winding.
- This high voltage is directed to the rotor.
- The rotor directs this high to the individual spark plugs in the sequence of the firing order.
- This high voltage tries to cross the spark plug gap and spark is produced.

ADVANTAGES OF THE COIL IGNITION SYSTEM

1. At the time of starting and idling at low speed good sparkling is available.
2. Initial expenditure is less . Hence, this system is used in cars and commercial vehicles.
3. Maintenance cost is less.
4. Distributor drive is simple and non-complicated.

DISADVANTAGE OF COIL IGNITION SYTEM

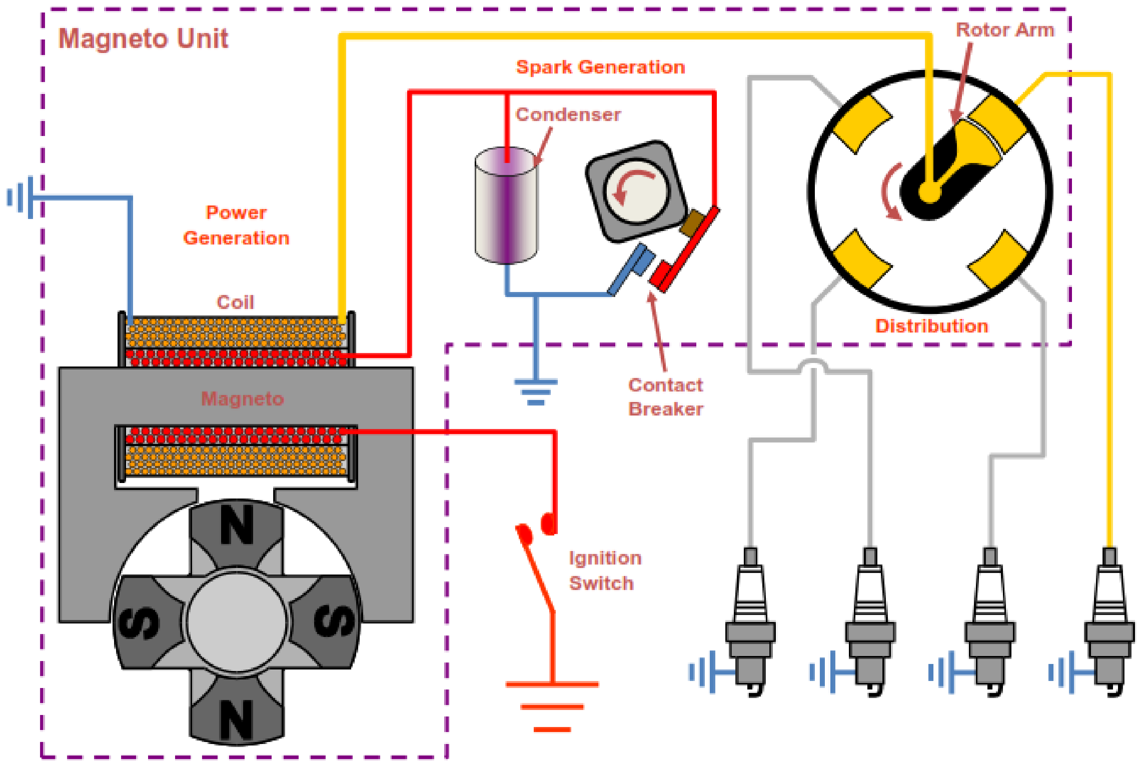
1. If the battery is discharged, then it is not possible to start the engine.
2. Battery is to be checked regularly.
3. It occupies more space.
4. Its wiring is complicated.

Magneto ignition system

Used in motor cycles, mopeds, scooters.

Principle is similar to battery ignition system except the magnetic field in primary & secondary windings produced by a rotating magnet.

It has own current generating unit, it consists of a fixed armature having primary and secondary windings.



IGNITION SYSTEM – Magneto System

Magnet driven by engine

When magnet turns magnet field produced and the change in the magnet flux, induces voltage and current in the primary winding.

When contact breaker points opened by the rotation of the distributor cam, a highly charged condenser discharges itself into the primary circuit.

And it will produces a rapid change in the magnetic flux.

Change in magnetic flux induces a very high voltage in the secondary windings. It sufficient to produce spark.

Another type- rotating armature type.

In this type the rotating member of an armature carrying both primary and secondary windings and the armature rotates between the poles of a stationary magnet.

Advantages:

- It has no maintenance problem.
- Less space is required as compared to battery ignition system.
- When the speed increases, it provides better intensity of spark and thus provides better combustion.
- Light in weight and compact in size.

Disadvantages:

- Minimum 75 rpm is necessary to start engine.
- Initial cost is high.

Differ battery ignition & magneto ignition

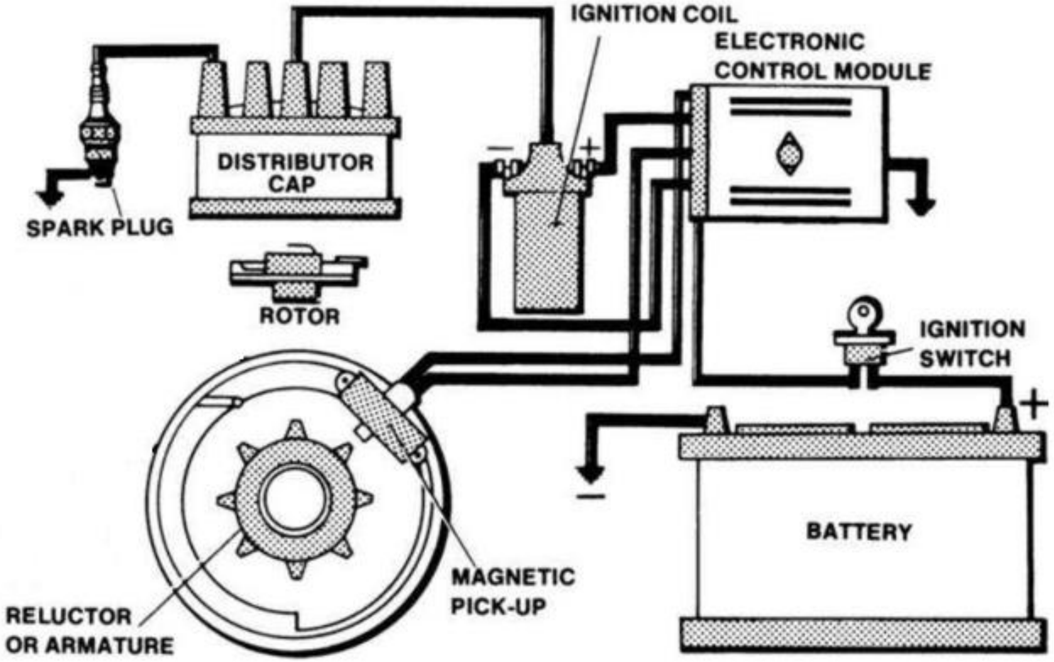
S.No	Battery	Magneto
1	Difficult to start the engine when battery is discharged.	No battery needed, no problem of battery discharge.
2	Maintenance problems are more due to battery	Maintenance problem is less
3	Current for primary circuit is obtained from battery.	Required electric current is generated by the magneto coil
4	Good spark Is available even at low speed	Quality of spark is poor due to low speed
5	Occupies more space	Less space is enough
6	Used in light commercial vehicles	Mainly used in racing cars

Electronic ignition system

- The contact point will wear out when it is operated with heavy current.
- Contact breaker is only a mechanical device which cannot operate precisely at high speed.
- Conventional contact breaker can give satisfactory performance only about 400 sparks per second, it limits the engine speed.
- Convention contact breaker can be completely eliminated by the use of electronic controlled ignition system.

- Basic difference between contact point and electronic ignition system is in primary circuit, contact breaker system is opened and closed by electronic control unit.
- In the secondary circuit, the distributor, ignition coil and wiring are altered to handle the higher voltage that the electronic ignition system produces.
- High voltage(47,000) has the advantages that the spark plugs with wider gaps can be used. It result longer spark which can ignite lean air fuel mixture .

Construction:



- Magnetic pick-up consists of a sensor coil through which the magnetic flux is generated by a permanent magnet.
- A star shaped reluctor or armature is mounted on the distributed shaft which modules the flux density in the coil and induced voltage in the coil.
- This voltage serves as a trigger signal for high voltage generator circuit.
- Number of teeth of armature is equal to the number of cylinder.

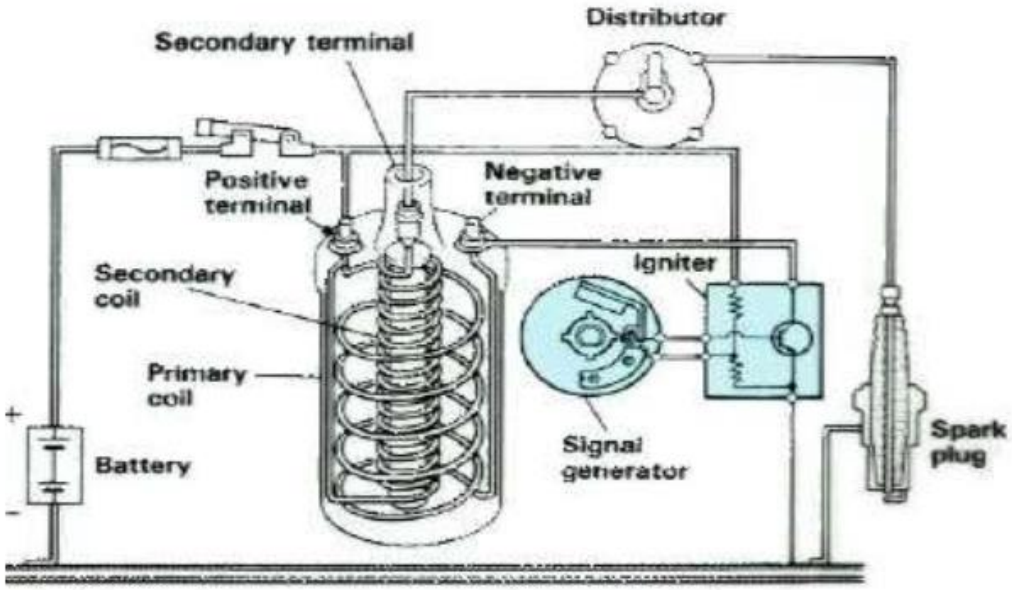
Working:

- When the switch is ON the armature rotates which makes the teeth of the armature cone closer to the permanent magnet.
- It reduce the air gap between armature teeth and sensor coil.
- When armature teeth come closer to the magnetic pickup coil, electric pulse is generated.
- This small current then triggers the electric control unit which stops the flow of battery current to the ignition coil.
- The magnetic field in the primary winding collapses and the high voltage is generated in the secondary winding.
- It lead to spark in a spark plug via distributor.

Advantages:

1. The parts such as armature, magnetic pickup and electronic control module are not subjected to wear in case of a mechanical contact breaker.
2. Periodic adjustment of engine timing is not necessary.
3. It gives very accurate control of timing.

Transistorised ignition system



When the contact breaker points are closed:

- A small current flows in the base circuit of the transistor.
- A large current flows in the collector circuit of the transistor and the primary winding of the ignition coil due to the normal transistor action.
- A magnetic field is set up in the primary winding of the coil.

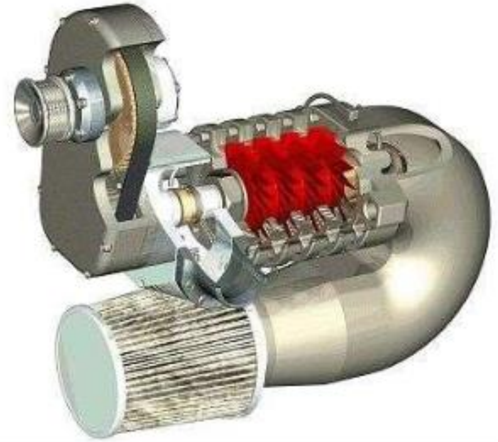
When the contact breaker points are open:

- The current flow in the base circuit is stopped.
- Magnetic field in the primary circuit collapse suddenly.
- It produces high voltage in the secondary circuit.
- This high voltage directed to the respective spark plugs through the rotor.
- This high voltage produces a spark when it is tried to jump the spark plug gap.

Supercharger,
The Engine Booster

A *supercharger* is an equipment that compresses the air being delivered to an engine, allowing the combustion chamber to be overfilled without enlarging the space.

The higher concentration of oxygen provided by a super-charger is matched with a larger amount of fuel from the fuel injectors thus boosting the power of the engine.



A typical supercharger

Why Supercharger ?

- Increases the power of an engine.
- Increases the torque produced.
- An efficiently working supercharger can achieve the same speed in one third time.
- Necessary in aero-planes as they have less oxygen at high altitudes.
- Ensures complete combustion of the fuel.
- Reduces pollution to some extent.

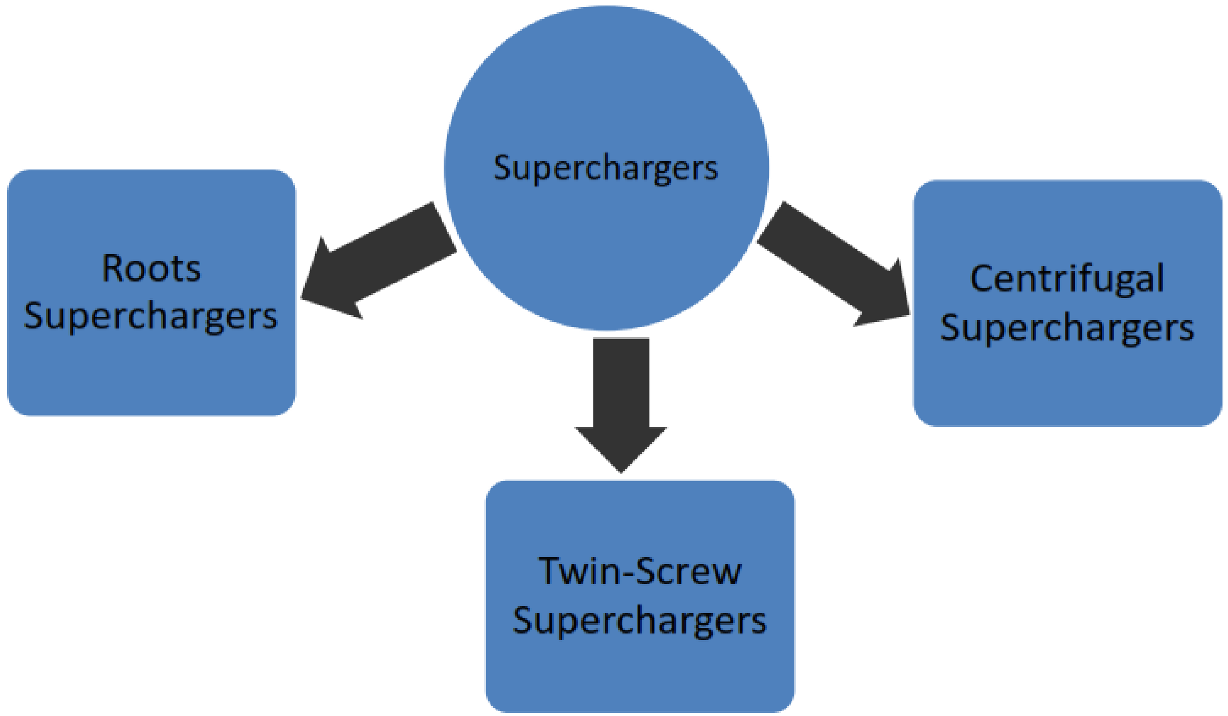
Classification of Superchargers

Based on method of compression, Superchargers can be classified as:-

1. ***Positive-displacement*** type, which deliver a nearly-fixed volume of air per revolution at all speeds and a fairly *constant level of boost* regardless of engine speed.

2. ***Dynamic compressors*** rely on accelerating the air to high speed and then exchanging that velocity for pressure by diffusing or slowing it down & deliver *increasing boost* with increasing engine speed.

Commonly used Superchargers



Roots supercharger

Working:-

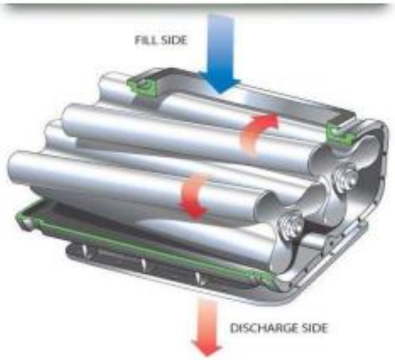
As the meshing lobes spin, air trapped in the pockets between the lobes is carried between the fill side and the discharge side & Large quantities of air move into the intake manifold and "stack up" to create positive pressure.

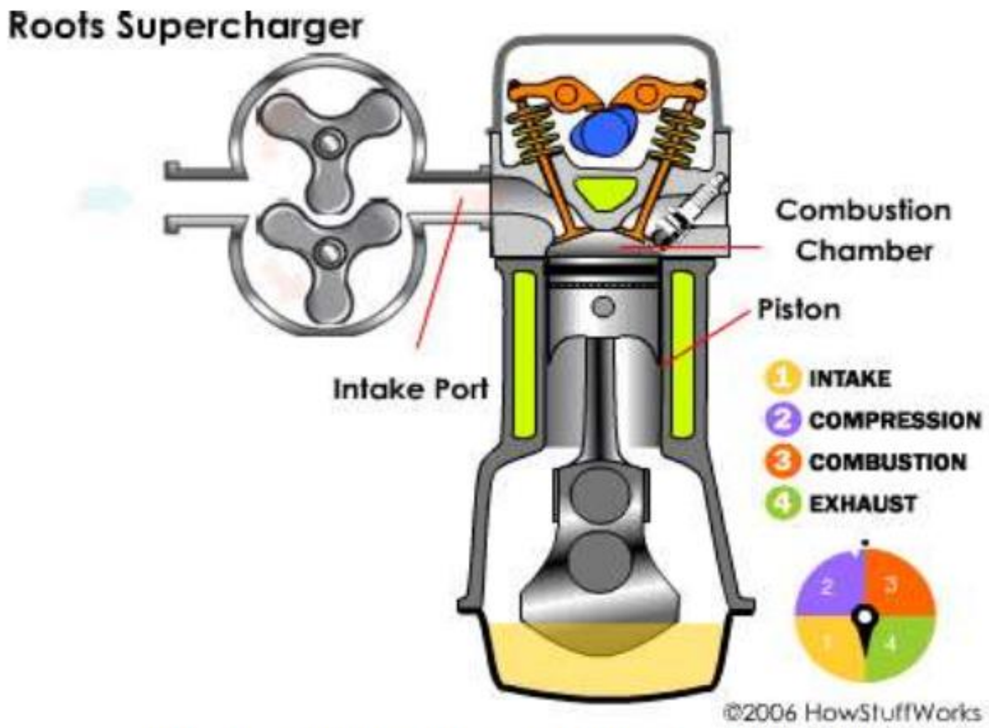
•Roots superchargers are usually large and sit on top of the engine.

•Roots superchargers are the least efficient supercharger for two reasons:-

1.)They add more weight to the vehicle.

2.)They provide air in discrete bursts instead of providing in a smooth and continuous manner.





A standard engine with the addition of a supercharger

Twin-Screw Supercharger

- A twin-screw supercharger operates by pulling air through a pair of meshing lobes that resemble a set of worm gears.

- A twin-screw supercharger compresses the air inside the rotor housing *(That's because the rotors have a conical taper, which means the air pockets decrease in size as air moves from the fill side to the discharge side*).

- As the air pockets shrink, the air is squeezed into a smaller space.

- Thus twin-screw superchargers are more efficient compared to roots supercharger.
- They cost more because the screw-type rotors require more precision in the manufacturing process.
- They also make a lot of noise.
- The compressed air exiting the discharge outlet creates a whine or whistle that must be checked with noise suppression techniques.

Twin-screw supercharger

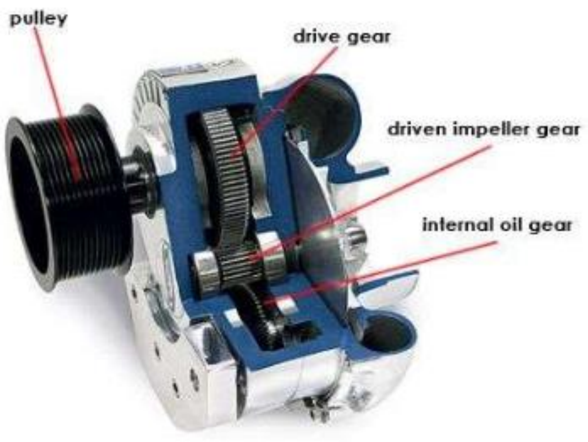
Centrifugal Supercharger

- A centrifugal supercharger works by powering an impeller *(a device similar to a rotor)* at very high speeds to quickly draw air into a small compressor housing.

- Impeller speeds can reach '50,000 to 60,000 RPM'.

- Centrifugal superchargers are the most efficient and the most common induction systems.

- They are small, lightweight and attachable to the front of the Engine.



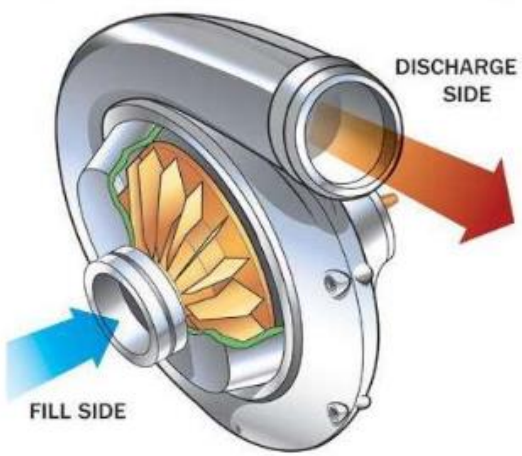
Working:-

•As the air is drawn in the hub of the impeller, centrifugal force causes it to radiate outward.

•The air leaves the impeller at high speed, but low pressure.

•A diffuser converts the high-speed , low-pressure air to low-speed , high-pressure air.

•Thus pressurized air is achieved.



Drives used in supercharger

Mechanical:-

- Belt (V belt, Toothed belt & Flat belt).
- Gear drive.
- Chain drive.

