ANNAMACHARYA INSTITUTE OF TECHNOLOGY AND SCIENCES, TIRUPATI
(Autonomous)
Course structure for Four Year Regular B.Tech. Degree Program
(Effective for the batches admitted from 2020-21)
MECHANICAL ENGINEERING (ME)

Year: IV Semester: I Branch of Study: ME

Subject Code	Subject Name	L	T	P	Credits
20APE0301	Automobile Engineering	3	0	0	3

Course Outcomes:

CO: 1 Understand the use and operation of engine components; the working of cooling and lubrication systems
CO: 2 Understand the fuel supply system of SI and CI engines of an automobile
CO: 3 Understand the working of battery, magneto and electronic ignition systems
CO: 4 Understand the working of manual transmission system, differential gear box, steering geometry and axles of an automobile
CO: 5 Understand the working of front axle, rear axle, and air suspension systems of an automobile and working of mechanical, hydraulic, pneumatic braking systems and emission standards of an automobile

Unit I:

Engine Parts: Function and constructional details of Cylinder block, Cylinder liners-wet and dry types, Piston, Connecting rods, Crankshaft, Camshaft, Air cleaner, Intake and Exhaust manifolds, Mufflers.

Cooling System: Need for cooling of automobile-Types of cooling-air cooling, water-cooling. Natural circulation (Thermo-syphon system), Forced circulation and sealed Systems. Components of water-cooling system. Water pump, fan, Radiator, Thermostats and temperature indicators. Anti-freeze mixtures.

Lubricating Systems: Need for lubrication-Functions of lubricating oil. Properties of lubricating oil, and S.A.E grading of lubricants. Lubricating systems-Petroil .Splash, Pressure feed, Wet and Dry sump, Semi pressure and pre-lubrication system

Unit II:

Fuel Supply Systems: Fuel supply system of diesel engine, fuel injection pumps, Super charging of diesel engines. Fuel supply system for petrol engines-Carburetors, Air-fuel ratios at different vehicle running conditions, Working of a simple carburetor. Various carburetor systems- Float, Starting, Idle, Low speed, High speed and acceleration systems. MPFI and EFI systems. Types of carburetors-Working and constructional details of SU, Zenith and Carter carburetors

Unit III:

Ignition-System: Electronic ignition system. Storage battery, Battery rating, Dynamo, Alternators, Cut outs, Voltage and Current regulators. Starting motors. Sparkplugs-Hot and Cold, Computer controlled coil ignition sensors

Unit IV:

Transmission System: Clutch-Principle and requirements of a clutch, types of clutches-Single plate, Multi plate and Centrifugal, Semi-centrifugal clutches.

Gearbox - Requirements of a gear box, Gear selecting mechanism, Types of gear boxes-Sliding mesh, Constant mesh and Synchromesh. Propeller shaft Functions and constructional details,

Differential: Principle of working and its construction, Front axle-stub axle-types of stub axles. Rear axle –Semi floating, Three-quarter floating and Full floating axles. Steering-Wheel alignment. Steering geometry-Camber-Castor, Kingpin inclination, Toe in, and Toe-out. Steering linkages-Under steering and over steering. Power steering

Unit V:

Suspension: Types of suspension springs, Front axle independent suspension systems-Wishbone type. Trailing link type, Vertical link type. Rear axle suspension systems, Shock absorbers, Air suspension system

Brakes: Requirements of good braking system. Types of brakes-Mechanical, Hydraulic and pneumatic systems Emission control, environmental effects on engines, Euro Standards and Bharat Stage Emission Norms.

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Text Books

1. Kirpal Singh, AutomobileEngineeringVol.1&2, Standard Publishers, New Delhi
2. R.B. Gupta, Automobile Engineering, Satya Prakasam Publishers, New Delhi

Reference Books

1. W.H.Crowse, Automotive Mechanics, TMH Publishers, New Delhi
2. Joseph Heitner, Automotive Mechanics, EWP Publishers, New Delhi
3. Heldt, High Speed Combustion Engines, Oxford and IBH Publishers, New Delhi

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3													
CO2			3											
CO3			3											
CO4					2									
CO5				1										

Unit-I

Engine Parts, Cooling System & Lubricating Systems

Engine Parts:

Functions of Cylinder or Engine block:

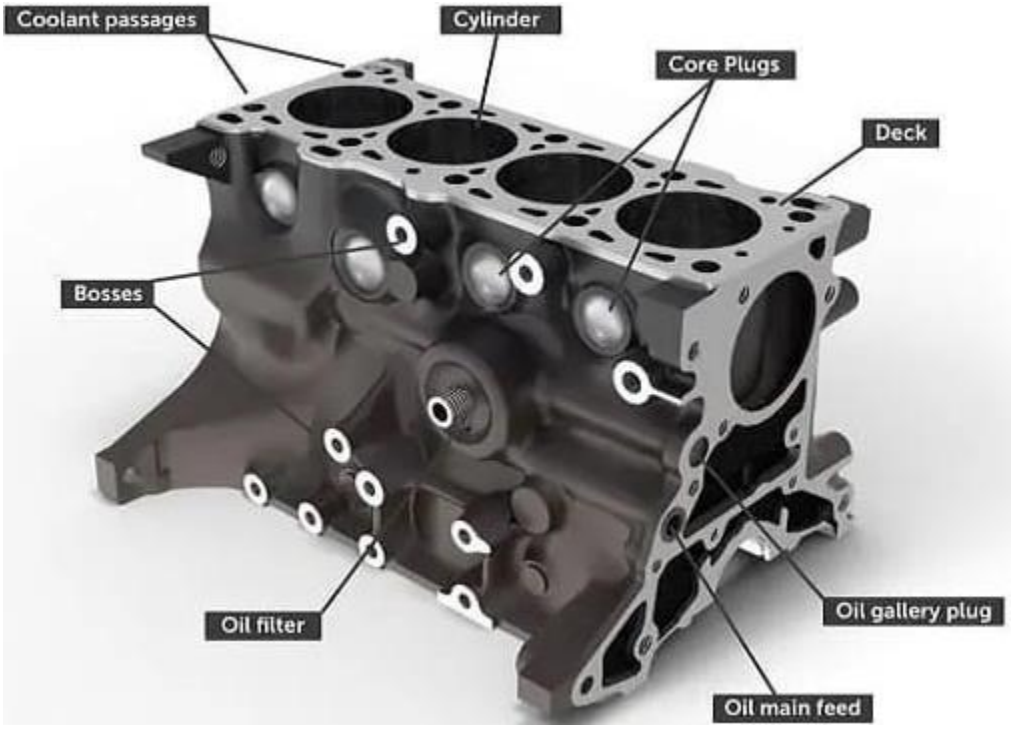
Functions of an engine include a variety of tasks essential for the optimum working of an internal combustion engine. These include:

- Enclose the piston, connecting rod, and crankshaft making sure they work properly inside the cylinder.
- Transfer of the gas forces used in the engine for the combustion process.
- Crankshaft drive mounting.
- Provide connection of the cylinder heads.
- Mounting of the camshaft.
- Mounting of the crankshaft.
- Pathway for transportation of lubricants and coolants.
- Connecting to the transmission via the flywheel drive.
- Sealing of the crankcase with the help of an oil sump.
- Circulation of water in water-cooled engines to keep the engine temperature within the working range and avoid excessive expansion.

Constructional details of Cylinder block:

An engine block consists of the following major parts:

- Cylinders
- Cylinder head
- Water pump mounting
- Core plugs
- Oil passages
- Head studs
- Oil filter
- Crankshaft
- Crankcase
- Head gasket
- Intake and exhaust ports
- Head valves



Cylinders:

The cylinders of an engine block are considered the most important part of an engine. It is responsible for the compression of the air-fuel mixture and power generation of the engine. It is also called the compression cylinder.

These are cylindrical holes on the engine block which consist of a piston moving in the upward and downward direction inside the cylinder. Each cycle of the upward and downward movement is called a stroke.

Modern engines generally consist of 4-stroke engines which are namely suction/intake stroke, compression stroke, power stroke, and exhaust stroke. The air-fuel mixture enters in the suction stroke, gets compressed in the compression stroke, generates power in the power stroke, and gets released through the exhaust in the exhaust stroke.

The size and number of cylinders present in the engine decide the cubic capacity and power generation capacity of the engine. It varies according to the power required and the type of engine.

Cylinder head:

The cylinder head or deck is the portion that sits above the cylinder and forms the roof of the combustion process in the cylinder. It is the upper portion of an engine block. It consists of the intake manifold, exhaust manifold, and coolant passageways.
The major function is the flow of intake and exhausts air-fuel mixture in and out of the cylinders after combustion. Another major function of the cylinder head is cooling the engine.

Methods of cooling are using two mediums, air, and water. Modern engines prefer water cooling rather than air cooling.

The coolant water flows through different parts of the engine block through the passages to the cylinder head and absorbs the heat produced in the combustion chamber. Generally made up of gray cast iron or aluminum alloy.

Water pump:

The water pump is located at the end of the cylinder head and is driven by a belt which also drives the alternator. It is also called a coolant pump. It supplies and regulates the circulating coolant water to the engine block required for cooling the engine through the coolant passages.

It is a very vital part of the cooling system as it ensures the engine maintains optimum working temperature and prevents overheating of the engine.

Core plugs:

The function of the core plug is to stop the coolant water from leaking out from the engine. It acts as a cap of the engine block at the end of the coolant passages.

Oil passage:

Lubrication is very important for the proper working and maintenance of the engine. The oil passages and galleries of the engine block are used to supply oil to lubricate different parts of the engine.

Head studs:

Head studs are used to withstand high loads to keep the cylinder head sealed tightly against the block. Threads are cut out equidistant from the center of the engine block in a single axis and provide accurate clamping forces. Head studs are preferred because they are less likely to twist when exposed to torque.

Oil filter:

The oil filter is generally located at the tail end or under the cylinder block. The function of this filter is to remove as many contaminants as possible before the lubricating oil is recirculate into the engine.

Crankshaft:

The crankshaft is the rotating part in the engine which brings about the movement in the piston and is converted into strokes.

It is connected to the connecting rod on which the piston is mounted. When the crankshaft rotates it causes up and down movement of the connecting rod thus affecting the piston.

Crankcase:

The crankcase is the casing of the crankshaft. It is mostly located below the cylinder block. It is used to avoid contamination of the crankshaft material. It may also contain a camshaft and an oil pump, depending upon the design of the engine.

Head Gasket:

It is the gasket located in between the cylinder head and cylinder block. It is responsible for acting as a sealant and separating the flow of elements in the head and block.

A broken head gasket can result in coolant from the head mixing up with the elements in the cylinder block.

Inlet and exhaust ports:

These ports are part of the cylinder head. An intake port is used to supply air into the combustion chamber through a channel.

An exhaust port is used to remove the gases after the combustion process and avoid the buildup of internal pressure in the chamber.

Head valves:

The purpose of valves in the engine is to stop or prevent the entry of air and fuel into the combustion chamber.

Each cylinder has two valves namely, the intake valve and the exhaust valve. The intake valve is comparatively larger in size and the exhaust valve is smaller in size.

Cylinder Liner

The cylinder liner is a sleeve in which the piston of an engine reciprocates.

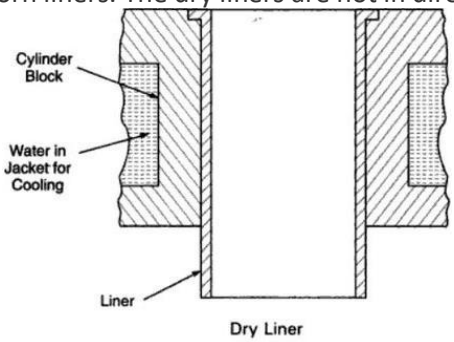
Types of Cylinder Liners

The cylinder liners or sleeves are of two types:

1. Dry liners
2. Wet liners

1. Dry Liners

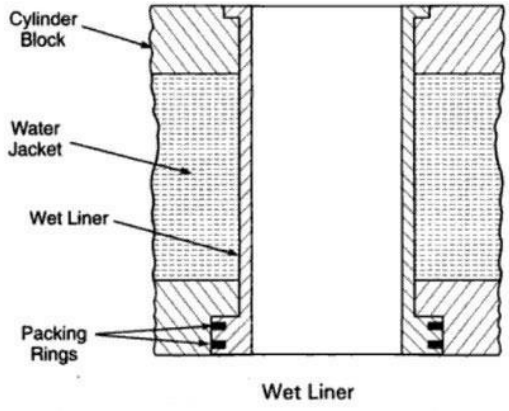
Dry liners are made in the shape of a barrel having a flange at the top. The flange keeps the liner in position in the cylinder block. The liner fits accurately in the cylinder. The perfect contact of the liner with the cylinder block is necessary for the effective cooling of the liner. Also, the gas pressure, piston thrust and impact loading during combustion are resisted by the combined thickness of the liner and the cylinder. Therefore, dry liners are thinner, having wall thickness varying from 1.5 mm to 3 mm and are used mostly for reconditioning worn liners. The dry liners are not in direct contact with cooling water.



Dry Liner

2. Wet Liners

A wet liner is so-called because the cooling water comes in contact with the liner. This liner is provided with a flange at the top, which fits into the groove made in the cylinder block. To stop leakage of cooling water in the crankcase, the lower end of the wet liner is sealed with the help of sealing rings or packing rings. As the wet liner has to withstand gas pressure, thrust and impact loading, the wall thickness of the liner is increased and is made more than that of the dry liner. Generally, the wall thickness of the wet liner ranges from 3 mm to 6 mm. The outside of the liner is coated with aluminum so that it is protected from rust. The wet liner is better cooled than the dry liner. It is easily removable when it is worn-out or damaged.