Exhaust gas turbines:-

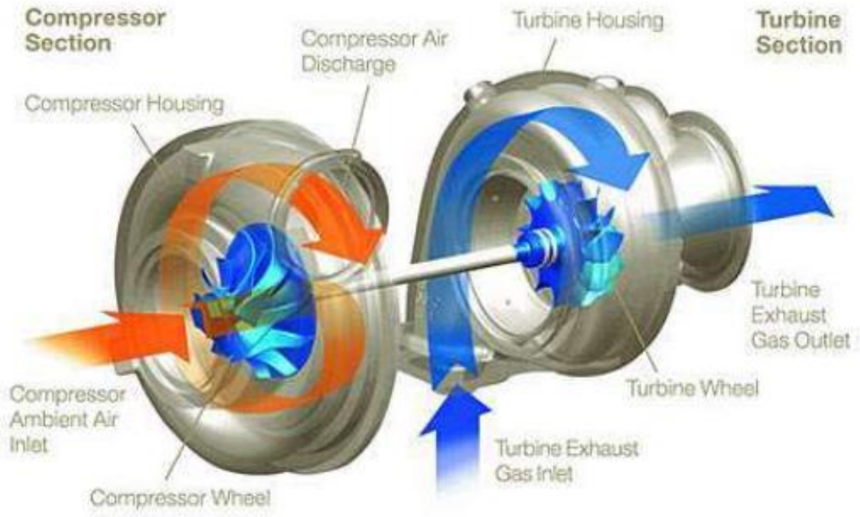
- Axial turbine.
- Radial turbine.

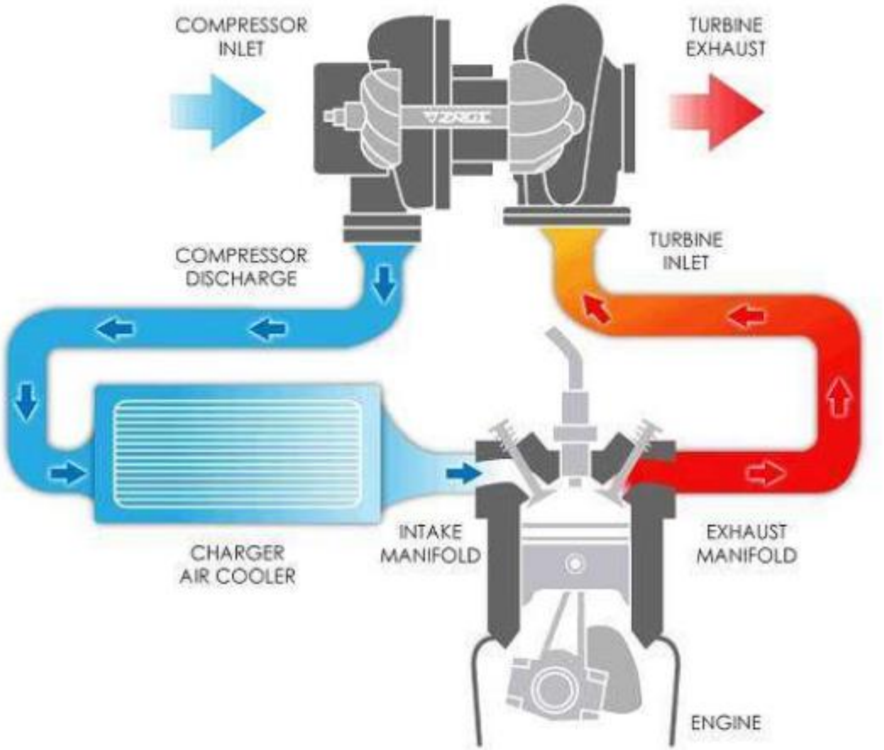
Other:-

- Electric motor.

Turbocharger

- A supercharger driven by a turbine powered by the engine's exhaust gases.

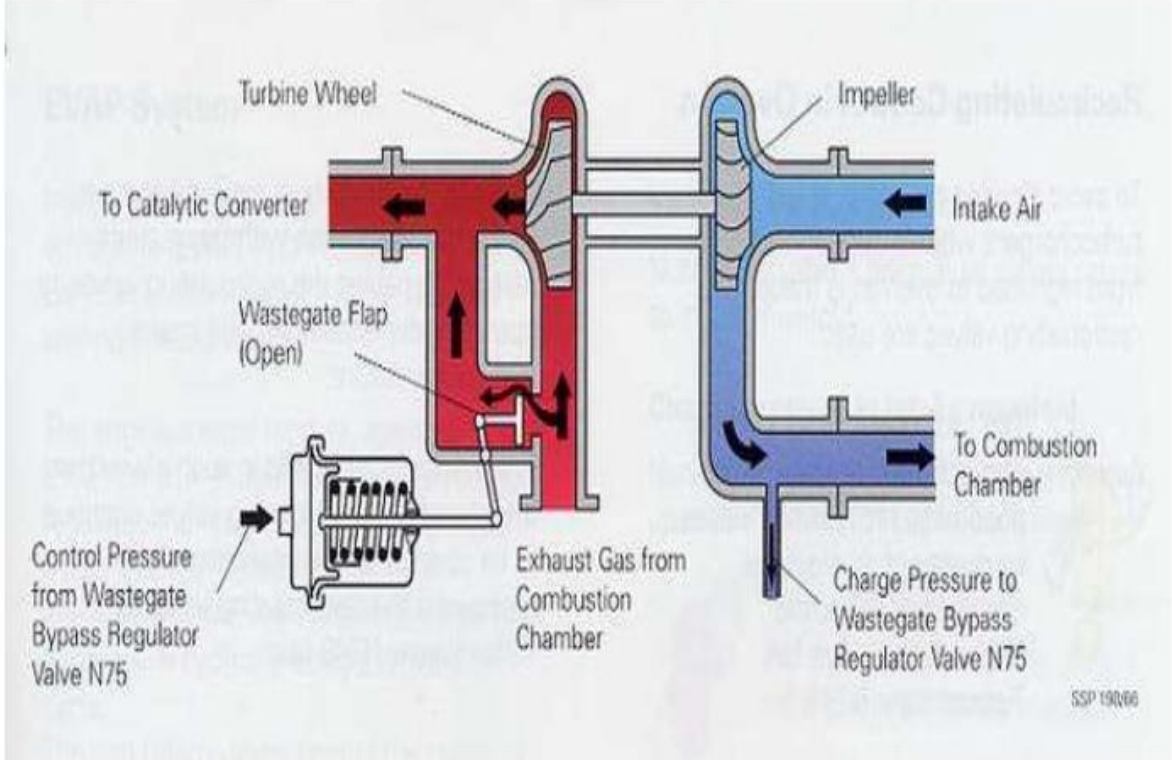



COMPRESSOR INLET
TURBINE EXHAUST
COMPRESSOR DISCHARGE
TURBINE INLET
CHARGER AIR COOLER
INTAKE MANIFOLD
EXHAUST MANIFOLD
ENGINE

Principle of working of a turbocharger:

- Waste gas from the cylinder exits through the exhaust outlet.
- The hot exhaust gases blowing past the turbine fan make it rotate at high speed.
- The spinning turbine is mounted on the same shaft as the compressor. So, as the turbine spins, the compressor spins too.
- Cool air enters the engine's air intake and heads toward the compressor.

- The compressor fan helps to suck air in. The compressor squeezes and heats up the incoming air and blows it out again.
- Hot, compressed air from the compressor passes through the heat exchanger, which cools it down.
- Cooled, compressed air enters the cylinder's air intake.
- The extra oxygen helps to burn fuel in the cylinder at a faster rate.



Turbine Wheel
Impeller
To Catalytic Converter
Intake Air
Wastegate Flap
(Open)
To Combustion
Chamber
Control Pressure
from Wastegate
Bypass Regulator
Valve N75
Exhaust Gas from
Combustion
Chamber
Charge Pressure to
Wastegate Bypass
Regulator Valve N75
SSP 190/66

Methods of turbo charging

1. **Constant pressure turbo charging:**

- Exhaust of all cylinders of all cylinders is connected to a common manifold.
- Exhaust gas expands in exhaust valves without doing work at constant pressure connected to a common manifold.
- Then it enters into the turbine.

2. Pulse turbo charging:

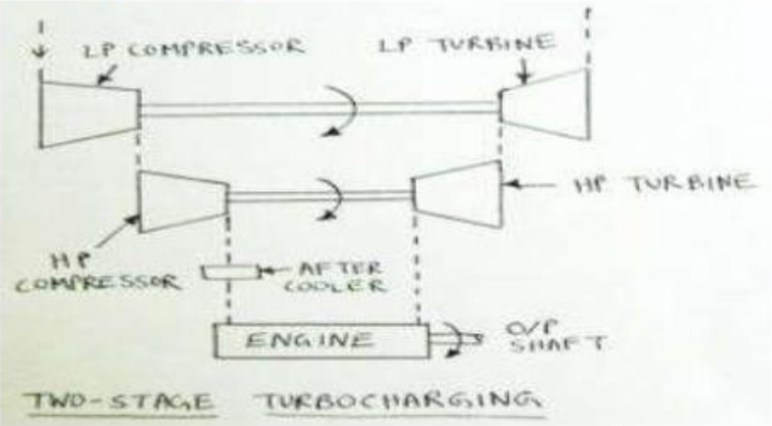
- Separate exhaust pipe for each cylinder.
- Blow-down energy is converted into exhaust pulses immediately when the exhaust valves open.

3. Pulse converter turbo charging:

- Combines pulse and constant pressure turbo charging.
- Achieved by connecting various branches of manifolds together, then connected with a specially designed venturi junction.

4. Two stage turbo charger:

- Two turbo charger in various sizes are connected in series.
- High pressure turbo charger is operated on pulse mode and a low pressure stage on a constant pressure mode.



Advantages:

- High power to weight ratio.
- Good torque and acceleration.
- High brake mean effective pressure can be achieved.

Disadvantages:

- More complex system.

Limitations:

- Need special exhaust manifold.
- Fuel injector modification for more fuel injection.
- Costly and need more engine modification.
- Turbo lag.

Catalytic converter

Catalytic converter are the most effective device to control automobile exhaust emission.

Two types:.,

Two way catalytic converter

Three way catalytic converter

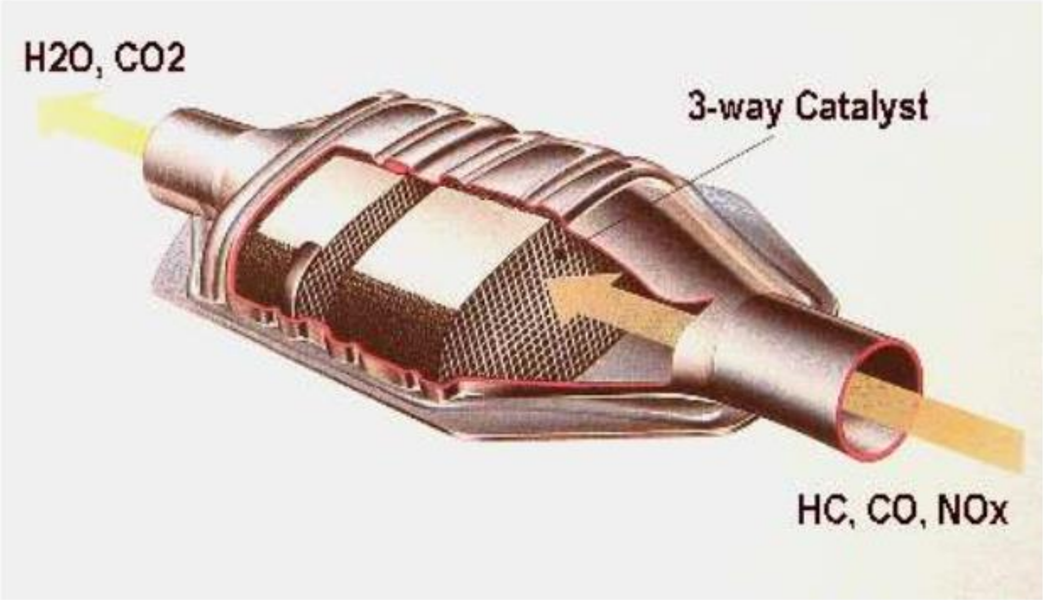
Two way catalytic converter

- Its also called as oxidation catalytic. Used in earlier days.
- Carbon monoxide to carbon dioxide.

$$2CO+0_2 \Rightarrow 2co_2$$

- Oxidation of unburnt hydrocarbons to carbon dioxide and water.
- Unable to control NOx gases

Three way catalytic convertor



- Most of the cars equipped with a 3 way catalytic converter.
- It use two different types of catalysts such as reduction catalyst and a oxidation catalyst.
- Both types consist of a base structure coated with a catalyst such as platinum, rhodium and palladium.
- The maximum surface area of the catalyst to the exhaust flow while minimizing the amount of catalyst required.

i) **Reduction catalyst:**

- It use platinum and rhodium to help in reducing Nox emissions.
- When No and No_2 molecule contacts the catalyst, the catalyst rips the nitrogen atom out of the molecule and holds on to it.

$$2NO \longrightarrow N_2 + O_2$$

$$2NO_2 \longrightarrow N_2 + 2O_2$$

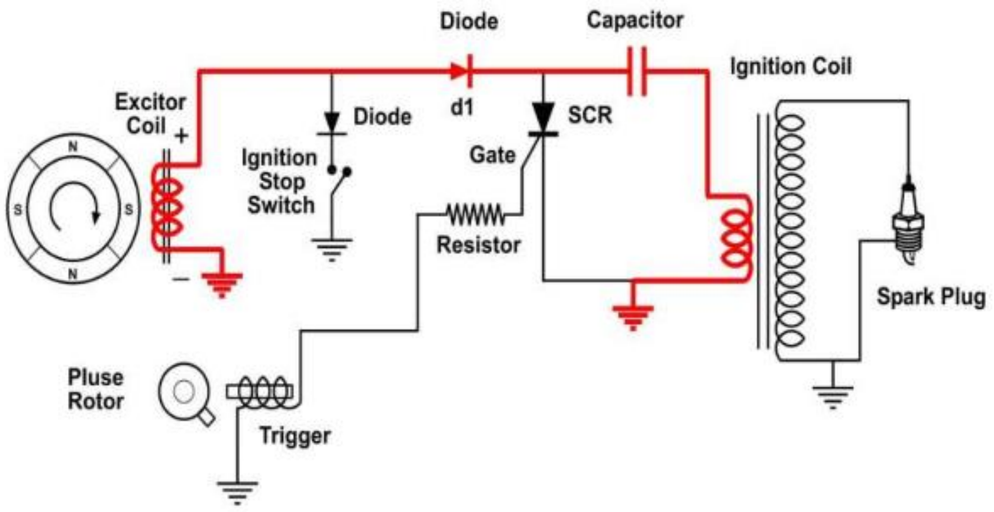
ii) Oxidation catalyst:

- It reduces the unburned hydrocarbons and carbon monoxide by burning them over a platinum and palladium catalyst.

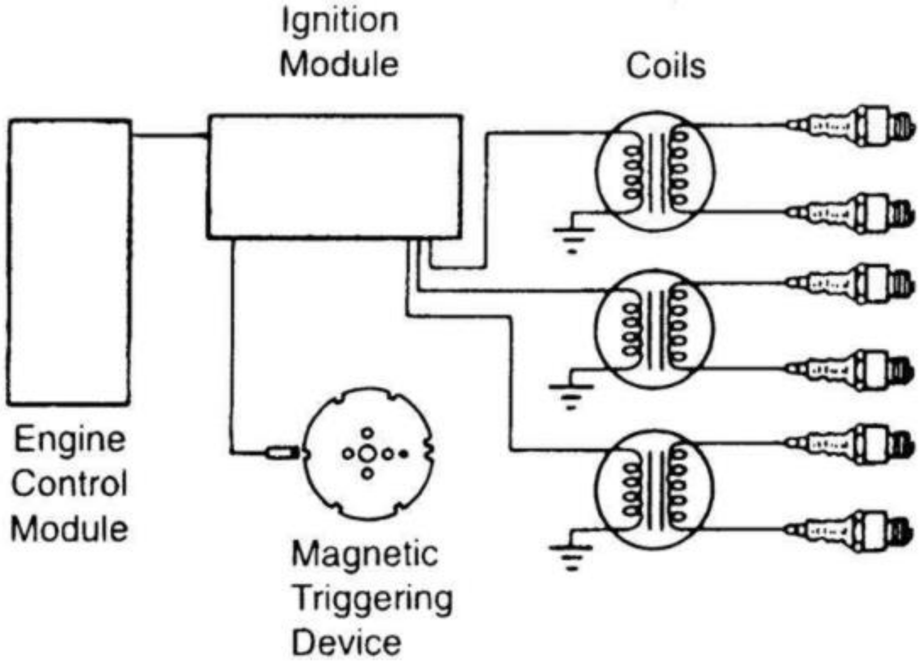
  $$2CO + O_2 \Rightarrow 2CO_2$$

- Lead in petrol make the catalyst inefficient.
- Feed back system is used to achieve the described air fuel ratio at all operating conditions.
- Oxygen sensor used to measure the oxygen level in the exhaust gas.

capacitive discharge ignition system



distributor less ignition system



Emission norms:.,

Euro norms

Emission limits for new vehicles with petrol engine						
	valid from	CO (g/km)	HC (g/km)	NOx (g/km)	HC+NOx (g/km)	PM
Euro I	12/92	2,72	-	-	0,97	-
Euro II	01/97	2,20	-	-	0,5	-
Euro III	01/00	2,30	0,20	0,15	-	-
Euro IV	01/05	1,00	0,10	0,08	-	-
Euro V	09/09	1,00	0,10	0,06	-	0,005*
Euro VI	08/14	1,00	0,10	0,06	-	0,005*

* with direct injection

Table 9.5: EU Emission Standards for Diesel Passenger Cars (Category M_1*), g/km

Tier	Date	CO	HC	HC+NOx	NOx	PM
Euro 1†	July 1992	2.72 (3.16)	-	0.97 (1.13)	-	0.14 (0.18)
Euro 2, IDI*	Jan. 1996	1.0	-	0.7	-	0.08
Euro 2, DI*	Jan. 1996†	1.0	-	0.9	-	0.10
Euro 3	Jan. 2000	0.64	-	0.56	0.50	0.05
Euro 4	Jan. 2005	0.50	-	0.30	0.25	0.025
Euro 5 (proposed)	mid-2008	0.50	-	0.25	0.20	0.005

Source: Cygnus Research, EEA documents and press releases

† until 30 Sept. 1999 (after that date DI engines must meet the IDI limits)

*Direct Injection Engine (DI), Indirect Injection Engine (IDI)

BS norms:

Evolution of Bus Emission Norms in India

- The Emission standards for Bus engines(g/kWh) are as under:

Year	Reference	CO	HC	NOx	PM
1992	-	17.3-32.6	2.7-3.7	-	-
1996	-	11.20	2.40	14.4	-
2000	Euro I	4.5	1.1	8.0	0.36
2005	Euro II	4.0	1.1	7.0	0.15
2010	Euro III	2.1	0.66	5.0	0.10

EMBARQ India

AUTOMOBILE ENGINEERING UNIT 3

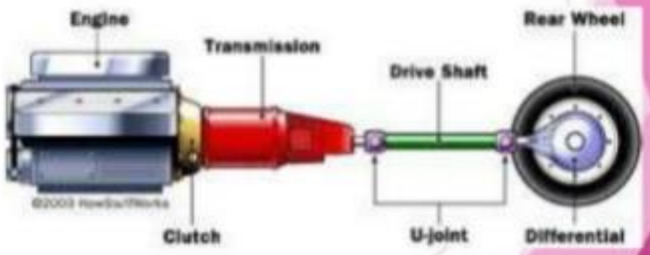
BY

V VIGNESHWARAN, M.TECH, AP

Definition Of Transmission System :-

The mechanism that transmits the power developed by the engine of automobile to the engine to the driving wheels is called the TRANSMISSION SYSTEM (or POWER TRAIN).It is composed of -

- *Clutch*
- *The gear box*
- *Propeller shaft*
- *Universal joints*
- *Rear axle*
- *Wheel*
- *Tyres*



<u>*Requirements Of Transmission System*</u> *:-*

- *Provide means of connection and disconnection of engine with rest of power train without shock and smoothly.*
- *Provide a varied leverage between the engine and the drive wheels*
- *Provide means to transfer power in opposite direction.*
- *Enable power transmission at varied angles and varied lengths.*
- *Enable speed reduction between engine and the drive wheels in the ratio of 5:1.*
- *Enable diversion of power flow at right angles.*
- *Provide means to drive the driving wheels at different speeds when required.*
- *Bear the effect of torque reaction , driving thrust and braking effort effectively.*

CLUTCH

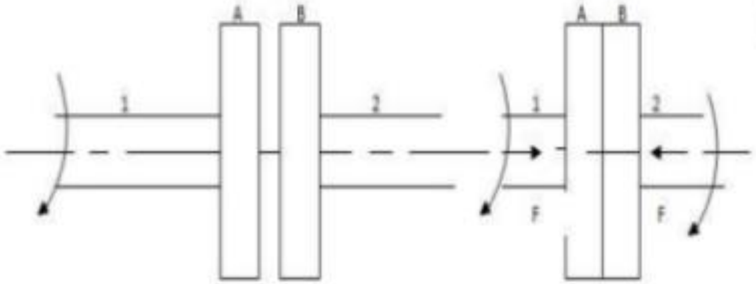
- A **clutch** is a mechanical device that engages and disengages the power transmission, especially riven shaft.

- When clutch engaged, the engine will be connected to the transmission and power flows from engine to rear.

- When clutch is disengaged by pedal the engine will be disengaged from the transmission. Power does not flow to rear wheels while the engine is still running.