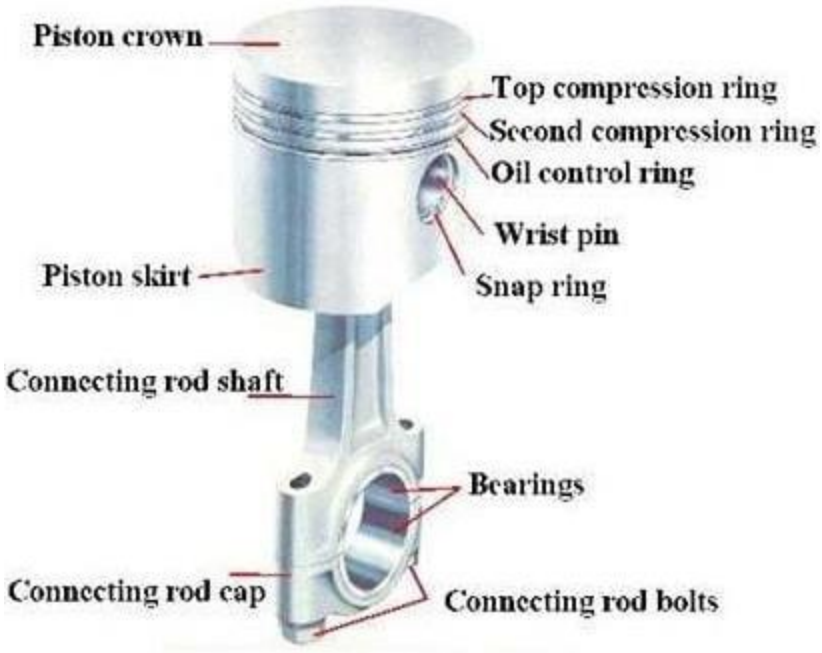
Wet Liner

Difference between Dry Liners and Wet Liners

S.No.	Dry Liner	Wet Liner
1	Dry liner is not in direct contact with of cooling water	Wet liner is in direct contact with of cooling water cooling water
2	It is difficult to replace	It is easy to replace
3	No leak proof joint is Provided	A leak proof joint between cylinder casting and liner has to be provided
4	The casting of cylinder block is complicated	The casting of cylinder block is simplified
5	Block is more robust	Block is less robust
6	Very accurate machining of block and outer liner surface is required	Very accurate machining of block and outer liner surface is not required
7	A dry liner cannot be finished accurately before fitting	A wet liner can be finished accurately before fitting

Piston:

A Piston slides inside the cylinder in reciprocating motion and transfers mechanical energy to the crankshaft with the help of connecting rod. The piston is designed in such a way that it is strong, light, and sufficient handle the pressure and temperature which are generated after the combustion of fuel. The piston is made up of cast iron or sometimes made of aluminum alloy.



Piston Rings:

The piston rings are used to provide the sealing effect between the cylinder and the piston. It helps to do not leak the engine's combustion gas and bypass the piston and also helps to overcome the friction around the piston.

Piston rings are made up of cast iron and alloy cast iron. It is of two types:

1. Compressor Ring (Pressure Ring)
2. Oil Controller Ring

Compressor Ring transfers heat from the piston to the cylinder liner and it is inserted into the top grooves of the piston. Compressor rings are also used to overcome the side thrust over the piston which causes fluctuations. The oil controller ring maintains the proper lubrication between the cylinder and the piston and is placed under the pressure ring. it also maintains access to lubrication.

Connecting Rod:

A connecting rod is used to connect the piston to the crankshaft with the help of a piston pin and crank pin. Connecting rod transmits the reciprocating motion of the piston to into rotary motion of the crankshaft so this is works as a lever arm that transfers the motion from one end to another end. One end is called the big end which is connected to the crankshaft and another end is called the small end which is connected to the piston. Connecting rod made up of Low carbon steel, for the small engine, it is made up of cast aluminum alloy by the manufacturing process of Heat treatment and forging process.

Crank:

Crank means simply rotating or turning the engine's crankshaft. The crank works as a rotating member that receives power from the connecting rod and transmits to the crankshaft, so the crank works as a lever between the connecting and crankshaft.

Crankshaft:

In an engine, the crankshaft receives the power or efforts or thrust by the piston through the connecting rod and transmits this power of reciprocating motion of the piston into rotary motion of the crankshaft which is further connected to the flywheel and transmission shaft which is used to move the vehicle. Crankshaft made by casting and forging process using the material of alloy steel or cast iron.

Cam Shaft:

It is a vital part of an IC Engine; it is used for opening and closing of Valves at the right time. The rotation of the camshaft is half of the crankshaft in a four-stroke engine, and a two-stroke engine rotation of both crank and camshaft is same. It is made of Cast Iron or Steel.

Air Cleaner:

An air cleaner or air filter is any device that stops particles that are present in the air from entering air-breathing machinery. Special features include an air cleaner that filters exhaust emissions from other cars. The carburetor breathes through an oil bath air cleaner.

Manifold:

There are two manifolds in the engine Intake and Exhaust Manifold.

Intake manifold: The intake manifold is connected to inlet valves; it is the pipe that helps to provide air-fuel mixture into the engine for proper combustion. Whereas in diesel engine intake manifold is used for bringing only air to the combustion chamber.

Exhaust Manifold: Exhaust manifold is responsible for taking out the exhaust gases from the combustion chamber after combustion which is further connected to the exhaust valves and its design and construction are the same as the inlet manifold.

Mufflers:

A muffler or silencer is a device for reducing the noise emitted by the exhaust of an internal combustion engine.

Cooling System:

Need for cooling of Automobile:

The cooling system serves mainly three important functions.

1. It removes excess heat from the engine.
2. It maintains the engine operating temperature where it works most efficiently.
3. It brings the engine up to the right operating temperature as quickly as possible.

Types of cooling systems:

There are two types of cooling systems:
(i) Air cooling system and
(ii) Water-cooling system.

Air cooling system

In this type of cooling system, the heat, which is conducted to the outer parts of the engine, is radiated and conducted away by the stream of air, which is obtained from the atmosphere. In order to have efficient cooling by means of air, providing fins around the cylinder and cylinder head increases the

contact area. The fins are metallic ridges, which are formed during the casting of the cylinder and cylinder head. The amount of heat carried off by the air-cooling depends upon the following factors:
(i) The total area of the fin surfaces,
(ii) The velocity and amount of the cooling air and
(iii) The temperature of the fins and of the cooling air.

Air-cooling is mostly tractors of less horsepower, motorcycles, scooters, small cars and small aircraft engines where the forward motion of the machine gives good velocity to cool the engine. Air-cooling is also provided in some small industrial engines. In this system, individual cylinders are generally employed to provide ample cooling area by providing fins. A blower is used to provide air.

1. Its design of air-cooled engine is simple.
2. It is lighter in weight than water-cooled engines due to the absence of water jackets, radiator, circulating pump and the weight of the cooling water.
3. It is cheaper to manufacture.
4. It needs less care and maintenance.
5. This system of cooling is particularly advantageous where there are extreme climatic conditions in the arctic or where there is scarcity of water as in deserts.
6. No risk of damage from frost, such as cracking of cylinder jackets or radiator water tubes.

Water cooling system

It serves two purposes in the working of an engine:
a) It takes away the excessive heat generated in the engine and saves it from overheating.
b) It keeps the engine at working temperature for efficient and economical working.

This cooling system has four types of systems:
(i) Direct or non-return system,
(ii) Thermo-Syphone system,
(iii) Hopper system and
(iv) Pump/forced circulation system.
Though the present tractor has a forced circulation system, it is still worthwhile to get acquainted with the other three systems.

Non-Return Water Cooling System

This is suitable for large installations and where plenty of water is available. The water from a storage tank is directly supplied to the engine cylinder. The hot water is not cooled for reuse but simply discharges. The
low H.P. engine, coupled with the irrigation pump is an example.