Principles of operation of friction clutch:

Clutch working on the principle of friction. Shaft 1 engaged with flange A is rotate

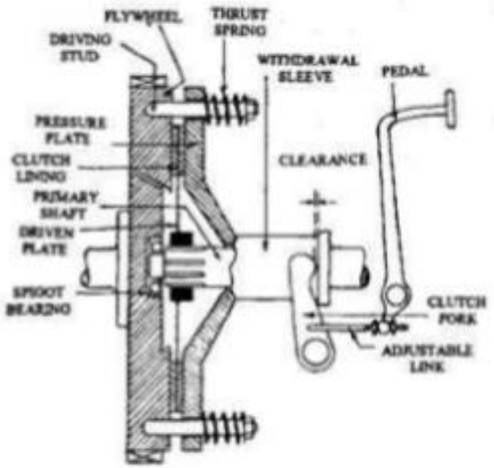


nge B is keye

Requirements of clutch:

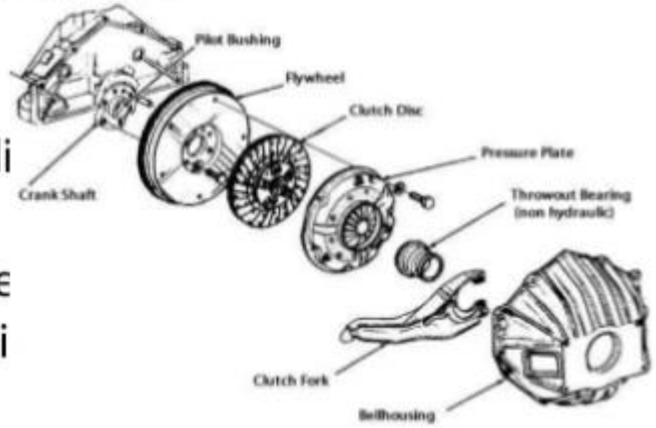
a) Transmission of torque.
b) Gradual engagement.
c) Dissipation of heat.
d) Dynamic balancing.
e) Size of the clutch.
f) Vibration damping.

Single plate clutch



Single plate clutch consists of a

- Flywheel
- Pilot bearing
- Clutch plate or di
- Pressure plate
- Clutch cover asse
- Release mechani
- Clutch shaft



I) Flywheel:

Is the mounting surface for the clutch. Pressure plates bolts to the flywheel face.

Clutch disc is clamped and held against the flywheel by the spring action of the pressure plate.

Face of the flywheel is [illegible] for better heat dissipates.

II) Pilot bearing:

Is pressed into the end of the crankshaft to support the end of the transmission input shaft.

Pilot bearing is a solid bronze bushing, but is also may be a roller or ball bearing.

End of the transmission input shaft has a small journal, this journal slides inside the pilot bearing.

It prevents the transmission shaft and clutch disc from up and down movement.

III) Clutch plate:

Important driving member of a single plate clutch. B/w flywheel and pressure plate.

It consists of a central hub machined with internal splines.

Cushion drive clutch plate provide a damping action against the torsional vibrations and the variation of the driving torque between engine and transmission.

Damping action achieved by coupling the splined center hub to the driven plate with the help of flexible mounting.

Torsion spring – cushion the clutch engagement.

IV) Pressure plate.

Made of special cast iron, heaviest part of the clutch assembly.

Main function- establish even contact with the driven plate facing through which the pressure springs can exert a sufficient force to transmit the full torque of the engine.

Pressure plate presses the clutch plate on to the flywheel from its machined surface.

V) Clutch cover assembly:

Is bolted to the flywheel. it consist of pressure plate, release lever mechanism, clutch cover, and pressure springs.

Clutch plate revolves with the flywheel, when the clutch is disengaged, the flywheel as well as the pressure plates will be forced to rotate independently.

Release mechanism used to release the clutch.

- Release mechanism.
- Clutch shaft.
- Working.
- Advantages:

  Easy to change gears than a cone type.

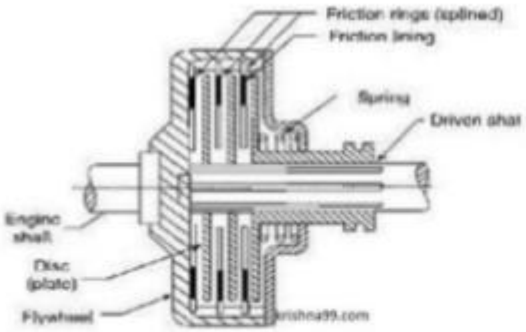
  It is reliable than a cone clutch.
- Disadvantages:

  More force to release.

  Space required is more

Multi-Plate clutch

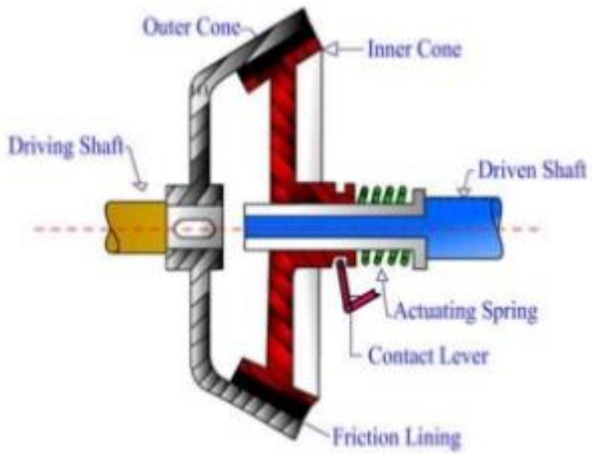
- Mostly used in heavy and racing cars for transmitting high torque.
- No of clutch plates is on increased, the friction surface will be also increased.
- Increase in friction surface, increases the capacity of clutch to transmit more torque.
- Wet or dry type; when clutch operated in oil bath is called as wet. Mostly wet clutches used in automatic transmission system.
- Construction is similar to single plate clutch type.
- One set of plates are slides in grooves on the flywheel and other one set of plates are slides on splines on the pressure plate hub.
- Working same as single plate clutch.


Friction rings (splined)
Friction lining
Spring
Driven shat
Engine shaft
Disc (plate)
Flywheel
rishna99.com


Clutch pedal released

Cone clutch

- Contact surface are in the form of cone.
- Its contain outer and inner cone leather facings.
- Outer cone is fixed with driving shaft and inner cone is splined on the driven shaft.
- When clutch engaged inner cone is fully inside the outer cone, it will make the friction surfaces are in perfect contact. It is done by the pressure springs.
- Now the torque transmitted.
- Clutch pedal pressed, inner cone slides against the spring force and the clutch is disengaged.



Advantages:

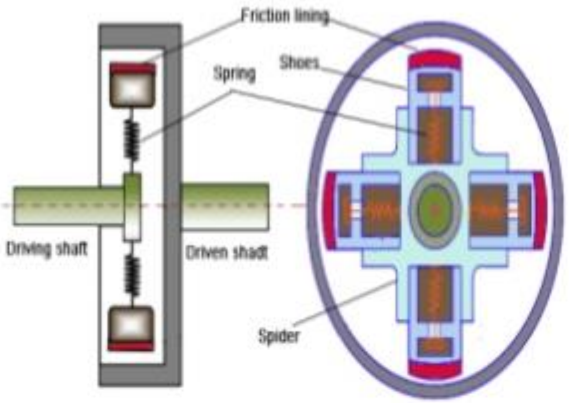
1. Normal force acting on the contact surface is larger than the axial force, which reduces the effort required to operate the clutch.

Disadvantages:

1. Need heavy force to disengage the clutch.
2. Possibility for more wear

Centrifugal Clutch

- This clutch controlled by the engine speed.
- When the engine speed falls down, the clutch will automatically disengage.
- When speed rises above the predetermined value the clutch is engaged. If the speed increases, centrifugal force will increase.
- have two members; driving and driven
- Driven member is just a drum which enclose the driving member.
- The driving member consists of a spider, shoes having friction lining at outer end and springs.
- Shoes are attached to the spider by means of springs.



Centrifugal Clutch

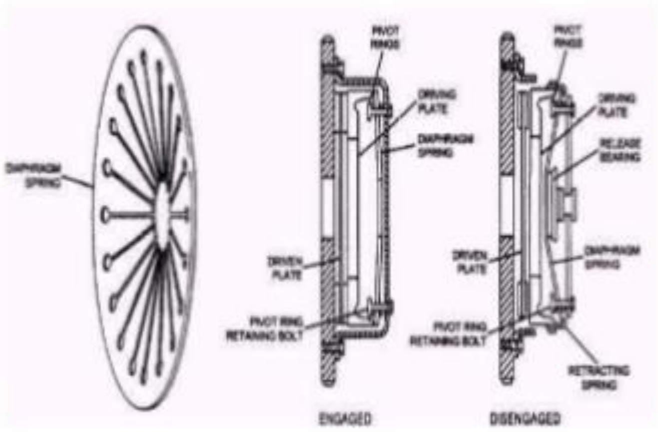
- The driving member rotates with the engine shaft.
- As engine speed increases the shoes inside the driving member drum will fly outward due to centrifugal force and come into contact with the inner surface of the driven member.
- The increase in centrifugal force due to higher engine speed binds the driving member with the driven member.

Diaphragm clutch

- Similar to a single plate clutch except the diaphragm springs.
- No release lever required and the spring itself acts as a series of levers.
- Pressure of the spring increases till the spring reaches to its flat position.
- No need for heavy pedal pressure to hold the clutch out.

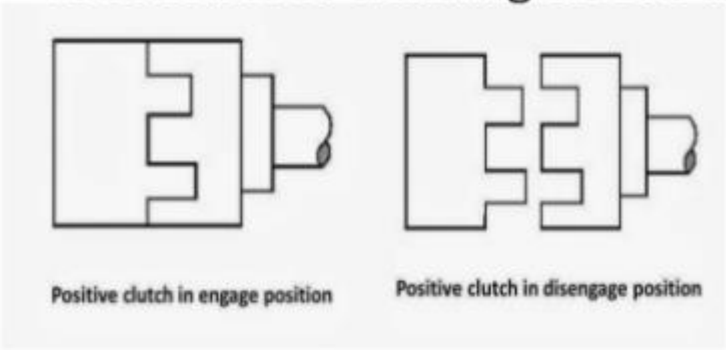
Advantages:

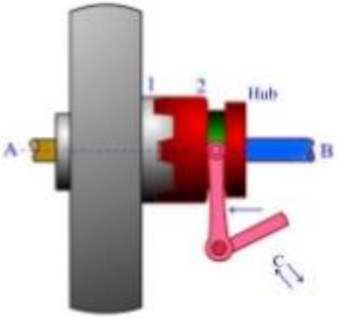
- Require lower operating effort.
- Constant and uniform plate on the driven plate.
- It provide accurate balancing at all times.
- Compact design, clutch housing required is quite short


DIAPHRAGM SPRING
PIVOT RINGS
DRIVING PLATE
DIAPHRAGM SPRING
DRIVEN PLATE
PIVOT RING RETAINING BOLT
ENGAGED
PIVOT RINGS
DRIVING PLATE
RELEASE BEARING
DIAPHRAGM SPRING
DRIVEN PLATE
PIVOT RING RETAINING BOLT
RETRACTING SPRING
DISENGAGED

Positive clutch

- It is generally used to lock two shafts together.
- It consists of a sliding sleeve fitted with the

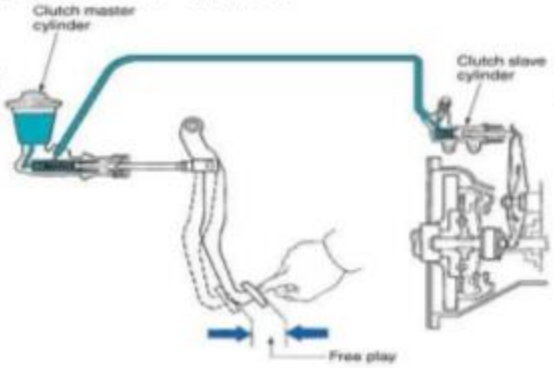




Hydraulic Clutch

Operated under the following situations.

1. When the difficulty to run rods and or able from the foot pedal to clutch
2. The fore requir ... e the clutch beco



- Consists of a master cylinder, slave cylinder and an oil reservoir.
- Clutch pedal is pressed – the fluid under pressure from the master cylinder reaches the slave cylinder.
- Slave cylinder mounted on the clutch itself.
- The fluid actuates the slave cylinder push rod which further operates the clutch release fork.

Electromagnetic clutch

- In this type of clutch, the flywheel consists of winding.The current supplied in the winding from the battery or dynamo. When the current passes through the winding, it produces an electromagnetic field which attracts the pressure plate, thereby engaging the clutch. When the supply is cut-off, the clutch is disengaged.

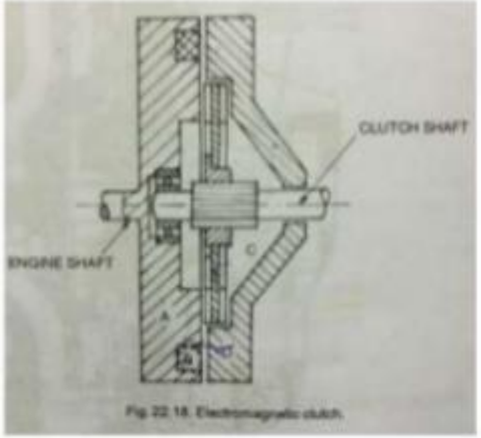
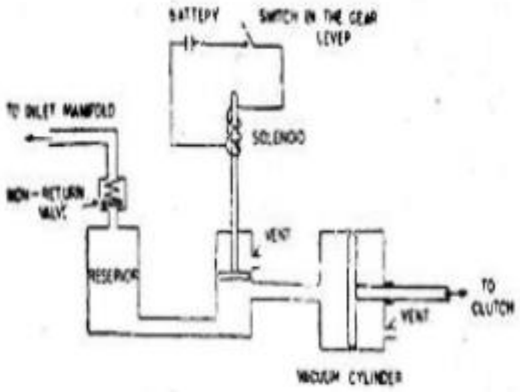
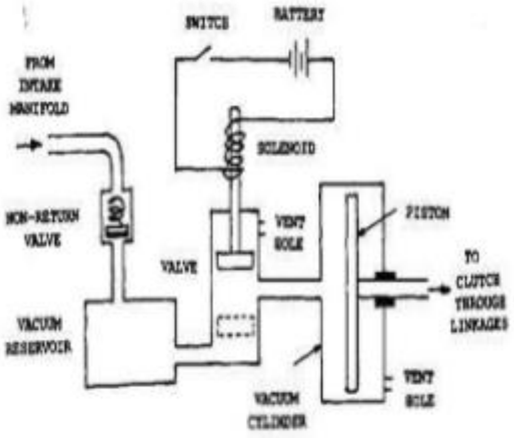


Fig 22.18. Electromagnetic clutch.

Vacuum clutch





Vacuum clutch

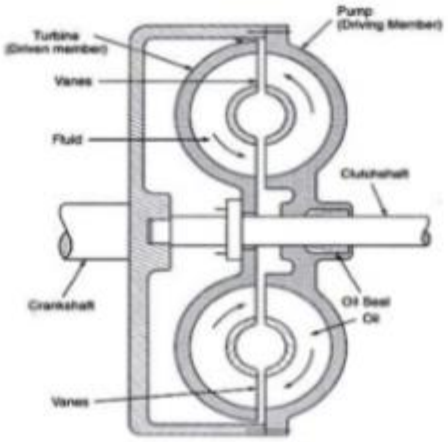
- The vacuum clutch is operated by the vacuum existing in the engine manifold.
- It consists of a vacuum cylinder with piston, solenoid operated valve, reservoir and a non-return valve.
- The reservoir is connected to the engine manifold through a non return valve. Vacuum cylinder is connected to the reservoir through solenoid operated valve.
- The solenoid is operated from the battery and the circuit incorporates a switch which is placed in the gear lever. The switch is operated when the driver holds the lever to change gears.
- When the throttle is wide opened, the pressure in the inlet manifold increases due to which the non-return valve closes, isolating the reservoir from the manifold. Thus a vacuum exists in the reservoir all the time.

- In the normal operation, the switch in the gear lever remains off, the solenoid operated valve remains in its bottom position.
- In this positions the atmospheric pressure acts on both the side of the vacuum cylinder, because the vacuum cylinder is open, so also atmosphere though a vent.
- When the driver holds the lever to change the gear, the switch is closed; energizing the solenoid which pulls the valve up. This connects one side of vacuum cylinder to the reservoir.
- Due to the difference of pressure on the vacuum cylinder piston, it moves. This movement of the piston is transmitted by a linkage to the clutch, causing it to disengage.
- When the driver is not operating the gear lever, the switch is open and the clutch remains engaged due to the force of springs.

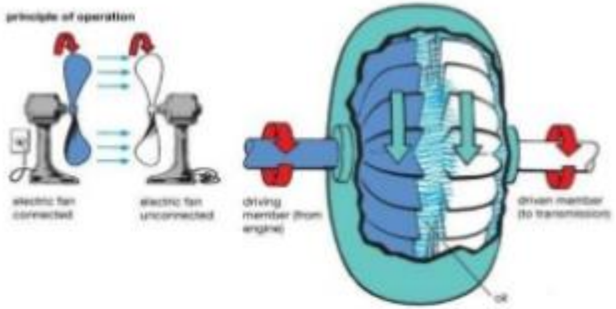
Fluid Flywheel

- Known as fluid coupling which couples the driving member with driven member through fluid.
- Driving member connected with flywheel and driven member connected with transmission shaft.
- Driven member is free to slide on the transmission shaft. Two rotors are filled with fluid of required viscosity.

- When engine started, driving member 'impeller' starts to move inside the housing containing oil.
- Pockets of moving driving member are completely filled with oil. Due to this, the centrifugal force forces the oil outward radially.
- Splashed oil will strike the pockets of the driven member. Hence it is forced to move in the same direction.
- When engine speed increases, the oil coming from the pocket of the driving member strikes the pockets of the driven member with greater force.



Fluid flywheel



FLUID COUPLING

Advantages:

- It gives smoother power take up.
- Fluid in the coupling behaves as a cushioning agent between engine and gearbox to absorb shocks during breaking.
- No wear on moving parts.
- No maintenance, except oil level
- Simple in design.
- No skill is required for operating.

Torque converter gearbox

- Construction is same as fluid coupling, additional stationary member called 'stator' is attached.
- Torque converter increases the torque in the ratio of 2:1 to 3:1.

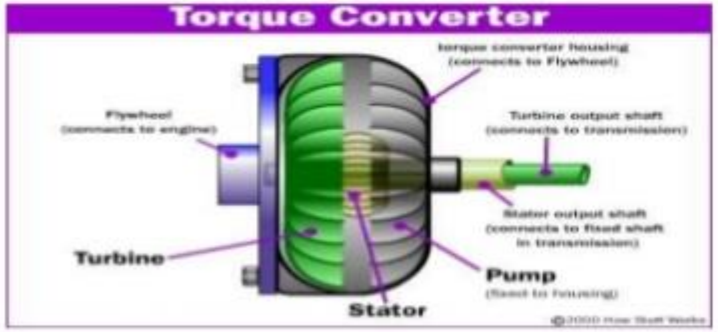
Main parts are

1. Impeller or driven member
2. Turbine or driving
3. Stator

- Due to the rotation of driving member oil is pushed in the outward direction by centrifugal force.
- Turbine started to rotate when the engine starts.
- First, the oil from turbine is pushed into the impeller due to high centrifugal force at the turbine.
- At that time the impeller is held stationary.
- By this, the oil gets high kinetic energy from the engine through the turbine.
- Flow of high energy oil creates enough force that tends to rotate the impeller.

- Impeller blade angle changes the direction of the oil flow to come out of the impeller at centre.
- Now the direction of oil is entirely backward.
- If it will enter the turbine directly it will push the turbine in opposite direction.
- Oil from the impeller is made to strike a stationary member to avoid this dragging action on the turbine.
- Stator changes the oil direction suitably to leave the oil from the stator striking the turbine in the same direction of turbine turning.
- Oil is thrown back by the turbine into the impeller edges.
- This continuous process makes the torque on the impeller to increase which is called torque multiplication.

- The maximum torque multiplication is possible when the impeller is stationary and turbine is running fast with the engine speed.
- When the vehicle starts to move, the impeller speed will start to increase. But the torque multiplication will gradually reduce due to decrease of the difference in both impeller and turbine speed.
- When the turbine speed becomes equal to the impeller speed, the torque multiplication will become unity. (Direct gear)

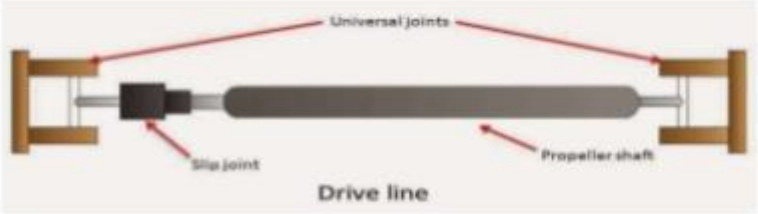


Propeller shaft

- Propeller shaft is connected between transmission shaft and input shaft of the differential.
- Called as driveline shaft or drive shaft.
- Length and short shaft.
- Transmission output shaft and the input shaft to the rear axle housing are in different planes.

PROPELLER SYSTEM

- Whenever the rear wheels absorb irregulations in the road, the rear axle housing will move up and down by compressing and expanding the suspension system.
- Then the angle b/w transmission output shaft and propeller shaft is changed.
- Length occupied by the propeller shaft will change.
- Defined as the distance between transmission shaft and pinion shaft of the differential.



Functions of the propeller shaft:

- It transmits rotary motion of the gearbox output shaft to the differential.
- It transmits motion at an angle which frequently varies.
- It allows some changes in length between gearbox and rear axle.

Propeller shaft construction:

a. Variation of angle and length are considered.

b. Propeller shaft is made of two shafts and two types of flexible joints such as slip joint and two universal joints.

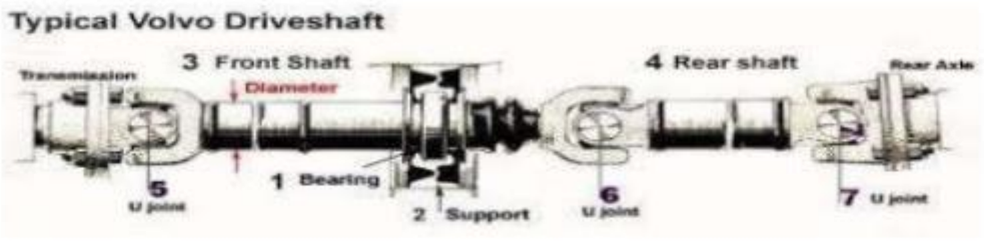
c. Shafts are thin walled steel tubes. Dia--50mm to 70mm. Thickness varies from 1.5mm to 7.5mm. Tubular section…

d. Universal joints are fitted at the end of the shaft.

e. If any variation in the inclination of the propeller shaft, the universal joint will take care.

f. If the distance between transmission shaft and pinion shaft is more, one or more intermediate propeller shafts are used.

g. Intermediate shaft is always supported by bearing unit. The bearing unit is consists of runner pad and ball bearing



Types:

1. **Open type:**

- Used in heavy commercial vehicle, has tubular cross section but it is not enclosed.
- Two universal joints are connected with each end. One with gearbox main shaft another one with pinion of differential.
- Longer, so it is made up of two portions.
- Propeller shaft connected to the frame member with the help of bearings.

2. Enclosed type:

- This type propeller shaft is of a solid cross-section.
- This propeller shaft is supported by roller bearings inside torque tubes.
- Diameter is small when compare to open type.
- The torque and twisting motion of rear axle casing are resisted by this shaft when the brake is applied.

Slip joints

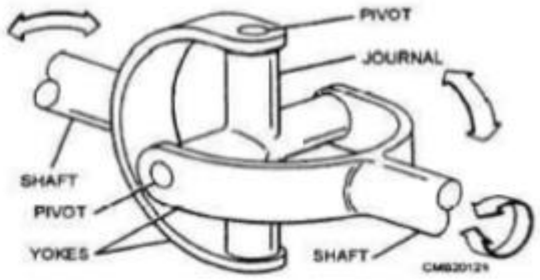
- Propeller shaft is inclined towards down from the transmission shaft.
- Propeller shaft will also be shortened and lengthened again when the axle rises as the rear springs are compressed and at the time the axle returns to its original position.
- Slip joint is always used between propeller shaft and universal joints.

- Slip joints compensate the change in length and it helps to transmit power from engine to rear axle at the same time.
- In torque tube drive, no need for a slip joints.
- The joint consists of a male splined end of the main shaft to slide in corresponding grooves with the female member of the joint.
- The female part is integral with the universal joint hub.

Universal joints

- Transmission of power under varying condition is impossible without using a flexible device.
- Universal joints are mainly used to make a flexible connection between two rigid shafts at an angle.
- It used to connect propeller shaft with the gear box shaft to transmit rotary motion.

Universal joint consists of two yokes. These two yokes are connected to each end of the shaft.



Types of universal joints

Variable velocity joints:

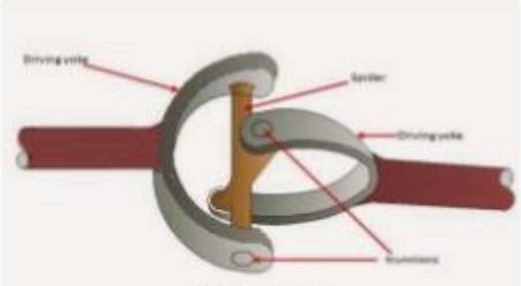
- Both the driven and driving shafts do not turn at the same speed.
- The driven and driving shafts should be placed in a straight line to turn at the same speed through each part of a revolution.
- Practically is not possible in any automobile. The drive shaft is always inclined.
- If there is an angle b/w driven and driving shaft, the driven shaft will turn lower than driving shaft through half a revolution and it is faster than driving shaft through the other half revolution.
- Speed variation in the driven shaft increase in flex angle of the universal joint.

Types of variable joints are,:

i) Cross or spider type:

Two yokes in which one is connected to the driving shaft and the other one is connected to the driven shaft at right angle to each other by a cross or spider.

Needle type bearings are mounted b/w yokes and cross ends.

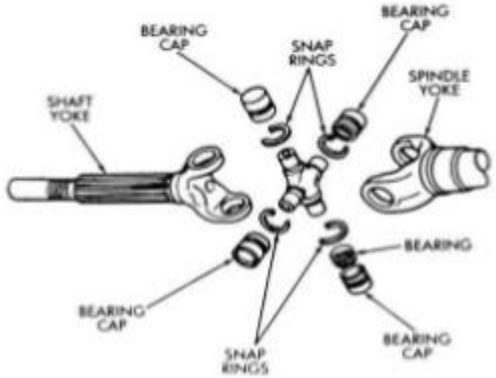


Universal joint

ii) Ring type:

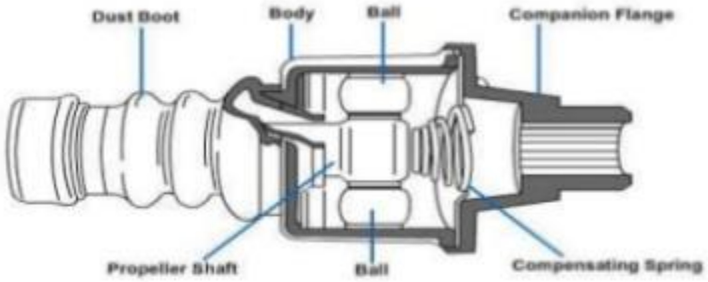
This type of joint uses a flexible ring, is made of one or more rings of rubber to provide enough strength.

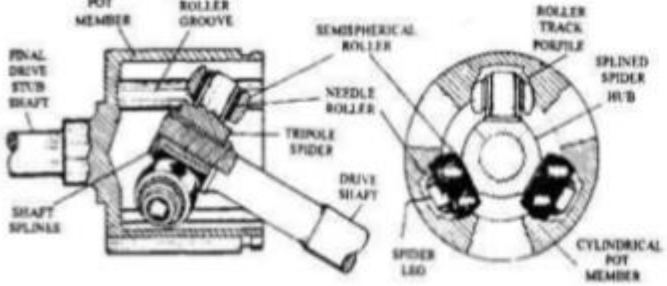
It smoothens the torque fluctuations and it needs no lubrication.



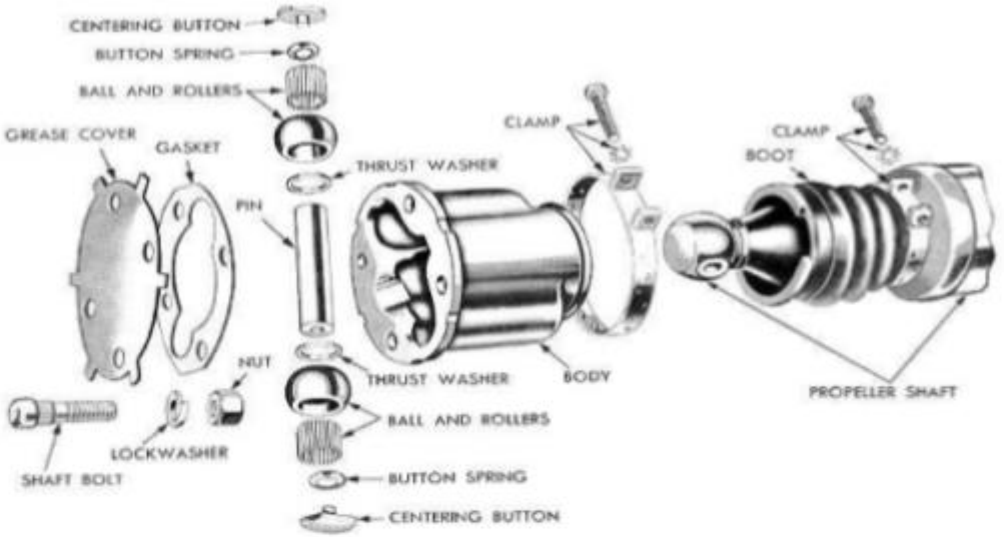
iii) Ball and trunion type:

- A combination of both universal and slip joint.
- A pin is connected in the end of universal joint shaft.
- Each end of the pin has a ball mounted on needle bearings.
- Heavy spring resists excessive longitudinal movement of shaft.
- Power transmitted through the trunion, balls and cross shaft.
- Bending moment occurs in one direction by rolling action of balls and other direction by moving balls lengthwise in grooves.
- Open end of the shaft is covered by leather or rubber boot cover.





Needle Bearing

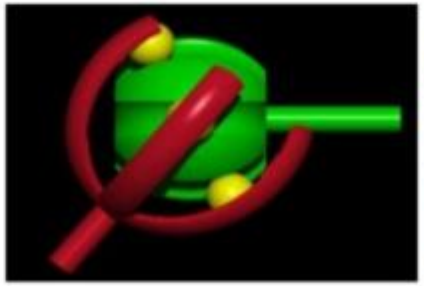

CENTERING BUTTON
BUTTON SPRING
BALL AND ROLLERS
GREASE COVER
GASKET
THRUST WASHER
PIN
CLAMP
CLAMP
BOOT
NUT
THRUST WASHER
BODY
PROPELLER SHAFT
BALL AND ROLLERS
LOCKWASHER
SHAFT BOLT
BUTTON SPRING
CENTERING BUTTON

Constant velocity joints:

- The driven shaft is turned at the same speed as the driving shaft turns through each part of revolution at any degree of flex.
- Mainly used in front drive axle for transmitting power through a large angle required.

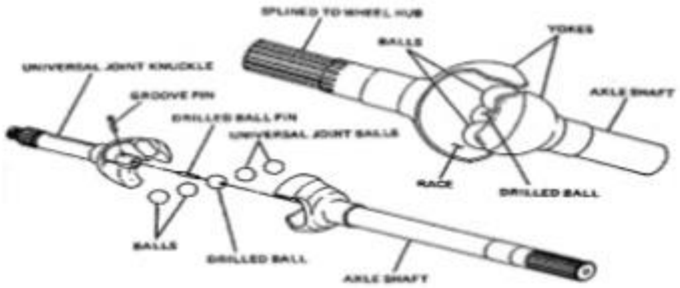
Types,:

i) **Rzeppa:**



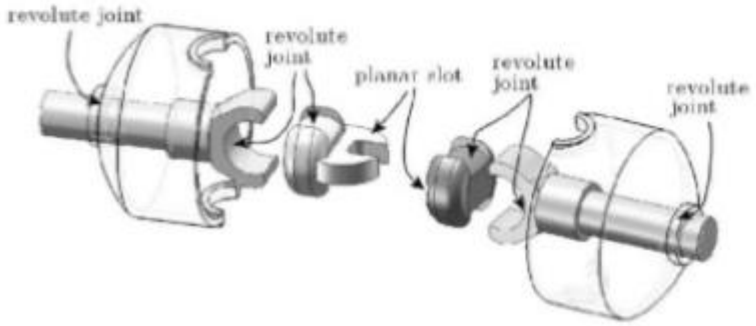
- It consists of spherical inner and outer ball races having grooves cut parallel to shafts.
- Steel balls are placed in grooves on the spherical races.
- The torque transmission is done from one race to another ball.
- The circular pattern of balls causes both shafts to turn at the same velocity.

ii) Bendix weiss:



- The principle of driving through balls held in a circle around a sphere is used here.
- Four number of driving balls are used.
- A fifth ball is placed b/w two yokes as an inner race.
- Driving balls are arranged in the same manner to rzeppa joint.

iii) Tracta:



The Tracta joint works on the principle of the double tongue and groove joint.

It consist only four individual parts: the two forks (yokes, one driving and one driven) and the two semi-spherical sliding pieces which interlock in a floating (movable) connection.

Both circular segment and floating action of two yokes provide a constant velocity joint.

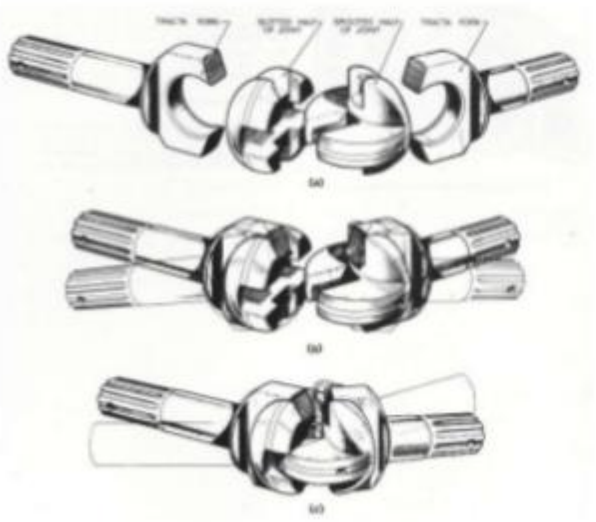
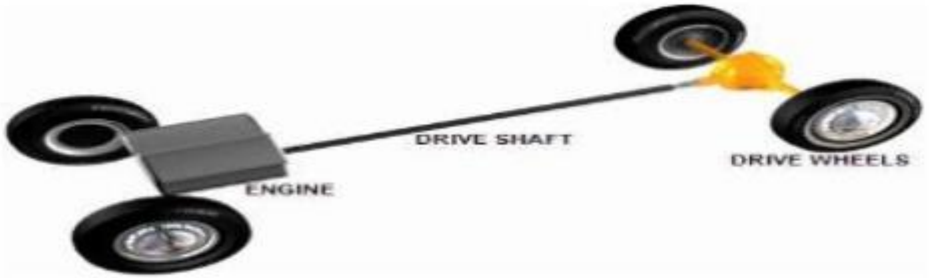


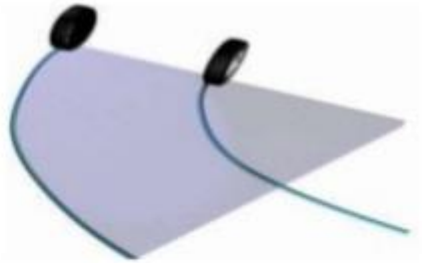
Diagram (a) shows the joint separated, (b) how each articulating half fits into its Tracta fork, (c) the assembled joint showing the range of movement.

Why the Differential gear is used?

Wheels receive power from the engine via a drive shaft. The wheels that receive power and make the vehicle move forward are called the drive wheels. The main function of the differential gear is to allow the drive wheels to turn at different rpms while both receiving power from the engine.



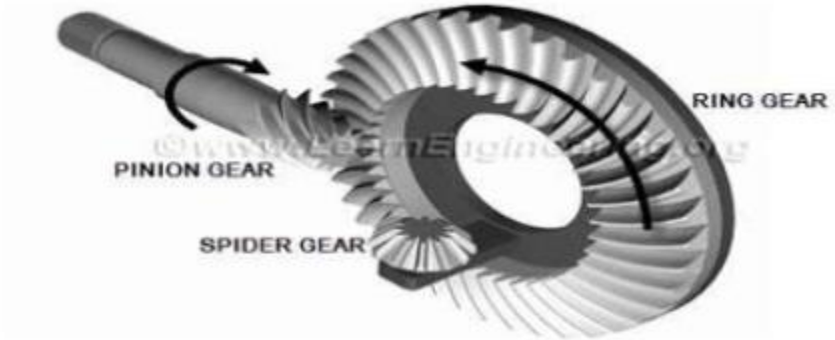
Consider these wheels, It is clear that the left wheel has to travel a greater distance compared to the right wheel.

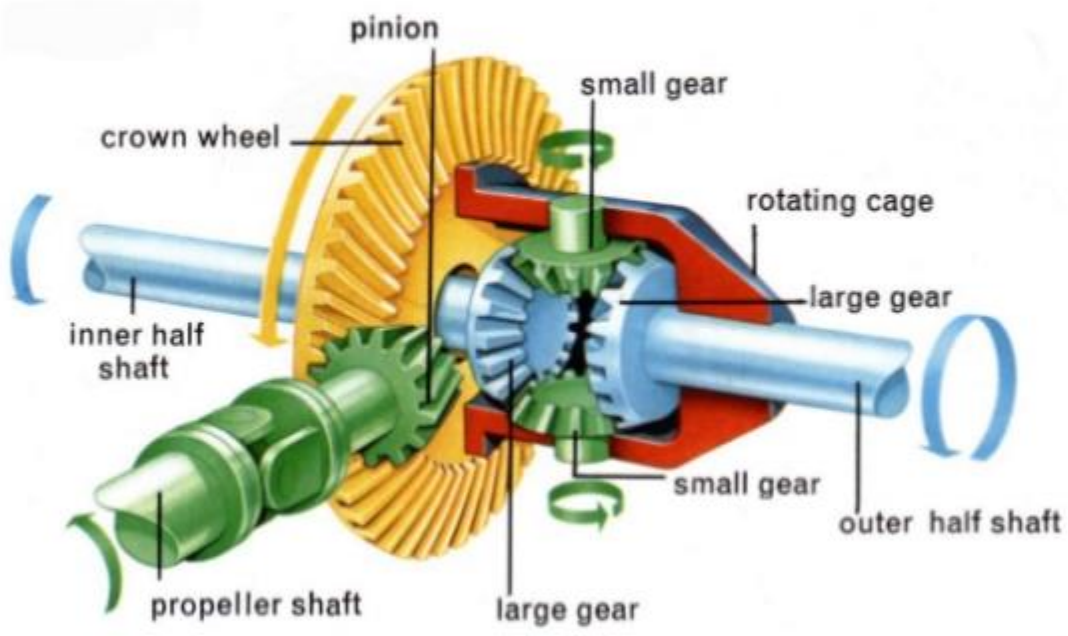


This means that the left wheel has to rotate at a higher speed compared to the right wheel. If these wheels were connected using a solid shaft, the wheels would have to slip to achieve the turn. This is exactly where a differential comes in handy. The ingenious mechanism in a differential allows the left and right wheels to turn at different rpms, while transferring power to both wheels.

Parts of a Differential

Power from the engine is transferred to the ring gear through a pinion gear. The ring gear is connected to a spider gear.




pinion
small gear
crown wheel
rotating cage
large gear
inner half
shaft
small gear
outer half shaft
propeller shaft
large gear

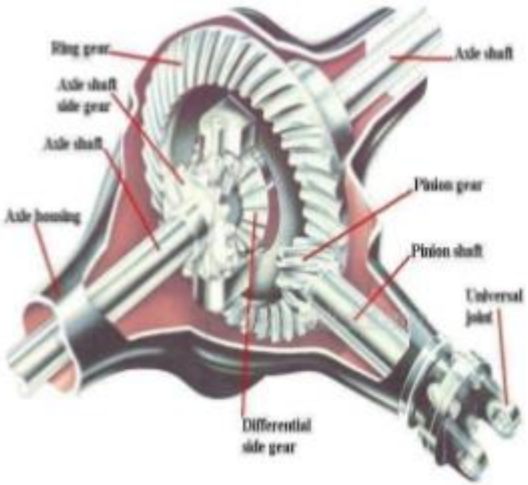
The spider gear lies at the heart of the differential, and special mention should be made about its rotation. The spider gear is free to make 2 kinds of rotations: one along with the ring gear (*rotation*) and the second on its own axis (*spin*).

•The spider gear is meshed with 2 side gears. both the spider and side gears are bevel gears.

•From the drive shaft power is transferred to the pinion gear first, and since the pinion and ring gear are meshed, power flows to the ring gear.

•As the spider gear is connected with the ring gear, power flows to it.

•Finally from the spider gear, power gets transferred to both the side gears.



Differential Operation

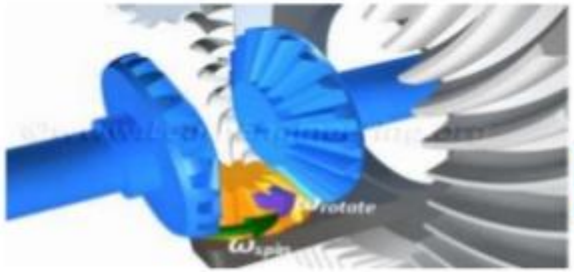
The vehicle moves straight

In this case, the spider gear rotates along with the ring gear but does not rotate on its own axis. So the spider gear will push and make both the side gears turn, and both will turn at the same speed. In short, when the vehicle moves straight, the spider-side gear assembly will move as a single solid unit.

Fig.6 While the vehicle moves straight, the spider gear does not spin; it pushes and rotate the side gears

The vehicle takes a right turn

Now consider the case when the vehicle is taking a right turn. The spider gear plays a pivotal role in this case. Along with the rotation of the ring gear it rotates on its own axis. So, the spider gear is has a combined rotation.



•When properly meshed, the side gear has to have the same peripheral velocity as the spider gear.
•Both gears should have the same pitch line velocity.
•When the spider gear is spinning as well as rotating, peripheral velocity on the left side of spider gear is the sum of the spinning and rotational velocities.
•But on the right side, it is the difference of the two, since the spin velocity is in the opposite direction on this side.
•This means the left side gear will have higher speed compared to the right side gear.
•This is the way the differential manages to turn left and right wheels at different speeds.

The vehicle takes a left turn

While taking a left turn, the right wheel should rotate at a higher speed. By comparing with the previous case, it is clear that, if the spider gear spins in the opposite direction, the right side gear will have a higher speed.

Drawback of a Standard Differential

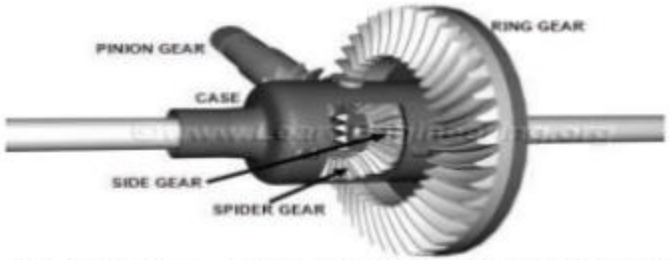
The differential we have gone through so far is known as open or standard differential. It is capable of turning the wheels at different rpm, but it has got one major drawback. Consider a situation where one wheel of the vehicle is on a surface with good traction and the other wheel on a slippery track.

In this case a standard differential will send the majority of the power to the slippery wheel, so the vehicle won't be able to move. To overcome this problem, Limited Slip Differentials are introduced.

One way to overcome this problem is to limit the independency or relative motion between the left and right axles.Limited slip differentials are introduced for this purpose. One of the most commonly used LSD technology is clutch-pack based.

Constructional Features of LSD

The basic components of a standard differential are shown below. It has got pinion gear, ring gear, case, spider gears and side gears.