Thermo-Syphone Water Cooling System

This system works on the principle that hot water being lighter rises up and the cold water being heavier goes down. In this system the radiator is placed at a higher level than the engine for the easy flow of water towards the engine. Heat is conducted to the water jackets from where it is taken away due to convection by the circulating water. As the water jacket becomes hot, it rises to the top of the radiator. Cold water from the radiator takes the place of the rising hot water and in this way a circulation of water is set up m the system. This helps in keeping the engine at working temperature. Disadvantages of Thermo-Syphone system
1 Rate of circulation is too slow.

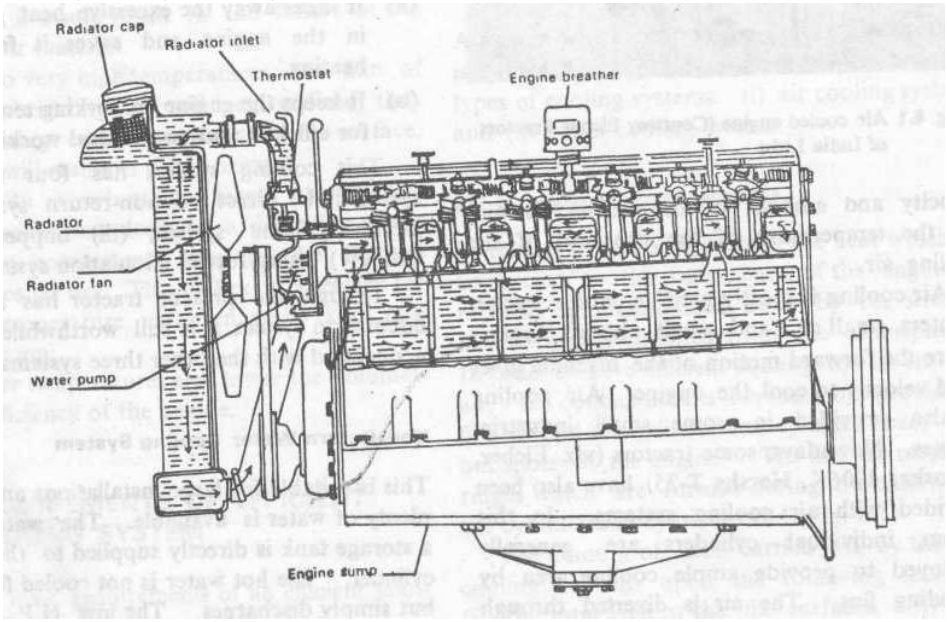
2. Circulation commences only when there is a marked difference in temperature.
3. Circulation stops as the level of water falls below the top of the delivery pipe of the radiator. For these reasons this system has become obsolete and is no more in use.

Hopper Water Cooling System

This also works on the same principle as the thermo-syphone system. In this there is a hopper on a jacket containing water, which surrounds the engine cylinder. In this system, as soon as water starts boiling, it is replaced by cold water. An engine fitted with this system cannot run for several hours without it being refilled with water.

Force Circulation Water Cooling System

This system is similar in construction to the thermo-syphone system except that it makes use of a centrifugal pump to circulate the water throughout the water jackets and radiator. The water flows from the lower portion of the radiator to the water jacket of the engine through the centrifugal pump. After the circulation water comes back to the radiator, it loses its heat by the process of radiation. This system is employed in cars, trucks, tractors, etc.



Sealed cooling system

Coolant in a sealed system does not evaporate to the atmosphere, and should never need topping up. Instead, a pressure cap is fitted to the system, and a tube leads from the top of the radiator to a glass, plastic or metal tank or container.

Components of water cooling system

The main parts in the water-cooling system are: (i) water pump, (ii) fan, (iii) radiator and pressure cap, (iv) fan belt (v) water jacket, (vi) thermostat valve, (vii) temperature gauge and (viii) hose pipes.

Water Pump

This is a centrifugal type pump. It is centrally mounted at the front of the cylinder block and is usually driven by means of a belt. This type of pump consists of the following parts: (i) body or casing, (ii) impeller (rotor), (iii) shaft, (iv) bearings, or bush, (v) water pump seal and (vi) pulley.

The bottom of the radiator is connected to the suction side of the pump. The power is transmitted to the pump spindle from a pulley mounted at the end of the crankshaft. Seals of various designs are incorporated in the pump to prevent loss of coolant from the system.

Fan

The fan is generally mounted on the water pump pulley; although on some engines it is attached directly to the crankshaft. It serves two purposes in the cooling system of a engine.

(a) It draws atmospheric air through the radiator and thus increases the efficiency of the radiator in cooling hot water.

(b)

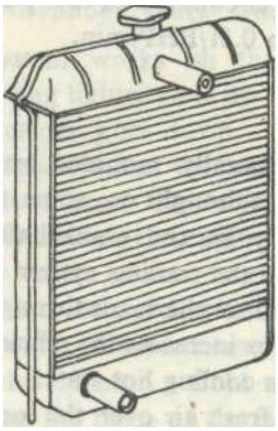
It throws fresh air over the outer surface of the engine, which takes away the heat conducted by the engine parts and thus increases the efficiency of the entire cooling system.

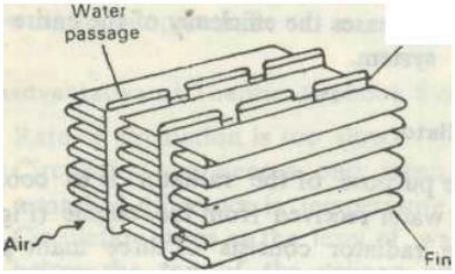
Radiator

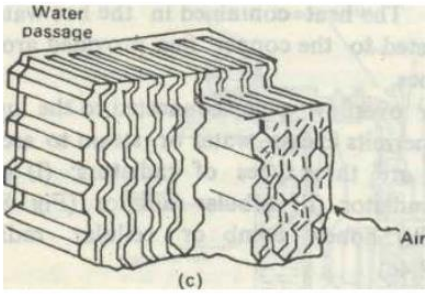
The purpose of the radiator is to cool down the water received from the engine. The radiator consists of three main parts: (i) upper tank, (ii) lower tank and (iii) tubes.

Hot water from the upper tank, which comes from the engine, flows downwards through the tubes. The heat contained in the hot water is conducted to the copper fins provided around the tubes.

An overflow pipe, connected to the upper1 tank, permits excess water or steam to escape. There are three types of radiators: (i) gilled tube radiator, (ii) tubular radiator and (iii) honey comb or cellular radiator.







Thermostat Valve

It is a kind of check valve which opens and closes with the effect of temperature. It is fitted in the water outlet of the engine. During the warm-up period, the thermostat is closed and the water pump circulates the water only throughout the cylinder block and cylinder head. When the normal operating temperature is reached, the thermostat valve opens and allows hot water to flow towards the radiator.

Standard thermostats are designed to start opening at 70 to 75°C and they fully open at 82°C. High temperature thermostats, with permanent anti-freeze solutions (Prestine, Zerex, etc.), start opening at 80 to 90°C and fully open at 92°C.

Temperature Indicators

Temperature indicators are used to indicate the driver regarding overheating or an abnormal condition of the cooling system. For this purpose, a temperature indicating light and/or gauge is installed in the

instrument panel of the car. Both balancing-coil and bimetal thermostat type gauges are in use for temperature indication. The indicator light warns the driver about the abnormal situation.