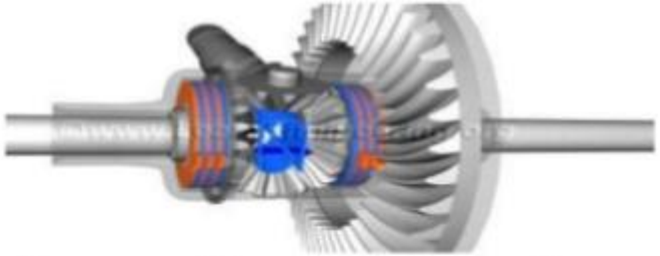
- Apart from its basic components a Limited slip differential has got a series of friction and steel plates packed between the side gear and the casing.
- Friction discs are having internal teeth and they are locked with the splines of the side gear.
- So the friction discs and the side gear will always move together.

•Steels plates are having external tabs and are made to fit in the case groove. So they can rotate with the case.

•If any of the clutch pack assembly is well pressed, the frictional force within them will make it move as a single solid unit.

•Since steel plates are locked with the case and friction discs with the side gear, in a well pressed clutch pack casing and the clutch pack will move together.

•Space between the side gears is fitted with a pre-load spring. Pre load spring will always give a thrust force and will press clutch pack together.



Separating action of Bevel gears

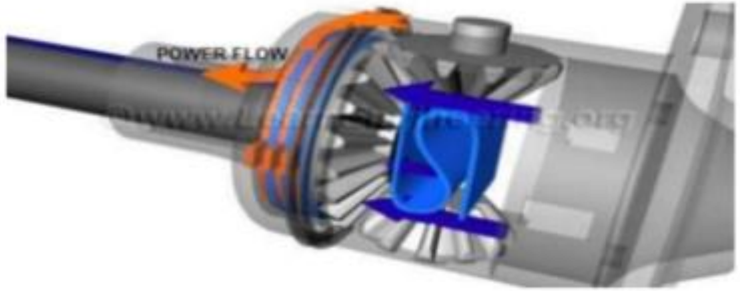
You can note that spider and side gear are bevel gears. It has got one specialty. When torque is transmitted through a bevel gear system axial forces are also induced apart from the tangential force. The axial force tries to separate out the gears.

You can note that side gear and axle are 2 separate units.
The side gear has got a small allowance for axial movement.

So during high torque transmission through spider-side gear arrangement, a high separating thrust force is also transmitted to the clutch pack. This force presses and locks the clutch pack assembly against wall of the casing.

Working of Limited Slip Differential

Now back to the initial problem. Since one wheel is on a high traction surface, the torque transmitted to it will be higher. So the thrust force developed due to the bevel gear separation action also will be high at that side. Thus clutch pack at high traction wheel side will be pressed firmly and clutch pack will be locked. So power from the differential casing will flow directly to high traction axle via clutch pack assembly.



On the other hand clutch pack on the low traction wheel side is not engaged yet, so power flow will be limited to that side. So the vehicle will be able to overcome the traction difference problem.

•However while taking a turn the LSD can act like a normal differential.
•In this case thrust force developed due to bevel gear separation action won't be that high.
•So the plates in clutch pack will easily overcome frictional resistance and will be able to slip against each other.
•Thus the right and left wheel can have different speed just like an open differential.

Cone clutch differential:

•In place of clutch packs, the friction lined cones are used.

•The operation is similar to clutch plate differential.

•Preload spring and side gear pressures force the cone into a depression in the differential case.

•Therefore, the side gear sends power to the wheel with the most traction.

Rear axle

Dead axles:

A dead axle, also called lazy axle, is not part of the drivetrain but is instead free-rotating. The rear axle of a front-wheel drive car is usually a dead axle.

Many trucks and trailers use dead axles for strictly load-bearing purposes.

Live axles:

A live axle is a type of beam axle in which the shaft transmits power to the wheels.

Rear axle casing

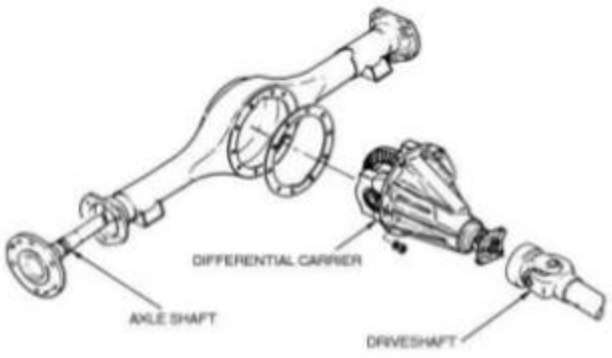
Split type axle casing:

In this type of axle split shaft are used with the central housing contain the differential gear and it is fitted with a tube on each side to carry the half axles and bearing.

Banjo type axle casing

•This type of axle is a single shaft and final drive assembly is carried in a separate casing which is bolted to the axle housing.

•The banjo construction is often used for smaller and lighter vehicle.



Carrier type axle casing:

This type of casing is more rigid than a banjo type and is often employed to support a hypoid gear. The final drive assembly is installed in a rigid malleable cast iron carrier, into which the axle tubes are pressed and welding.

Types of loads acting on rear axles

- Weight of the body
- Side thrust
- Driving thrust

Types of rear axles

1. Semi floating axle:

- An axle in which the shaft has to take the entire load.
- Wheel hub directly connected to the axle
- In this type all the loads are taken by the axle shaft.
- The whole load acts on the shaft and shaft has a tendency to shear at a particular point.
- Semi floating axle is simplest and cheapest but for a given torque they have to be of larger dia.

2. Full floating axle:

- Used for heavy vehicle.
- The axle shafts have flanges at the outer end which are connected to flanged sleeve by means of bolts.
- Two tapper roller bearing supporting for take up any side load.
- The axle shaft carry only the driving torque. So their failure does not affect the wheels.

3. Three quarter floating axle:

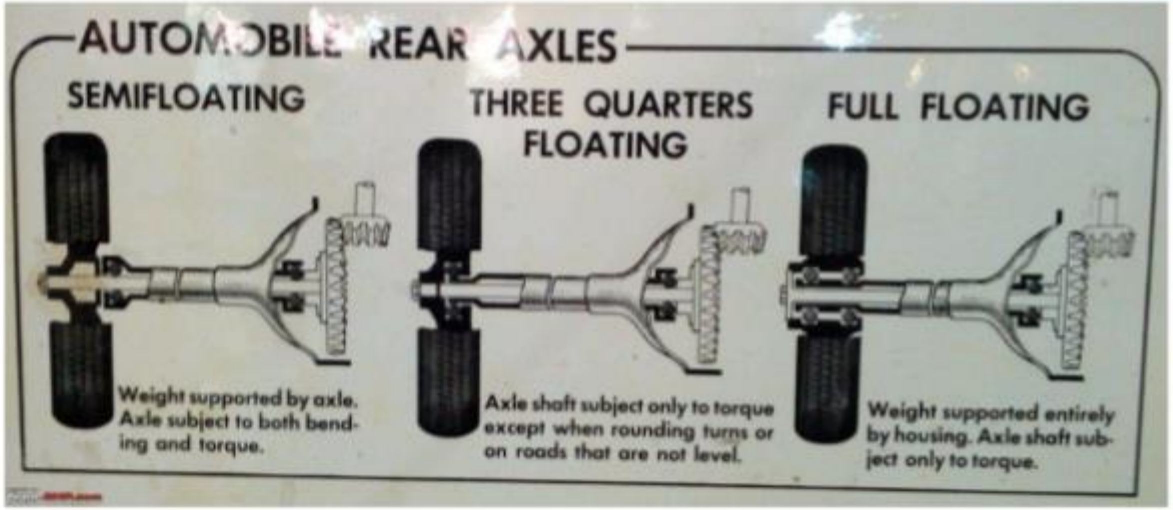
•Combination of full and semi floating bearing.

•Axle shaft maintain the alignment of the wheel.

•Construction of the inner end axle shaft is similar to a semi-floating axle.

•It has only one bearing at the outer end and it will carry some bending stresses.

Clip slide

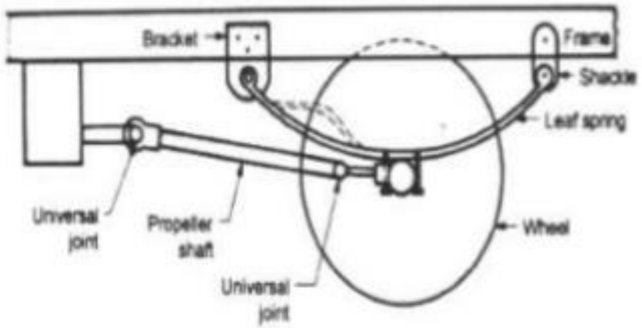

AUTOMOBILE REAR AXLES
SEMIFLOATING
THREE QUARTERS FLOATING
FULL FLOATING
Weight supported by axle. Axle subject to both bending and torque.
Axle shaft subject only to torque except when rounding turns or on roads that are not level.
Weight supported entirely by housing. Axle shaft subject only to torque.

Rear axle drives

1. **Hotchkiss drive:**

- It consists of a propeller shaft, two longitudinal leaf springs.
- Propeller shaft has a slip joint.
- Front end of leaf spring is connected to hinged to the frame and the rear end is connected with the frame by swinging shackles.
- The rear end torque is borne by springs. It gets deflected while driving and also braking.
- The deflection helps to improve flexibility and damp shocks.

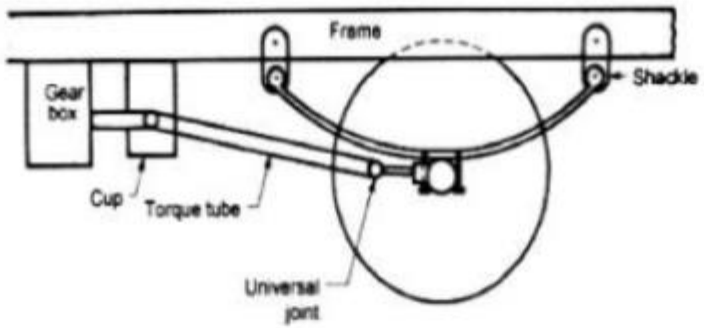
HOTCHKISS DRIVE



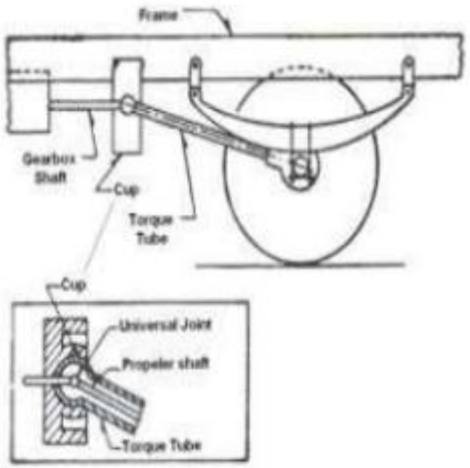
Hotchkiss Drive

2) Torque tube drive:

- A hollow tube encloses the propeller shaft.
- The tube is rigidly connected to the differential housing at one end. The other end of the tube is connected to the gearbox by flexible ball and socket.
- The driving thrust and rear end torque are carried by a hollow tube.
- The tube is used in bearings to support the propeller shaft.
- One universal joint and no sliding joint.
- Helical springs are used.
- If leaf springs are used, shackles will also be placed at both ends.



Torque tube drive



Rear axle

Dead axles:

A dead axle, also called lazy axle, is not part of the drive train but is instead free-rotating. The rear axle of a front-wheel drive car is usually a dead axle.

Many trucks and trailers use dead axles for strictly load-bearing purposes.

Live axles:

A live axle is a type of beam axle in which the shaft transmits power to the wheels.

Rear axle casing

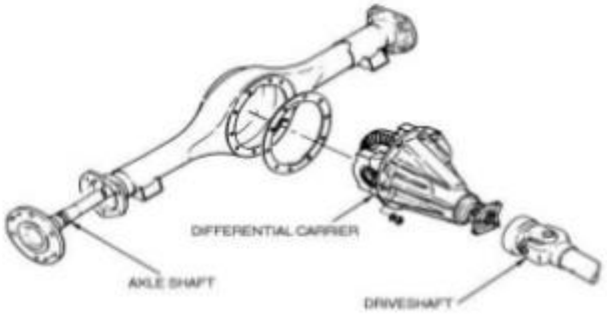
Split type axle casing:

In this type of axle split shaft are used with the central housing contain the differential gear and it is fitted with a tube on each side to carry the half axles and bearing.

Banjo type axle casing

•This type of axle is a single shaft and final drive assembly is carried in a separate casing which is bolted to the axle housing.

•The banjo construction is often used for smaller and lighter vehicle.



Carrier type axle casing:

•This type of casing is more rigid than a banjo type and is often employed to support a hypoid gear.

•The final drive assembly is installed in a rigid malleable cast iron carrier, into which the axle tubes are pressed and welding.

Types of loads acting on rear axles

- Weight of the body
- Side thrust
- Driving thrust

Types of rear axles

1. **Semi floating axle:**

- An axle in which the shaft has to take the entire load.
- Wheel hub directly connected to the axle
- In this type all the loads are taken by the axle shaft.
- The whole load acts on the shaft and shaft has a tendency to shear at a particular point.
- Semi floating axle is simplest and cheapest but for a given torque they have to be of larger dia.

2. Full floating axle:

- Used for heavy vehicle.
- The axle shafts have flanges at the outer end which are connected to flanged sleeve by means of bolts.
- Two tapper roller bearing supporting for take up any side load.
- The axle shaft carry only the driving torque. So their failure does not affect the wheels.

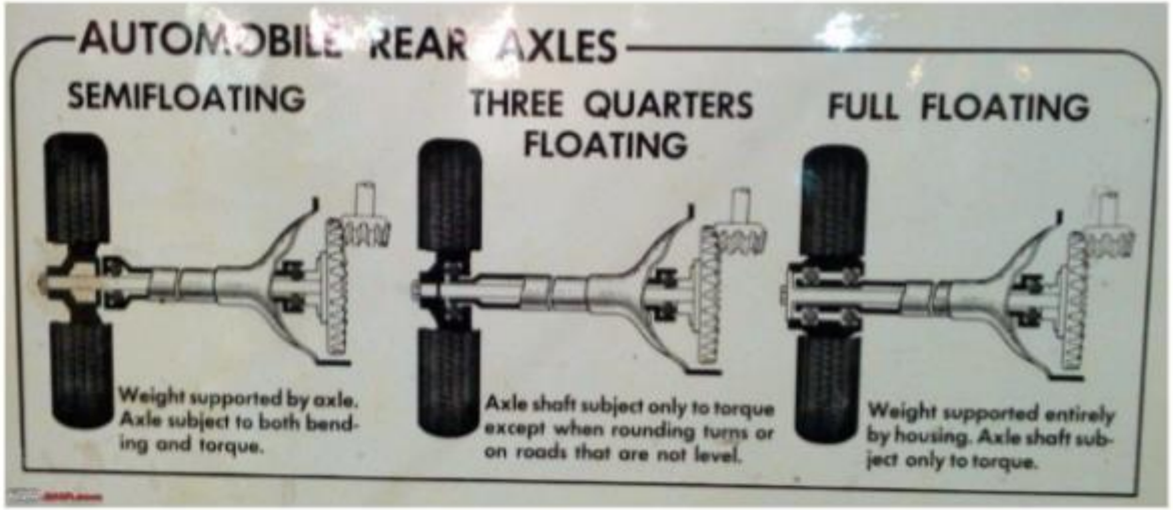
3. Three quarter floating axle:

Combination of full and semi floating bearing.

Axle shaft maintain the alignment of the wheel.

Construction of the inner end axle shaft is similar to a semi- floating axle.

It has only one bearing at the outer end and it will carry some bending stresses.


AUTOMOBILE REAR AXLES
SEMIFLOATING
THREE QUARTERS FLOATING
FULL FLOATING
Weight supported by axle. Axle subject to both bending and torque.
Axle shaft subject only to torque except when rounding turns or on roads that are not level.
Weight supported entirely by housing. Axle shaft subject only to torque.

GEARBOXES IN AUTOMOBILES

Introduction and Purpose

- Provides speed and torque conversions because of the limitations of internal combustion engines.
- Also facilitates change of direction of output shaft for reversing
- Automotive gearboxes are used to reduce load on the engine by manipulating torque and speed. They have the option to select one of several different gear ratios.
- Once the engine has reached a number of revolutions per minute, it is advisable to increase the gear to reduce the engine rpm to **reduce wear** on the engine, allow **more control**, and **greater speeds, better acceleration, and better fuel economy**
- Most gearboxes are used to increase torque & reduce the speed of a output shaft. This produces a **mechanical advantage**
- Automotive gearbox also have the provision to do the opposite ie provide an increase in output shaft speed with a reduction of torque (overdrive).

Basic Principle

- Because of the angle of cut, helical gear teeth have a much more gradual engagement with each other, and they operate more smoothly and quietly than spur gears.
- Helical gears can transmit more torque because at any time, more number of teeth are in mesh
- Gearboxes for cars and motorbikes almost always use helical gears.
- However, helical gears also exert undesirable axial thrust
- To prevent axial thrust, double helical gears are used which cancel out the thrust. Double Helical gears are called Herringbone gears.

Types of gear box:

1.Manual transmission.
    a) Sliding mesh gearbox
    b) Constant mesh gearbox
    c) Synchromesh gearbox
2. Epicyclic gearbox.
3. Automatic transmission.
    a) Hydramatic gearbox
    b) Torque converter gearbox

Types of gear box:

1.Manual transmission.
  - a) Sliding mesh gearbox
  - b) Constant mesh gearbox
  - c) Synchromesh gearbox

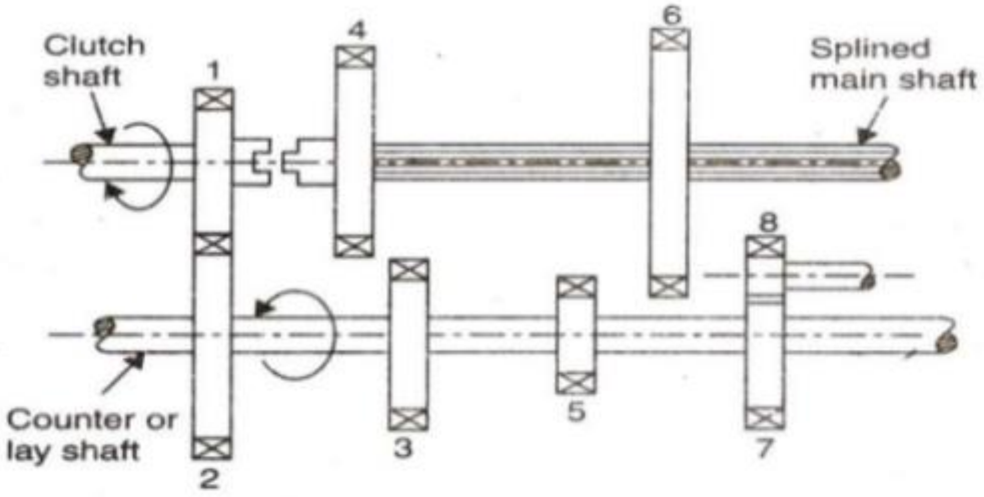
2. Epicyclic gearbox.
3. Automatic transmission.
  - a) Hydramatic gearbox
  - b) Torque converter gearbox

Sliding Mesh Gearbox

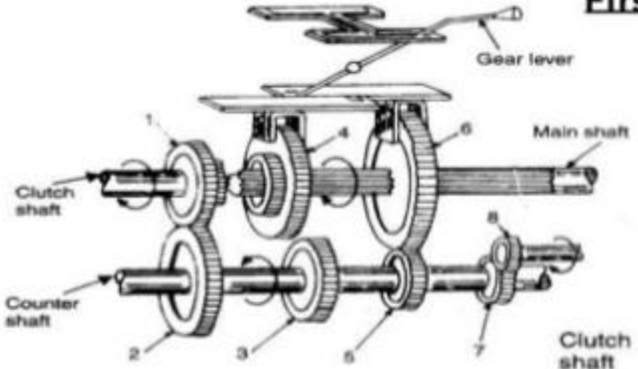
- In this type of gear box, gears are changed by sliding one gear on the other.
- This gear box consists of three shafts; main shaft, clutch shaft and a counter shaft.
- In a four speed gear box (which includes one reverse gear), the counter shaft has four gears which are rigidly connected to it.
- Clutch shaft has one gear and main shaft has two gears.