Anti-freeze solutions

In order to prevent the water in the cooling system from freezing, some chemical solutions which are known as anti-freeze solutions are mixed with water. In cold areas, if the engine is kept without this solution for some time, the water may freeze and expand leading to fractures in the cylinder block, cylinder head, pipes and/or radiators.

The boiling point of the anti-freeze solution should be as high as that of water. An ideal mixture should easily dissolve in water, be reasonably cheap and should not deposit any foreign matter in the jacket pipes and radiator. No single anti-freeze solution satisfies all these requirements. The materials commonly used are wood, alcohol, denatured alcohol, glycerine, ethylene, glycol, propylene glycol, mixtures of alcohol and glycerine and various mixtures of other chemicals.

Lubricating systems:

Need for lubrication

Lubrication is a crucial element in the efficiency and life-expectancy in automobiles. Lubrication reduces friction and allows automobile parts to move smoothly each other.

Functions of lubricating oil

- Reduce friction & wear - by creating a thin film (Clearance) between moving parts
- Seal power - The oil helps form a gastight seal between piston rings and cylinder walls
- Cleaning - Cleans As it circulates through the engine, the oil picks up metal particles and carbon, and brings them back down to the pan.
- Absorb shock - When heavy loads are imposed on the bearings, the oil helps to cushion the load
- Cooling - Cools Picks up heat when moving through the engine and then drops into the cooler oil pan, giving up some of this heat.

Properties of lubricating oil

A good lubricant generally possesses the following characteristics:

- A high boiling point and low freezing point (in order to stay liquid within a wide range of temperature)
- A high viscosity index
- Thermal stability
- Hydraulic stability
- Demulsibility
- Corrosion prevention
- A high resistance to oxidation
- Pour Point (the minimum temperature at which oil will flow under prescribed test conditions)

S.A.E grading of lubricants

SAE number code, for specifying the viscosity of lubricating oil, established by the U.S. Society of Automotive Engineers. The numbers for crankcase lubricants range from 5 to 50, for transmission and axle lubricants they range from 75 to 250; the lower the number, the more readily the oil flows.

Lubricating systems

The lubrication system can be classified into the following ways:

1. Petroil system
2. Splash system
3. Pressure system
4. Semi-pressure system
5. Dry sump system and
6. Wet sump lubrication system

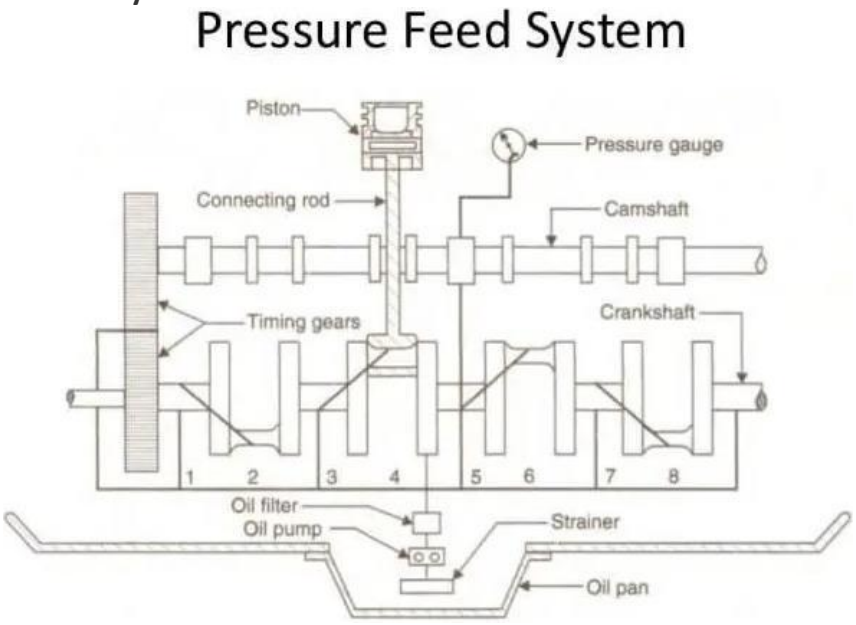
1. Petroil Lubrication System:

- This system is generally used in the two-stroke petrol engines like scooters, motorcycles.
- In this type of system, a certain amount of oil is mixed with petrol itself. therefore 3 to 6% of oil mixed with fuel.
- If this proportion is more, the engine gives dark smoke and excessive carbon deposits on the cylinder head.

2. Splash Lubrication System:

- This is the most popular type of lubrication system duly used in cars extra.
- It consists of a scoop, which is fitted at the lower end of the connecting rod as shown in the diagram.
- As when the engine runs scoop splashes, the oil from oil through by centrifugal force to all engine parts.

3. Pressure Lubrication System:



- Oil from the sump will be supplied to the engine parts through main galleries, via strainer and filter.
- The pressure of oil is about 2 to 4kg/cm2.
- For camshaft and timing gears, oil is supplied by a separate line through the pressure reducing valves.
- In this type of system, oil is pressurized by using a gear pump

4. Semi-Pressure Lubrication System:

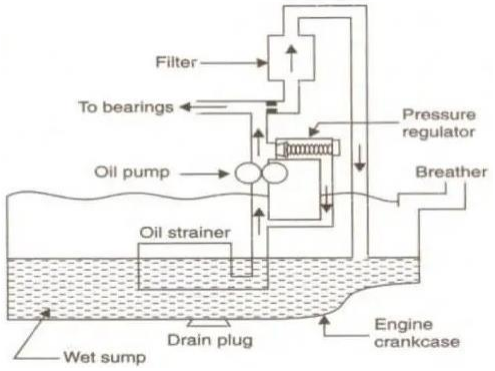
- In this type of system, the oil pressure is between 0.4 to 1 kg/cm2.
- In this system, some parts are lubricated by the splash system and some parts are by a pressure system.
- The parts such as cylinder wall, piston, piston pin, connecting rod extra are lubricated by splash system and remaining parts are by a pressure system.

5. Dry Sump Lubrication System:

- This system consists of two pumps.
- One scavenging pump placed below the sump, other pressure pump placed at the tank.
- Scavenging pumps supply lubricating oil to the main tank through the filter and, a pressure pump supplies oil to the different parts of an engine through the oil cooler.
- A dry-sump system gets you a couple of bonuses: First, it means the engine can sit a little lower, which gives the car a lower center of gravity and improves stability at speed.
- Second, it keeps extra oil from soaking the crankshaft, which can lower horsepower.
- And, since the sump can be located anywhere, it can also be any size and shape.
- In this system, the pressure of oil is about 4 to 5 kg/cm2.
- Here sump is kept dry. Hence called a Dry sump lubrication system.
- This type of system is used in the sports car, and certain military vehicles extra.
- In brief, an engine lubrication system in which the lubricating oil is carried in an external tank and not internally in a slump.
- The sump is kept relatively free from oil by scavenging pumps, which return the oil to the tank after cooling.
- The opposite of a wet sump system.
- The pumping capacity of scavenging pumps is higher than that of the engine-driven pumps supplying oil to the system.

6. Wet Sump Lubrication System:

Lubrication System – Wet Sump



- In this system, the pressure of oil is about 4 to 5kg/cm2.
- After lubrication oil is drawn back to the oil sump.
- Hence called a wet sump lubrication system.
- The advantage of a wet sump system is its simplicity. And the oil is close to where it will be used, there aren't too many parts to engineer or repair, and it's relatively cheap to build into a car.