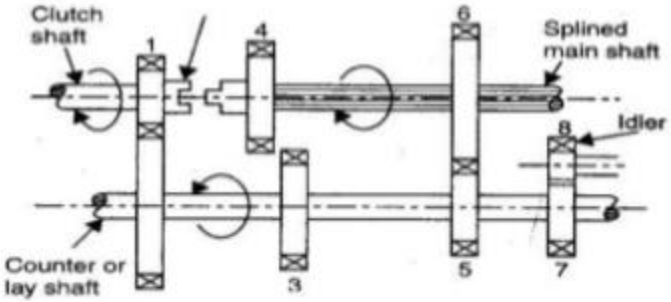
- These gears can be meshed with corresponding gears on the countershaft with the help of shifter yoke and shift lever.
- Shift lever is operated by hand in four wheelers for changing the gears.
- A reverse idler gear is mounted on another (third) shaft and is always in mesh with reverse gear on countershaft

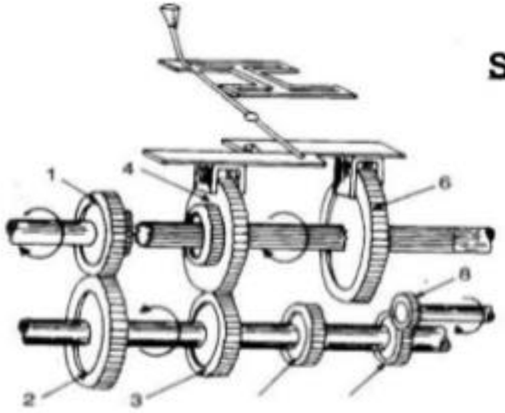
Sliding Mesh Gearbox



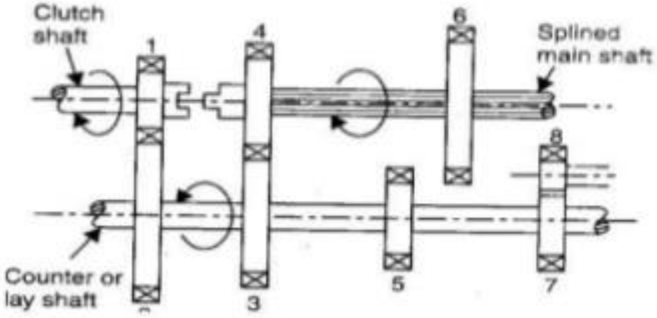
First gear position



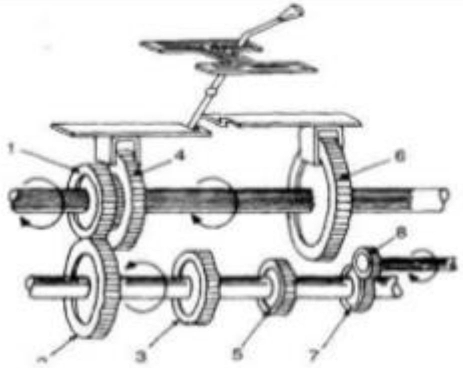


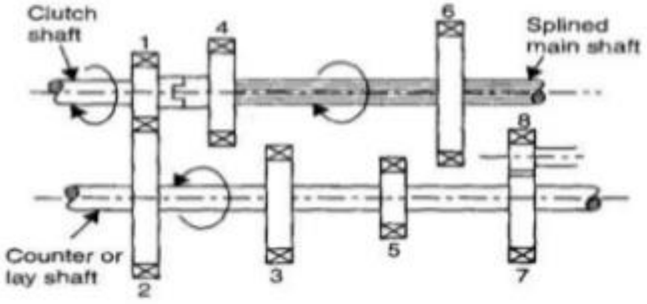


Second gear position

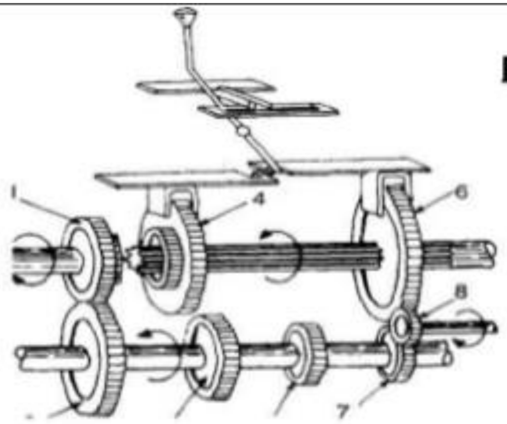


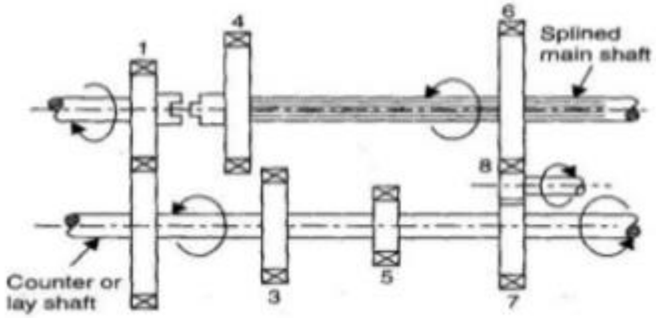
Third gear position





Reverse gear position





1. First gear:
   1-2-5-6
2. Second gear:
   1-2-3-4
3. Third or top gear:
   Both input and output shafts are coupled.
4. Reverse gear:
   1-2-7-8-6

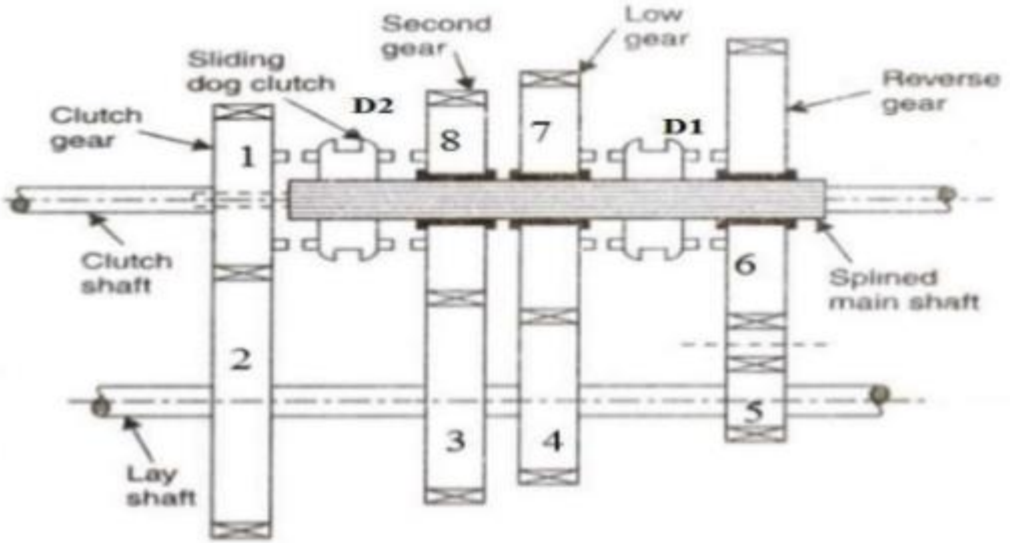
Constant Mesh Gearbox

- All the gears are always in mesh
- Gears on counter shaft are fixed to it
- Gears on main shaft are free to rotate
- Dog clutches can slide on the main shaft and rotate with it
- Dog clutches engage with gears on the main shaft to obtain desired speed

Advantages over Sliding mesh Gearbox:

- Helical and herringbone gear can be used in these gearboxes and therefore, constant mesh gearboxes are quieter.
- Since the gears are engaged by dog clutches, if any damage occurs while engaging the gears, the dog unit members get damaged and not the gear wheels.

Constant Mesh Gearbox



1. First gear:

   1-2-4-7

2. Second gear:

   1-2-3-8

3. Third or top gear:

   D2 engaged with gear 1.

4. Reverse gear:

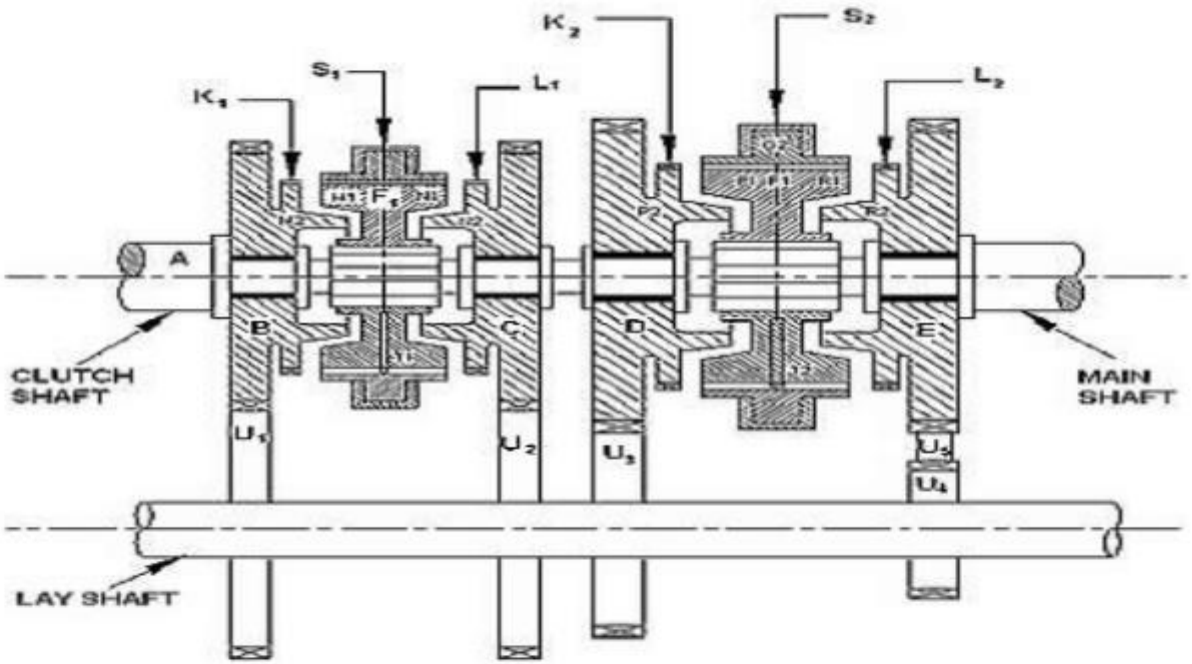
   1-2-5- Idler gear-6

Synchromesh Gearbox

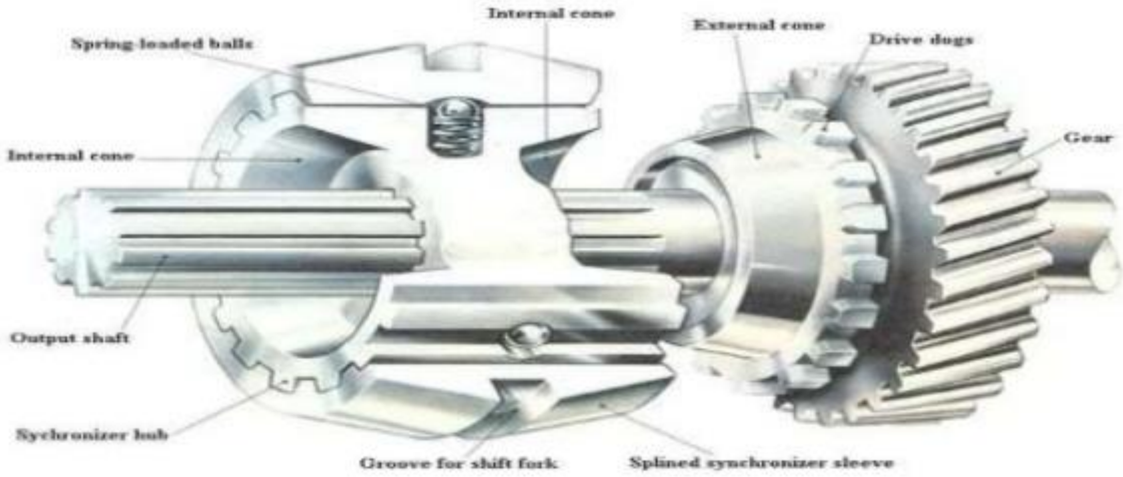
- Sliding sunchronizing units are provided to equalize the speeds of gear and dog before meshing
- The device works like a friction clutch
- Equal speeds ensure smooth meshing
- Normally not used in 1st and reverse gear

Working

- Output shaft is always rotating (because it is positively connected to the wheels)
- Layshaft is connected to the engine, but it rotates freely when the clutch is disengaged
- Because the gears are meshed all the time, the synchro brings the layshaft to the right speed for the dog gear to mesh.
- The layshaft is now rotating at a different speed to the engine. Now, the clutch gradually equalizes the speed of the engine and lay shaft, either bringing the engine to the same speed as the lay shaft or vice versa depending on engine torque and vehicle speed

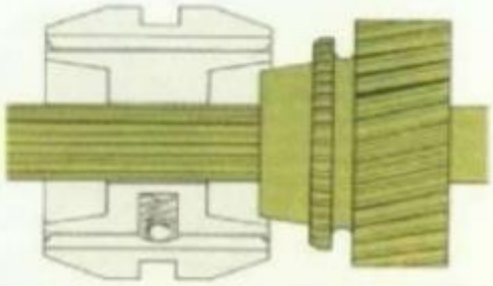


K1
S1
L1
K2
S2
L2
A
B
C
D
E
F1
U1
U2
U3
U4
U5
CLUTCH SHAFT
MAIN SHAFT
LAY SHAFT

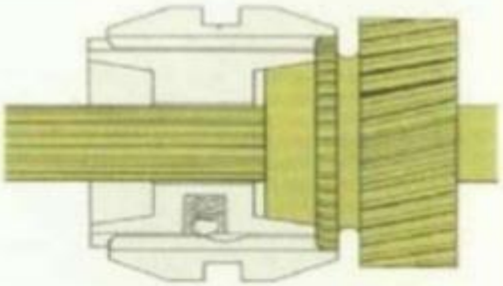


Internal cone
External cone
Drive dogs
Spring-loaded balls
Gear
Internal cone
Output shaft
Sychronizer hub
Groove for shift fork
Splined synchronizer sleeve

Synchromesh Gearbox

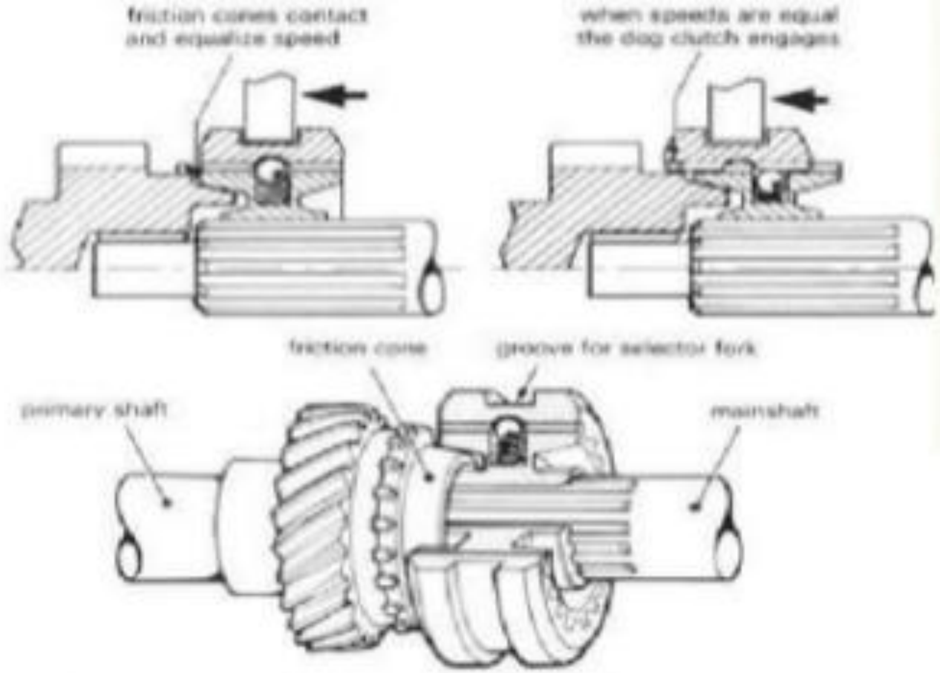


Spring-loaded balls hold the collar together

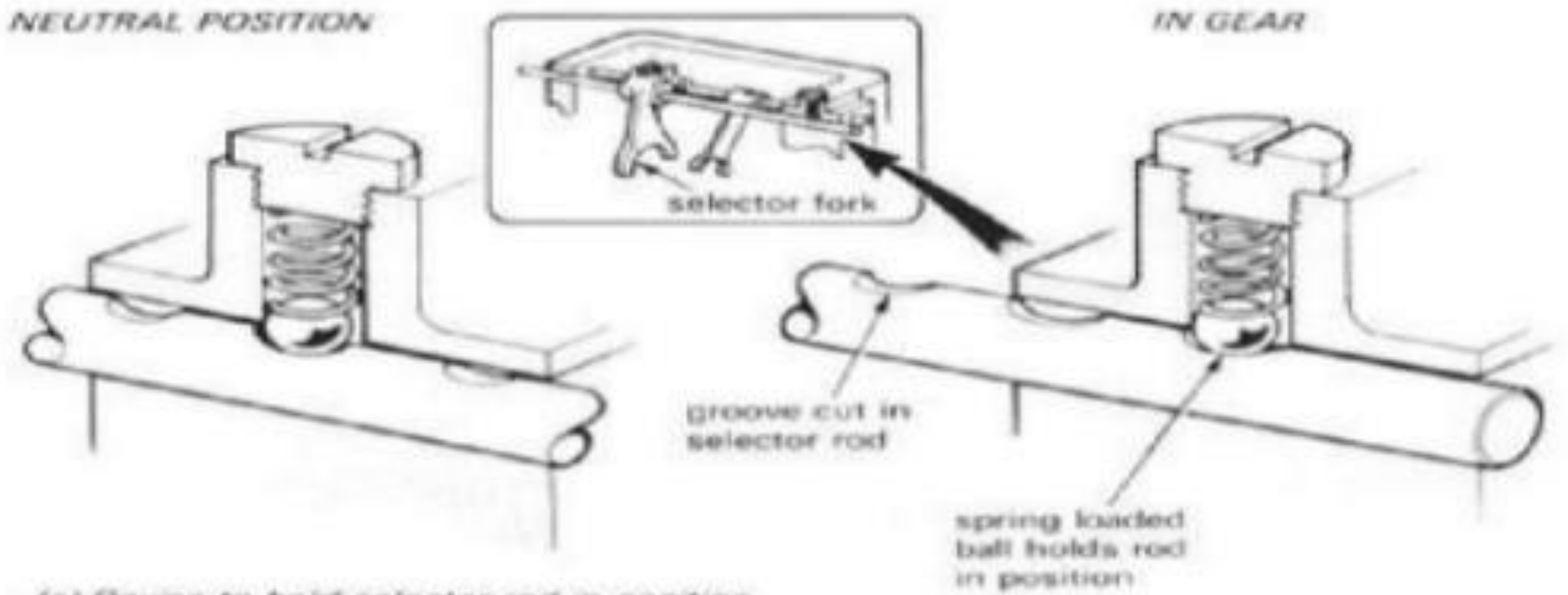


Pressure on the gear lever causes toothed outer ring to slide into engagement

Synchromesh Gearbox



Gear Selector Rod



(a) Device to hold selector rod in position

Explanation about the synchromesh gearbox

- This type of gearbox is similar to the constant mesh type gearbox.
- Instead of using dog clutches here synchronizers are used.
- The modern cars use helical gears and synchromesh devices in gearboxes, that synchronize the rotation of gears that are about to be meshed.

SYNCHRONIZERS

- This type of gearbox is similar to the constant mesh type in that all the gears on the main shaft are in constant mesh with the corresponding gears on the lay shaft.
- The gears on the lay shaft are fixed to it while those on the main shaft are free to rotate on the same.

Contd…

- Its working is also similar to the constant mesh type, but in the former there is one definite improvement over the latter.
- This is the provision of synchromesh device which avoids the necessity of double-declutching.
- The parts that ultimately are to be engaged are first brought into frictional contact, which equalizes their speed, after which these may be engaged smoothly.
- They are fitted only on the high gears and on the low and reverse gears ordinary dog clutches are only provided.
- This is done to reduce the cost.

Contd.

- In figure A is the engine shaft, Gears B, C, D, E are free on the main shaft and are always in mesh with corresponding gears on the lay shaft.
- Thus all the gears on main shaft as well as on lay shaft continue to rotate so long as shaft A is rotating.
- Members F1 and F2 are free to slide on splines on the main shaft.
- G1 and G2 are ring shaped members having internal teeth fit onto the external teeth members F1 and F2 respectively.
- K1 and K2 are dogteeth on B and D respectively and these also fit onto the teeth of G1 and G2. S1 and S2 are the forks.
- T1 and T2 are the balls supported by spring.

Contd

- These tend to prevent the sliding of members G1 (G2) on F1 (F2).
- However when the force applied on G1 (G2) slides over F1 (F2).
- These are usually six of these balls symmetrically placed circumferentially in one synchromesh device. M1, M2, N1, N2, P1, P2, R1, R2 are the frictional surfaces.
- To understand the working of this gearbox, consider figure which shows in steps how the gears are engaged.
- For direct gear, member G1 and hence member F1 (through spring- loaded balls) is slide towards left till cones M1 and M2 rub and friction makes their speed equal.

Contd.

- Further pushing the member G1 to left causes it to overdrive the balls and get engaged with dogs K1.
- Now the drive to the main shaft is direct from B via F1 and the splines.
- However, if member G1 is pushed too quickly so that there is not sufficient time for synchronization of speeds, a clash may result.
- Likewise defect will arise in case springs supporting the balls T1 have become weak.

Contd

- Similarly for second gear the members F1 and G1 are slide to the right so that finally the internal teeth on G1 are engaged with L1.
- Then the drive to main shaft will be from B via U1, U2, C, F1 and splines.
- For first gear, G2 and F2 are moved towards left. The drive will be from B via U1, U2, D, F2 and splines to the main shaft. For reverse gear, G2 and F2 are slid towards right.
- In this case the drive will be from B via U1, U2, U5, E, F2 and splines to the main shaft.

THANKYOU

AUTOMOBILE ENGINEERING

Unit V

Alternative energy sources

Alternate fuels

Natural gas

Liquefied petroleum gas (LPG)

Methanol

Ethanol

Gasohol

Bio diesel

Hydrogen

Fuel cells

Properties of alternate fuels

Energy density

Volatility

Octane number

Cetane number

Heat of vaporization

Flame speed

Flame temperature and luminosity

Auto ignition temperature

Flashpoint

Flammability

Natural gas

Natural gas is a fossil fuel such as petroleum and coal trapped in underground.

It is a mixture of hydrocarbons.

Properties

Natural gas is colourless, odourless, tasteless, shapeless and lighter than air.

It is gaseous even at -161 degree celsius.

Various forms

Methane

Ethanol

Methanol

Propane

Reformulated and oxygenated gasoline.