Pre-lubrication system

All engines suffer from accelerated wear as a result of periodic dry starts - especially today's high performance, fast starting diesels; and the larger the engine, the more significant the cost. Dry starts can occur in very cold weather, very hot climates, after prolonged shut-downs, or following routine oil changes.

Use of the engine prelube system will significantly reduce key engine component wear resulting in considerably longer engine life and lower operating costs. This has important implications for single shift operations, for marine and prime power and industrial applications where engines are operated for less than 2000 hours per year.

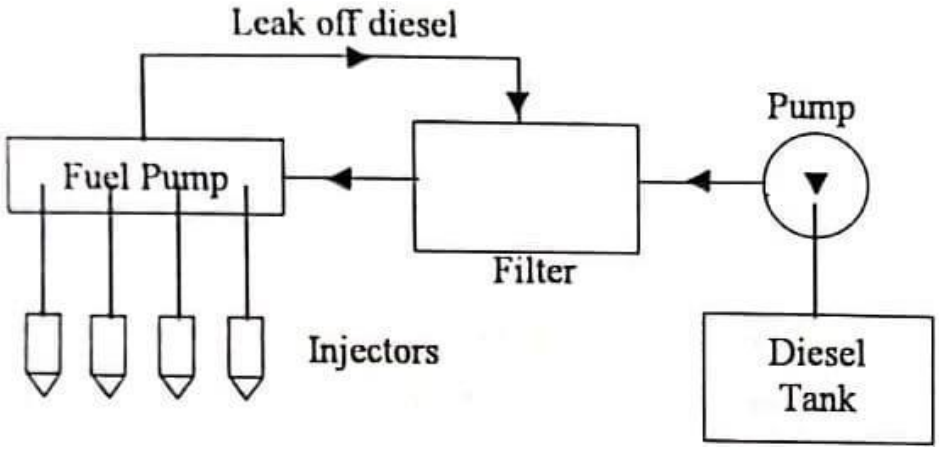
Prelube Key Benefits:

- Eliminate the Danger: Removes the danger of starting the engine with no oil
- Automatically Wired: Simply turn the machine's existing start switch to the "start" position and the prelube starter will automatically pressurize the engine with oil pressure.
- Protect Bearings: Guards bearings during cold weather or hot climate starts

Unit-II

Fuel supply systems:

Fuel supply system of diesel engine:



During engine operation, the fuel is supplied by gravity from fuel tank to the primary filter where coarse impurities are removed. From the primary filter, the fuel is drawn by fuel transfer pump and is delivered to fuel injection pump through second fuel filter. The fuel injection pump supplies fuel under high pressure to the injectors through high pressure pipes. The injectors atomise the fuel and inject it into the combustion chamber of the engine. The fuel injection pump is fed with fuel in abundance. The excess fuel is by-passed to the intake side of the fuel transfer pump through a relief valve. The main components of the fuel system in diesel engine are: (1) fuel filter (2) fuel lift pump (3) fuel injection pump (4) atomisers and (5) high pressure pipe.

Two conditions are essential for efficient operation of fuel system: (i) The fuel oil should be clean, free from water, suspended dirt, sand or other foreign matter, (ii) The fuel injection pump should create proper pressure, so that diesel fuel may be perfectly atomised by injectors and be injected in proper time and in proper quantity in the engine cylinder. Fuel should be filtered before filling the tank also. If these precautions are followed, ninety per cent of diesel engine troubles are eliminated.

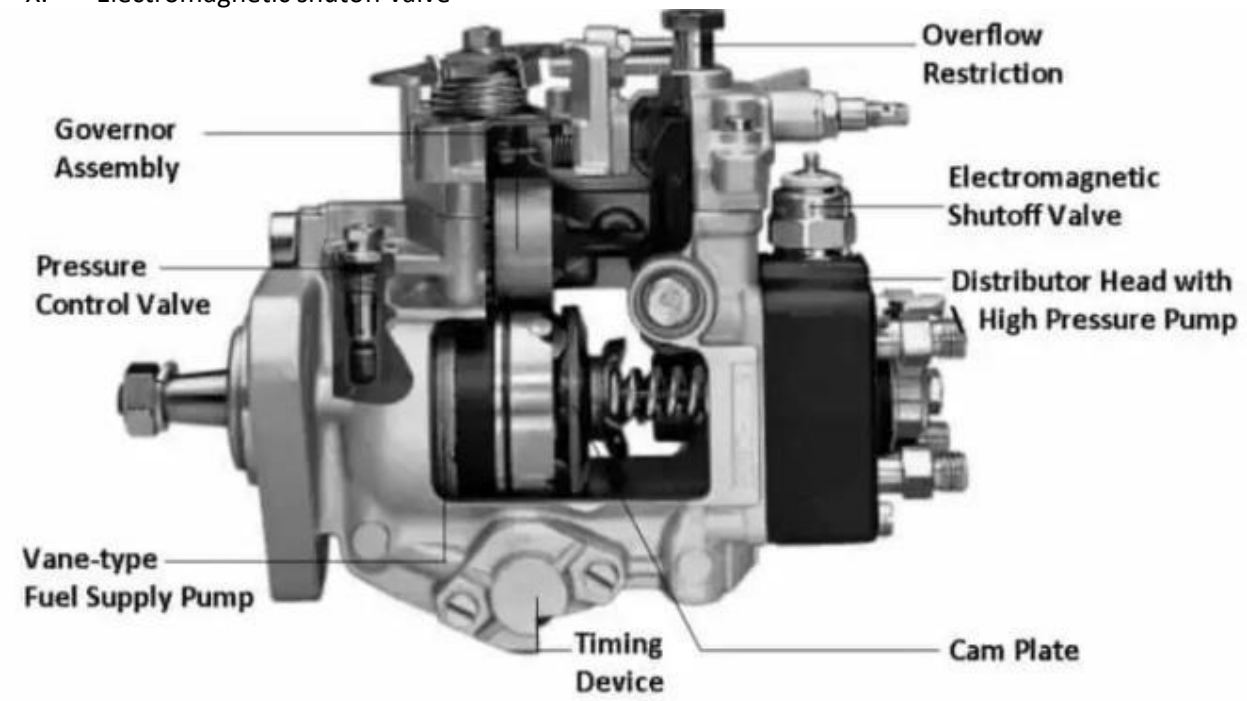
Fuel Injection Pump

A fuel injection pump is a device in an automobile that pumps fuel into the cylinders of a gasoline or diesel engine. The injection pump is driven indirectly from the crankshaft by a gear, chain, or timing belt, which also operates the camshaft.

Parts of Fuel Injection Pump

Following are the main parts of a fuel injection pump:

I. Delivery valve
II. Distributor plunger
III. Pressure control valve
IV. Governor assembly
V. Overflow restriction
VI. Distributor with high-pressure pump
VII. Vane-type fuel-supply pump
VIII. Timing device
IX. Cam plate
X. Electromagnetic shutoff valve



Parts of Fuel Injection Pump

Working of Fuel Injection Pump

It is a major component of the fuel injection system that performs various functions to keep the car running smoothly. The primary function of the injection pump is to extract fuel from the fuel tank and pump it to all the injectors at high pressure.

There is only one function of a fuel injection pump in an electronic fuel injection system, and that is to pressurize the fuel line. In an inline fuel injector pump, it helps measure or meter the amount of fuel supplied to the injectors.

Another crucial function of the fuel injection pump is to deliver fuel to all the injectors at precise times for combustion. In inline fuel injection, individual plungers and fuel barrels are used for each engine cylinder to supply fuel to all injectors. But in a distribution pump, the rotor allows fuel distribution to all the cylinders.

It is because of the fact that fuel injectors are directly subjected to the combustion process. Thus, the fuel injectors are exposed to a higher temperature during combustion. The fuel injection pump helps cool the fuel injectors by pumping low-temperature fuel into the injectors.

Types of Fuel Injection Pumps

The following are the main types of fuel injection pumps:

1. Individual Inline fuel injection pump
2. Distributor fuel injection pump
3. Continuous fuel injection pump

1 Individual Inline Fuel Injection Pump

It is an individual inline injection pump in which a plunger mechanism will perform each injector. In other words, the number of plungers is the same as the number of injectors. All these plungers are installed together in a line position in a pump unit, hence the name.

The inline fuel injection pump consists of the camshaft, plunger, and fuel barrel. The camshaft has the number of cams according to the number of plungers. A plunger works to increase fuel pressure. The fuel barrel is the small space where fuel is placed to be transferred to the injectors.

When the crankshaft rotates, the camshaft pump also rotates; resulting in the rotation of the camshaft causes the cam being alternately pressed against the plunger. As soon as the plunger is pressed, the fuel pressure increases, causing fuel to be sprayed from the injectors.

2 Distributor Fuel Injection Pump

It is small in size and used as a solution for vehicles with limited space. The main part of the distributor pump is its injection system. In the inline type, one plunger is used for one injector, but in the distributor type, one plunger is used for all injectors.

In this type, a plunger will alternately pressurize all the fuel in each fuel barrel. The fuel barrel can be found somewhere around the pump shaft. Pump shaft rotation causes the plunger to alternately press the fuel in the barrel when the ignition timing changes.

Despite the small design of the distributor pump, it does not have high fuel pressure. Because of this, it is rarely used for high-capacity diesel engines.

3 Continuous Fuel Injection Pump

The continuous pump is a modern type used as an injection pump that is applied to the general direct injection system. In terms of size, this pump is the smallest of the other two types of injection pumps. Due to this, it has only a single function.

Its primary function is to steadily increase fuel pressure to a high-pressure range from 30,000 – 40,000 PSI. In addition to increasing fuel pressure, the above two types control the timing and amount of fuel injected. So the form should be pretty straightforward.

This pump works like a water pump because it has a turbine, although some types use membranes as well. The pump will pressurize the fuel and maintain the fuel pressure at the applicable range.

Supercharging of diesel engines

The diesel engines are widely used in agriculture and engineering fields by its significant power, economy and emissions targets. The power of diesel engines is come into being by combustion of the fuel in the cylinder, which is restricted by the amount of fuel and the air sucked into the cylinder. The application of supercharger technology has greatly improved the performance of diesel engines. The air entering into the cylinder is increased by the supercharger technology that can not only improve the power of diesel engines but also ameliorate the economy of diesel engines by reducing the fuel consumption.

Air in the diesel engine air intake system is compressed into the cylinder for greater density so as to contain more oxygen molecules per unit volume requiring more fuel injected in accordance with the theoretical air-fuel mixing, so that greater density and quality of the combustible mixture will be obtained under constant displacement which can release more heat after burning to convert a greater driving force thereby. This is the supercharger working principle. In addition, the combustion is more thorough due to sufficient amount of air entering not only improving fuel economy but also reducing harmful exhaust emissions.

Fuel Supply system for petrol engines

The fuel supply system in a petrol engine comprises various components that work together to transfer a set amount of fuel from a car's fuel tank to its engine for combustion. These components include a fuel tank, fuel pump, carburetor, fuel injectors, fuel filters and fuel lines.

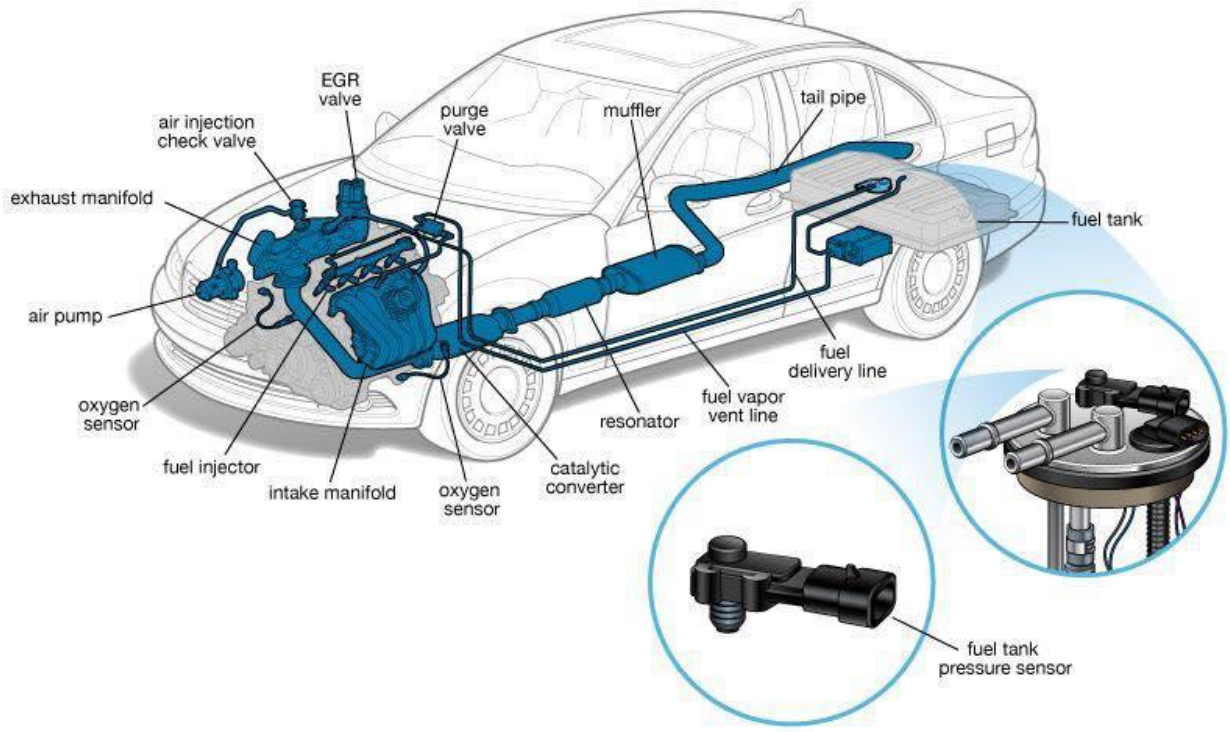
The primary function of this system is to store and supply fuel for the engines. Petrol gets drawn from the tank through fuel lines to the injector by fuel pumps. The fuel injection system pumps the required fuel to a car's engine for combustion.

Components

1. Fuel Tank

The fuel tank is the main storage for the fuel that runs the vehicle. Generally speaking, the gas tank is generally found at, or under, the rear of the vehicle.