Production of natural gas

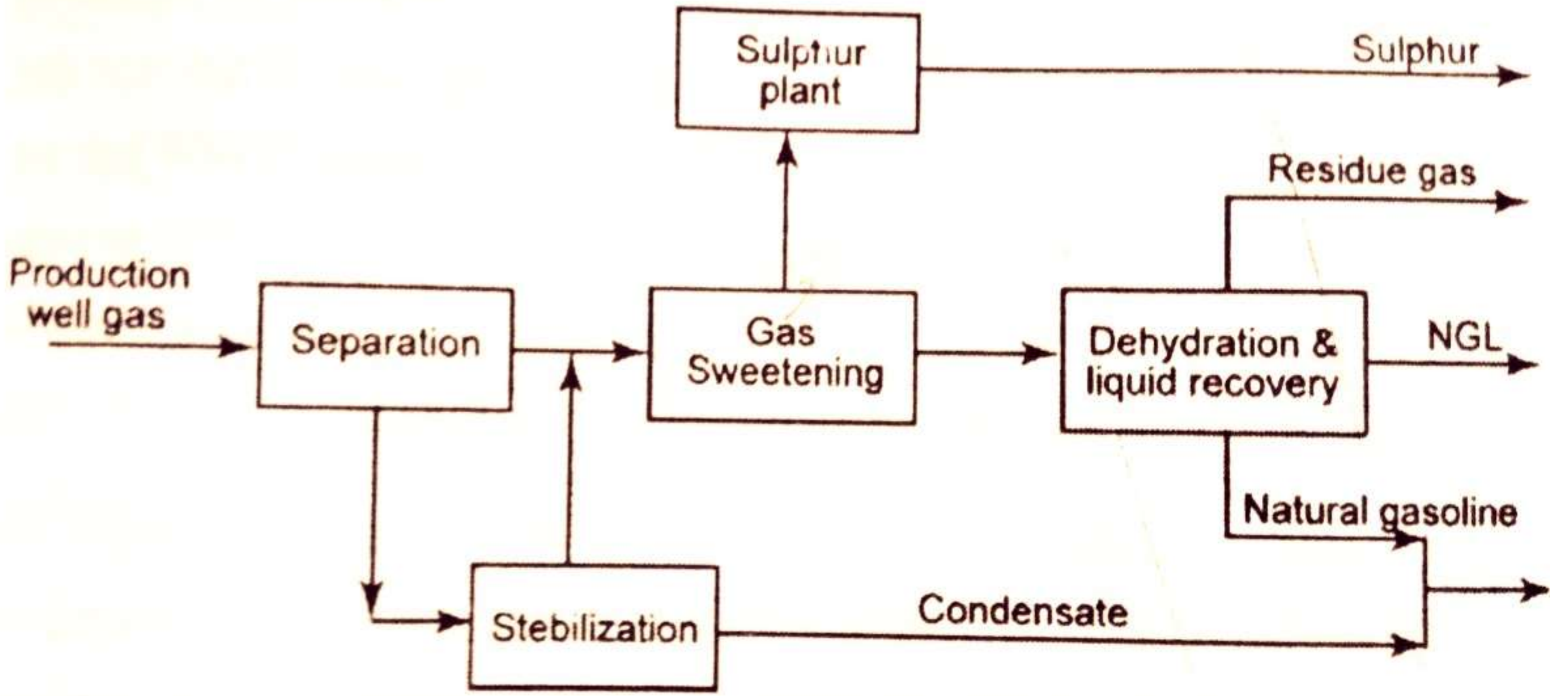


Figure 5.1 Production of Natural gas

Liquefied petroleum gas (LPG)

LPG is a mixture of propane and hydrocarbon gases.

It is gas at room temperature but turn to liquid when compressed.

Due to its low vapour tension it is stored in liquid state under low pressures.

Properties

1. Boiling point from -42'c to -5'c.
2. LPG in gaseous state is twice as heavy as air.
3. It burns when mixed with air.
4. Odourless.
5. Auto ignition temperature 480 degree Celsius.
6. Flash point -104 degree celsius.

Bio-Diesel

Bio diesel is derived from vegetable oil and animal fats.

It is mixed with fossil energy.

Properties

1. Specific gravity - 0.87 to 0.89
2. Cetane number - 46 to 70
3. Flash point - 130 degree Celsius
4. Sulphur, wt% - 0.0 to 0.0024

Production of bio diesel

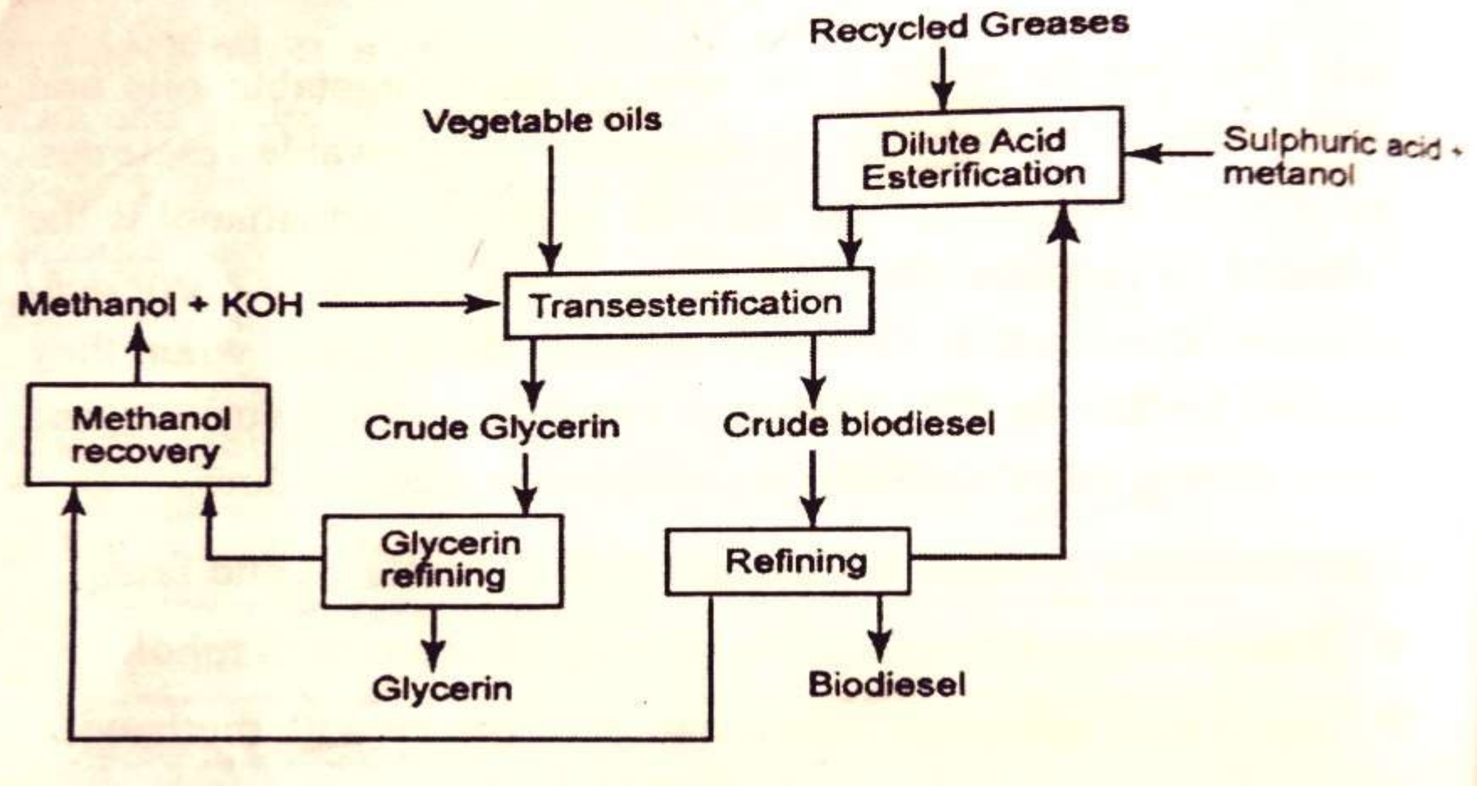
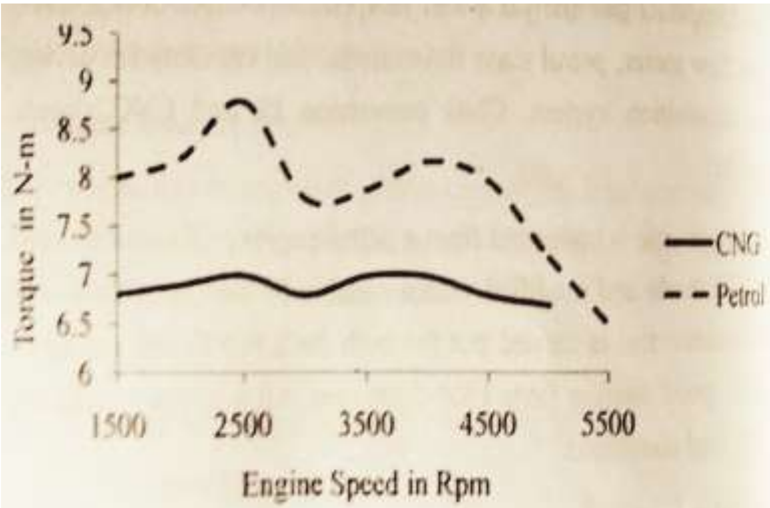
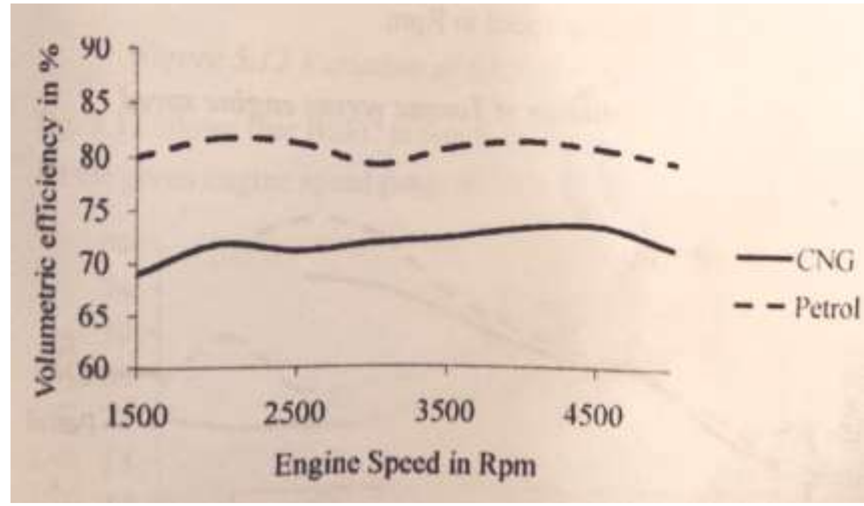


Figure 5.3 Production of Biodiesel

4 stroke SI vs CNG





Hybrid Vehicles

Hybrid vehicle is powered by two energy sources (i.e)., the combination of internal combustion engine and electric motor.

It have two to three times more fuel efficient than conventional vehicles.

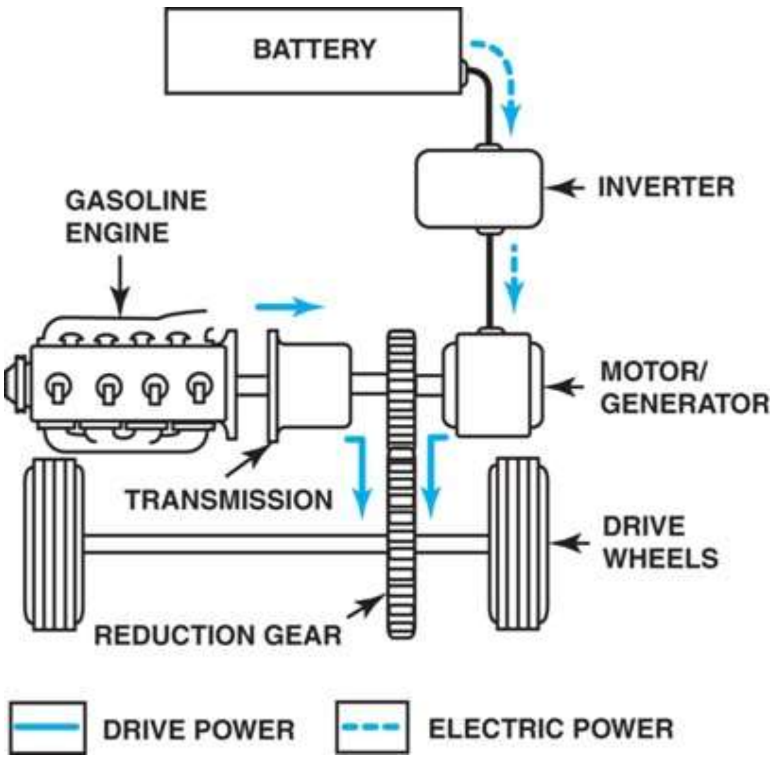
Types based on design

Parallel design

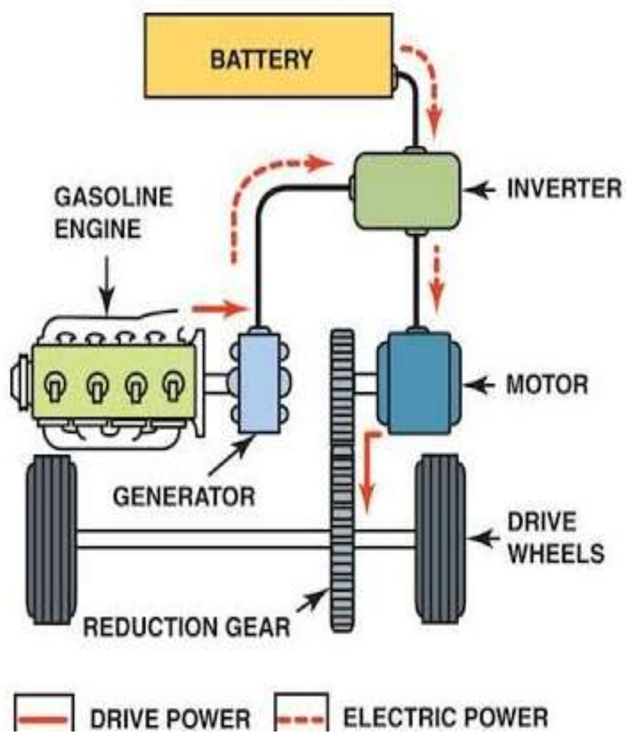
Series design

HEV design types

Parallel HEV



Series HEV



Hybrid vehicle components

1. Electric motor
2. Batteries
   I Lead-Acid batteries
   II Nickel cadmium batteries
   III Nickel Metal hydride batteries
   IV Lithium ion batteries
   V Lithium polymer
3. Power units
   I Spark ignition
   II Compression ignition
   III Gas turbine
   IV Fuel cells
4. Fuel systems
5. Emission control system

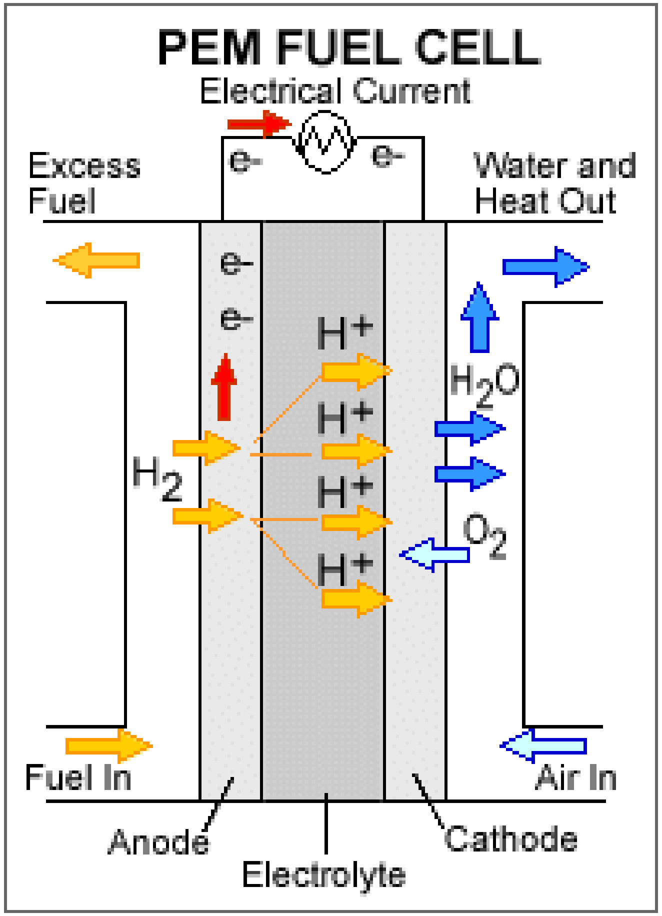
Hybrid electric vehicle benefits

- Low emissions and high efficiency
- High fuel economy and low costs
- Outstanding performance
- Energy security

Fuel cell

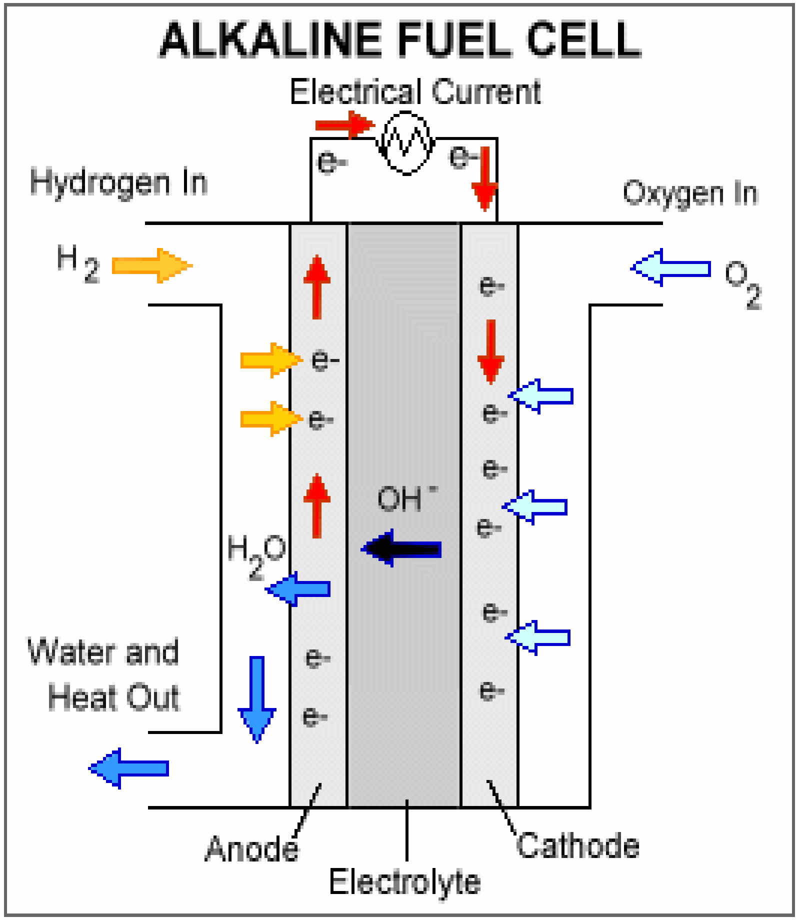
A fuel cells produces electricity directly from the reaction between hydrogen (derived from a hydrogen containing fuel or produced from the electrolysis of water) and oxygen from the air.

Polymer Electrolyte Membrane (PEM) fuel cells



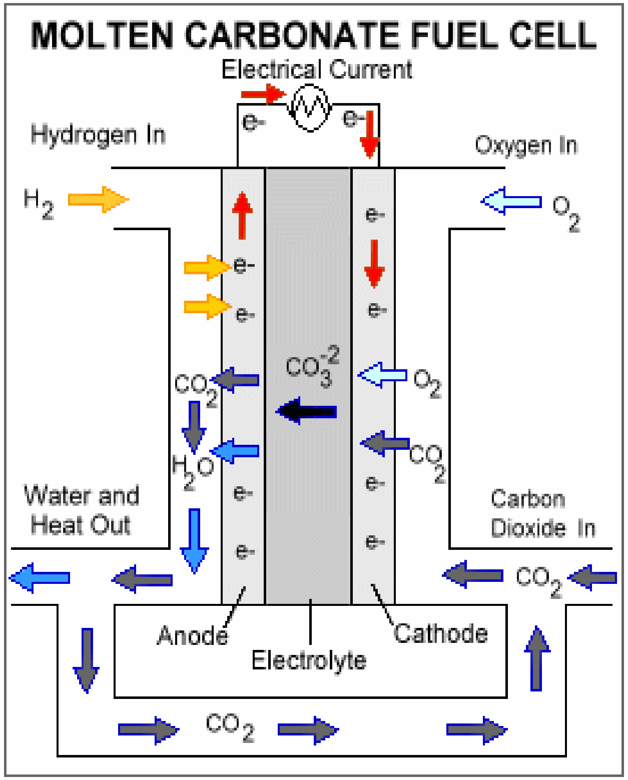
PEM fuel cells are called proton exchange membrane fuel cells deliver high power density and offer the advantages low weight and volume when compared to other fuel cells.

Alkaline fuel cells



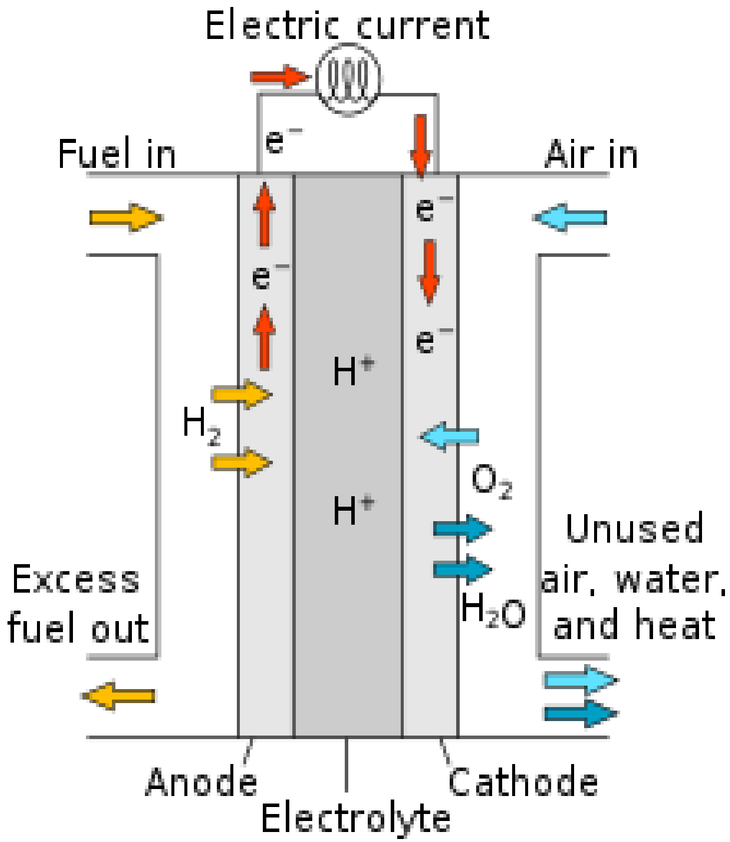
Alkaline fuel cells were one of the first fuel cell technologies developed, and they were the first type widely used in the U.S. Space program to produce electrical energy and water onboard spacecraft.

Molten carbonate fuel cells(MCFCs)



- MCFCs are currently being developed for natural gas and coal based power plants for electrical utility, industrial and military applications.

Phosphoric acid fuel cells



Phosphoric acid fuel cells use liquid phosphoric acid as an electrolyte. The acid is contained in a Teflon bonded silicon carbide matrix and porous carbon electrodes containing a platinum catalyst.

AUTOMOBILE ENGINEERING
UNIT 5

BY

V VIGNESHWARAN, M.TECH, AP

Uses of Natural Gases

- **Natural gas** is an ingredient used to make fertilizer, antifreeze, plastics, pharmaceuticals and fabrics.
- It is also used to manufacture a wide range of chemicals such as ammonia, methanol, butane, ethane, propane, and acetic acid.
- Many manufacturing processes require heat to melt, dry, bake, or glaze a product.

Alternate fuels

- Natural gas
- Liquefied petroleum gas (LPG)
- Methanol
- Ethanol
- Gasohol
- Bio diesel
- Hydrogen
- Fuel cells

Properties of alternate fuels

- Energy density
- Volatility
- Octane number
- Cetane number
- Heat of vaporization
- Flame speed
- Flame temperature and luminosity
- Auto ignition temperature
- Flashpoint
- Flammability

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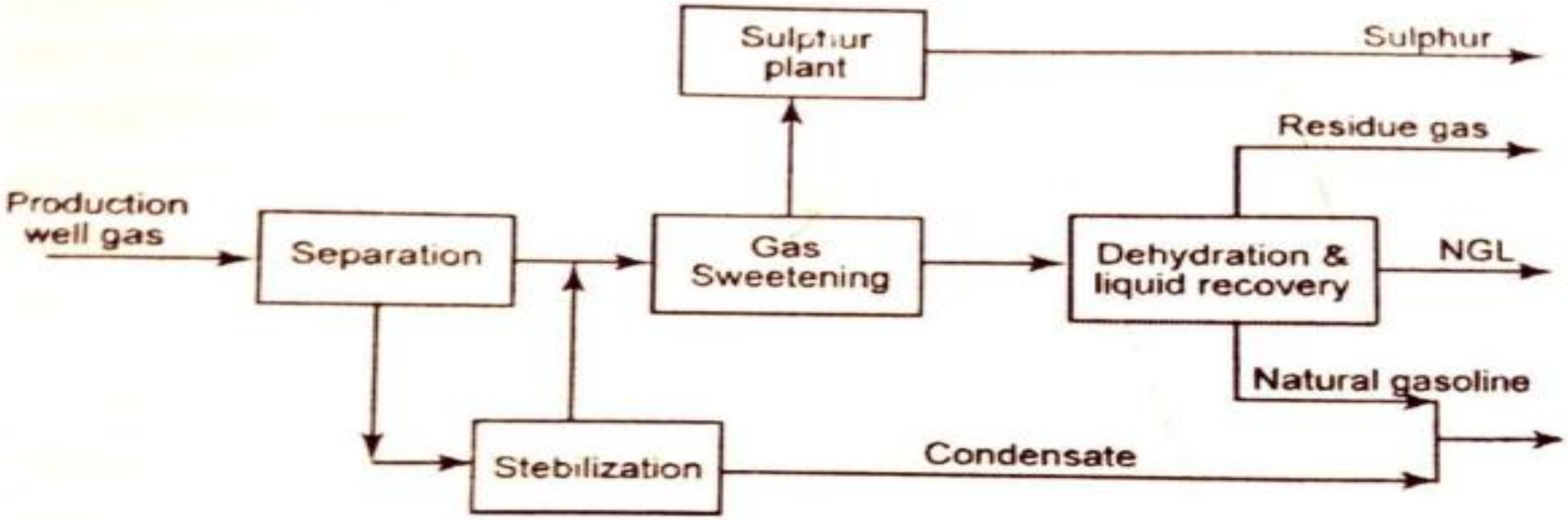
Production of natural gas



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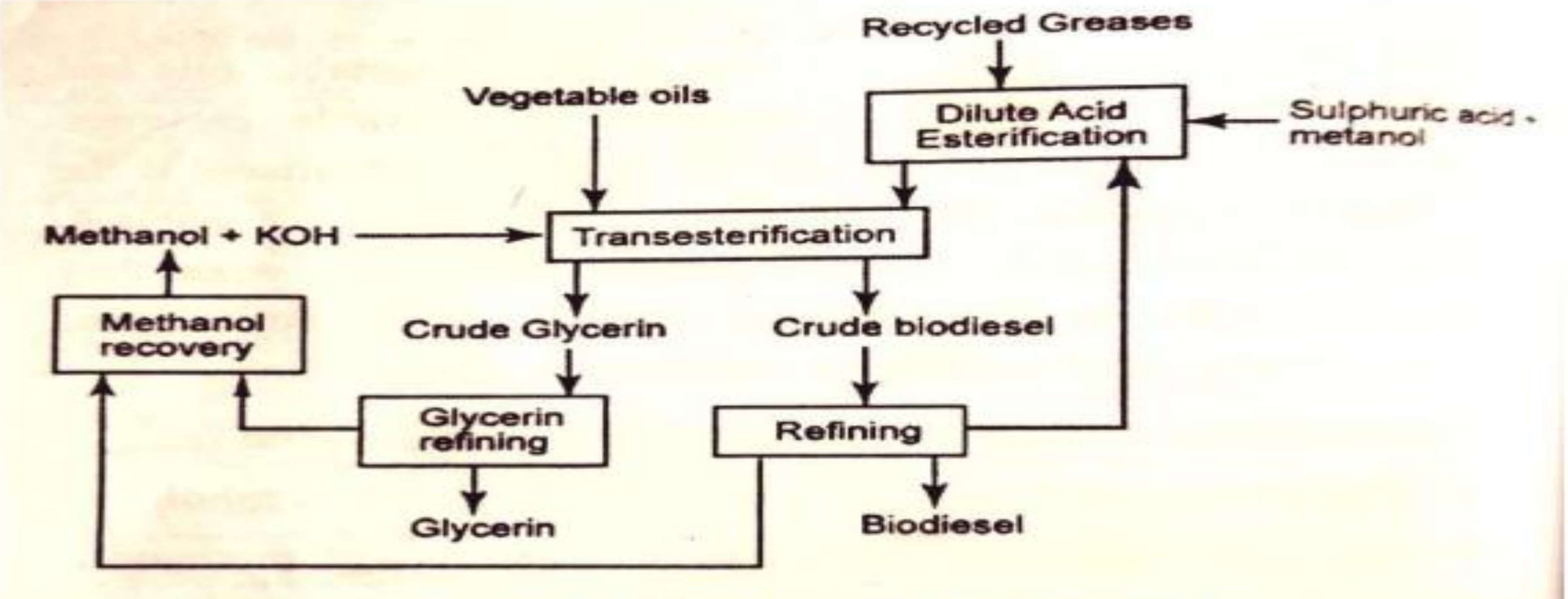
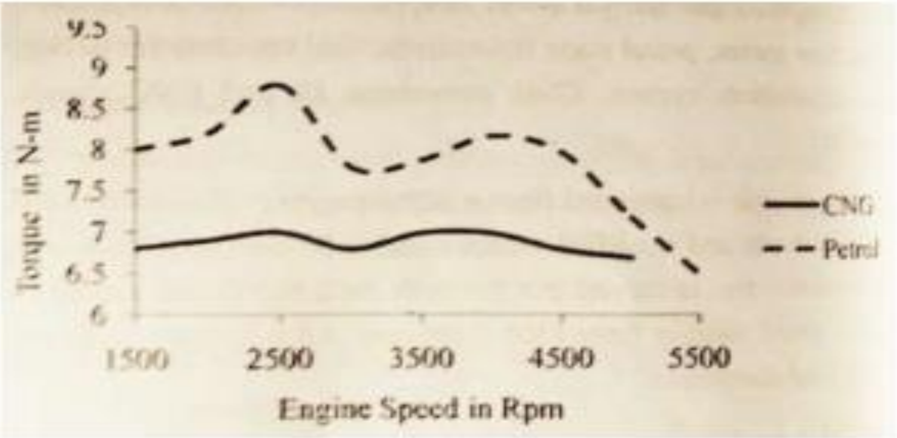
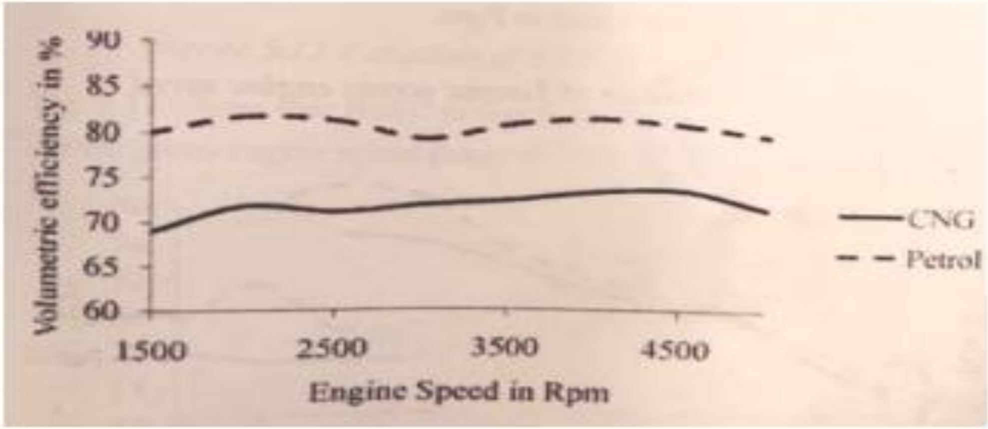


Figure 5.3 Production of Biodiesel

4 stroke SI vs CNG





Hybrid Vehicles

Hybrid vehicle is powered by two energy sources (i.e)., the combination of internal combustion engine and electric motor.

It have two to three times more fuel efficient than conventional vehicles.

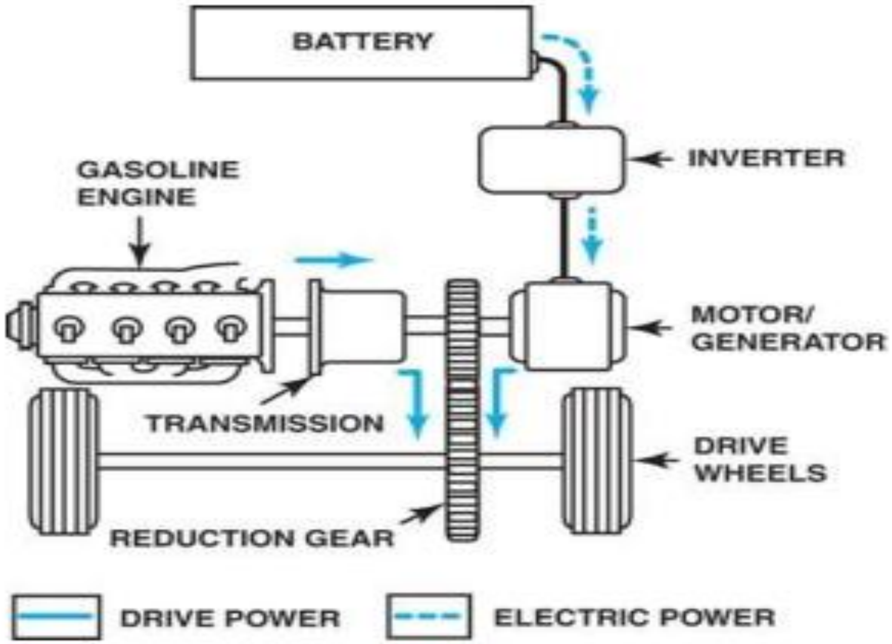
Types based on design

Parallel design

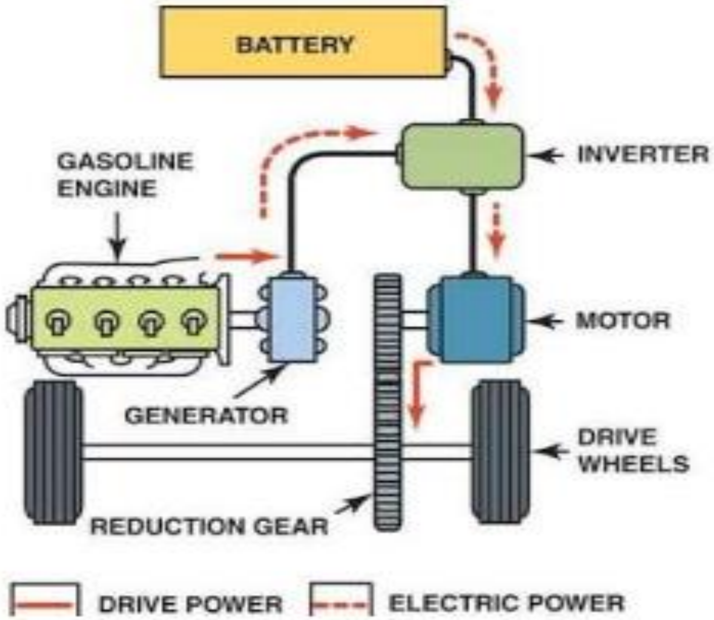
Series design

HEV design types

Parallel HEV



Series HEV



Hybrid vehicle components

1. Electric motor
2. Batteries
   - I Lead-Acid batteries
   - II Nickel cadmium batteries
   - III Nickel Metal hydride batteries
   - IV Lithium ion batteries
   - V Lithium polymer
3. Power units
   - I Spark ignition
   - II Compression ignition
   - III Gas turbine
   - IV Fuel cells
4. Fuel systems
5. Emission control system

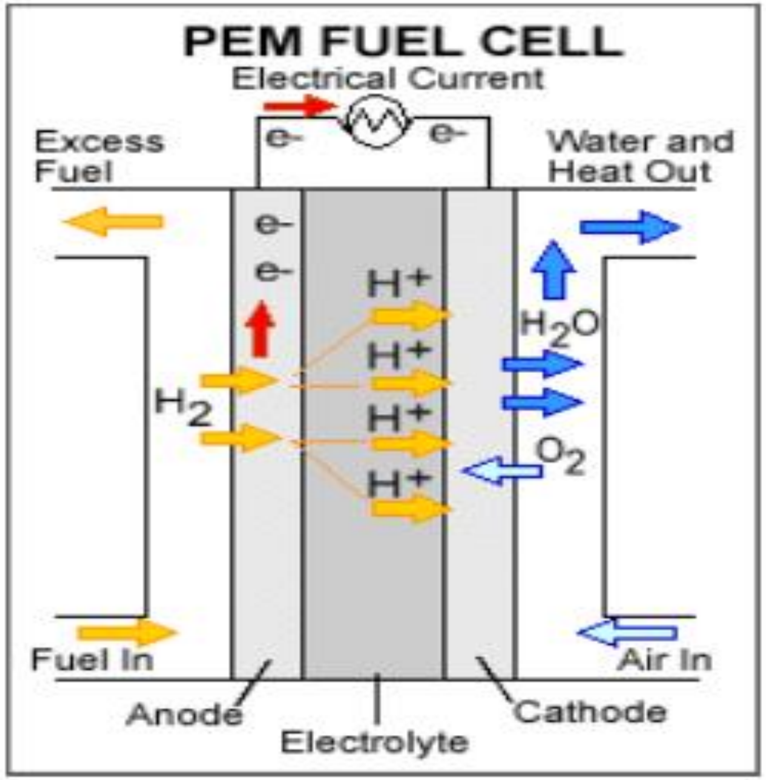
Hybrid electric vehicle benefits

- Low emissions and high efficiency
- High fuel economy and low costs
- Outstanding performance
- Energy security

Fuel cell

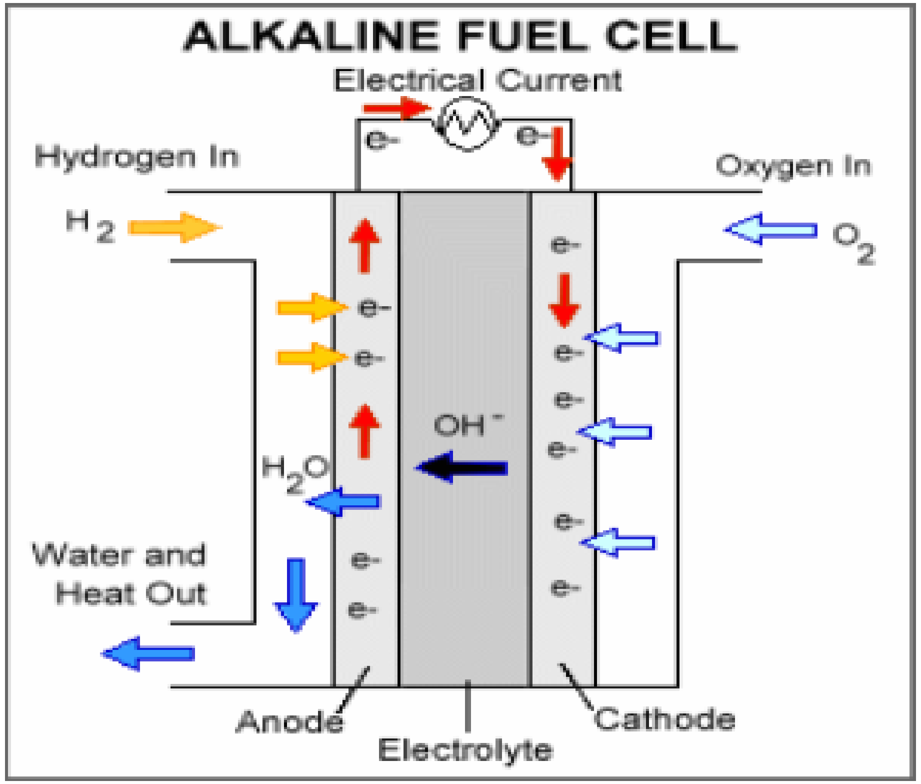
A fuel cells produces electricity directly from the reaction between hydrogen (derived from a hydrogen containing fuel or produced from the electrolysis of water) and oxygen from the air.

Polymer Electrolyte Membrane (PEM) fuel cells



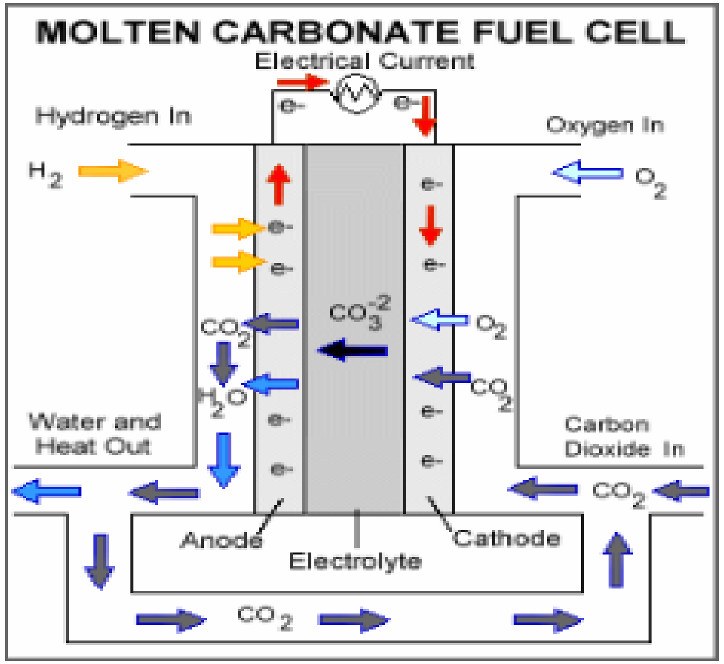
PEM fuel cells are called proton exchange membrane fuel cells deliver high power density and offer the advantages low weight and volume when compared to other fuel cells.

Alkaline fuel cells



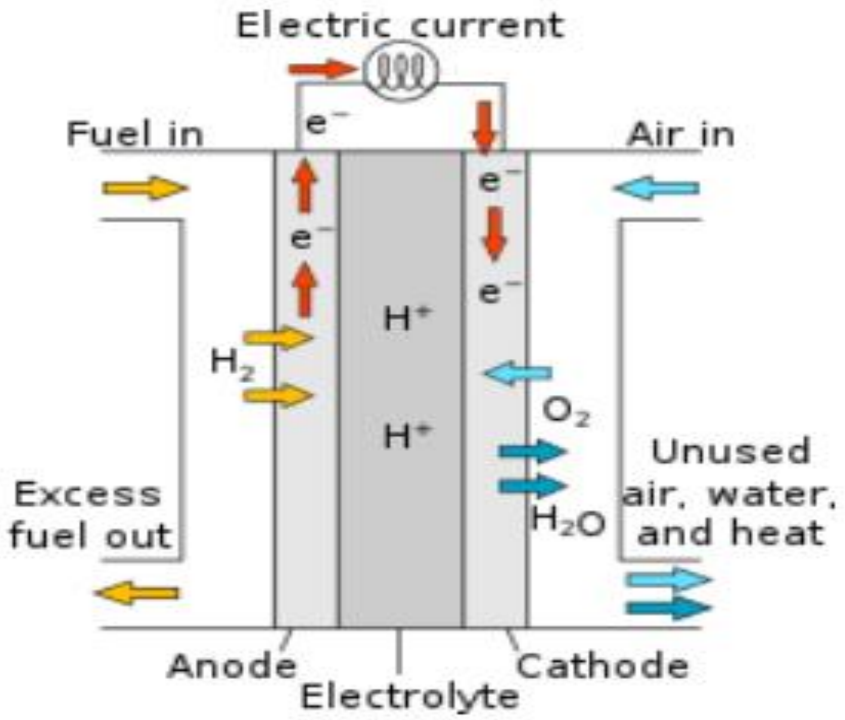
Alkaline fuel cells were one of the first fuel cell technologies developed, and they were the first type widely used in the U.S. Space program to produce electrical energy and water onboard spacecraft.

Molten carbonate fuel cells(MCFCs)



- MCFCs are currently being developed for natural gas and coal based power plants for electrical utility, industrial and military applications.

Phosphoric acid fuel cells



Phosphoric acid fuel cells use liquid phosphoric acid as an electrolyte. The acid is contained in a Teflon bonded silicon carbide matrix and porous carbon electrodes containing a platinum catalyst.