2. Fuel Pump



The fuel pump is used to pump the fuel from the fuel tank, via the fuel lines into the fuel injectors, which spray the fuel into the combustion chamber- in order to create combustion. There are two types, mechanical fuel pumps (used in carburetors) and electronic fuel pumps (used in electronic fuel injection).

• Mechanical fuel pumps: these are driven normally by auxiliary belts or chains from the engine.
• Electronic fuel pumps: controlled by the electronic fuel injection system, these are normally more reliable and have fewer reliability issues than their mechanical counterparts.

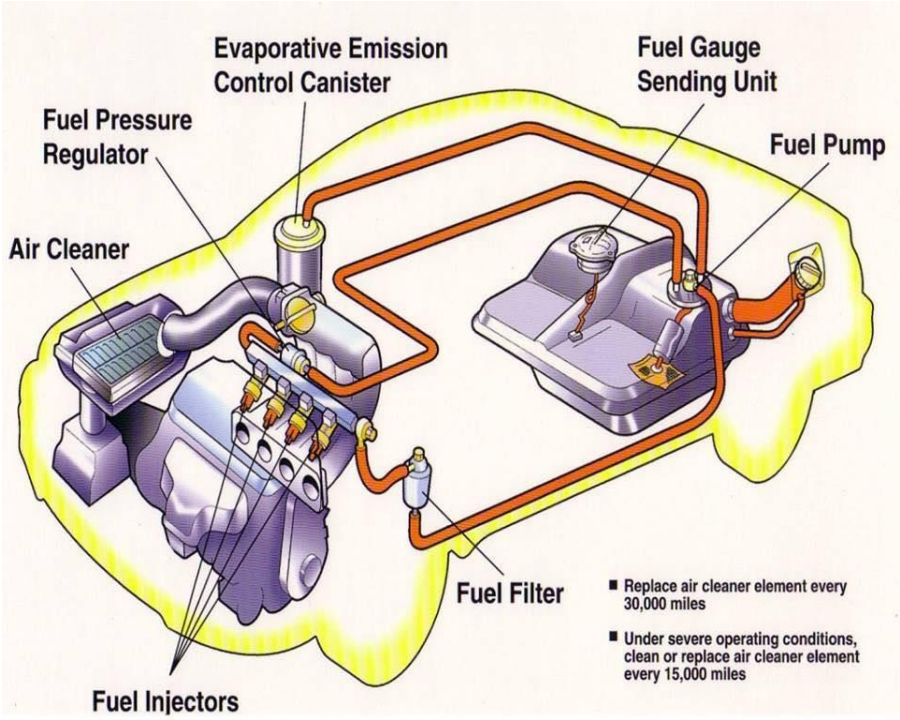
3. Carburetor

The process of preparing an air-fuel mixture away from the cylinders of an engine is called carburetion and the device in which this process take place is called carburetor.

4. Fuel Injectors

Sprays a fine mist of fuel into the combustion chamber of each cylinder or throttle body, depending on the design. The fuel injectors are driven by the fuel pump and their job is to spray a fuel and air mixture into the combustion chamber, ready to be ignited to produce power to the driven wheels. The fuel injectors are basically a nozzle, with a valve attached; the nozzle creates a spray of fuel and air droplets (atomization). This can be viewed similar to that of a perfume dispenser or deodorant can in principle, spraying a fine mist.

5. Fuel Filter



The fuel filter is the key to a properly functioning fuel delivery system. This is truer with fuel injection than with carbureted cars. Fuel injectors are more susceptible to damage from dirt because of their close tolerances, but also fuel injected cars use electric fuel pumps. When the filter clogs, the electric fuel pump works so hard to push past the filter that it burns itself up. Most cars use two filters. One inside the gas tank and one in a line to the fuel injectors or carburetor. Unless some severe and unusual conditions occur to cause a large amount of dirt to enter the gas tank, it is only necessary to replace the filter in the line.

6. Fuel Lines

The Fuel Lines connect all of the various Fuel System components. Steel lines and flexible hoses carry the fuel from the tank to the engine. When servicing or replacing the steel lines, copper or aluminum must never be used. Steel lines must be replaced with steel. When replacing flexible rubber hoses, the proper hose must be used. Ordinary rubber such as used in vacuum or water hose will soften and deteriorate. Be careful to route all hoses away from the exhaust system.

Types of Fuel Supply Systems in Petrol Engines

Below are the various kinds of fuel supply systems in petrol engines that you will find in modern cars:

1. Gravity system

The manufacturers mount the fuel tank at the spark-ignition engine's highest point in this fuel system. Petrol drops into the carburettor from its highest position due to gravity. The mechanisms of this fuel system are quite simple and extremely inexpensive. Therefore, one can find gravity systems in small

engines with less fuel consumption. Moreover, manufacturers do not develop good heads for large engines.

Advantages:

- The gravity fuel system is cheaper than all other fuel supply systems.

Disadvantages:

- It causes rigidity when the manufacturers mount the petrol tank over the carburetor.

2. Pressure system

In this fuel system, car manufacturers place a pressure seal tank or an air-tight tank to neat a car's engine or under the seat. A pump creates pressure with the help of air and then pushes petrol towards the combustion chamber.

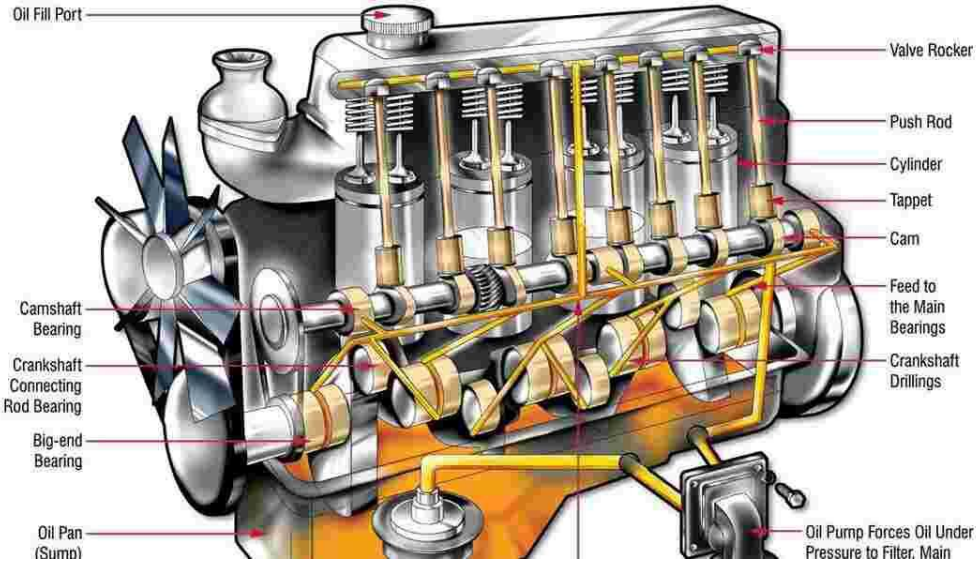
Advantages:

- Car manufacturers can choose to place the petrol tank in any suitable location.

Disadvantages:

- Pressure can leak anytime from air-tight enclosures within its chambers.

3. Pump system



A steel pipe is placed in this fuel supply system, and its job is to carry petrol to the fuel pump. This fuel pump then pumps petrol into the float chamber inside the carburetor through another steel pipe. Nowadays, mechanical, electrical, and diaphragm pumps supply petrol from the fuel tank.

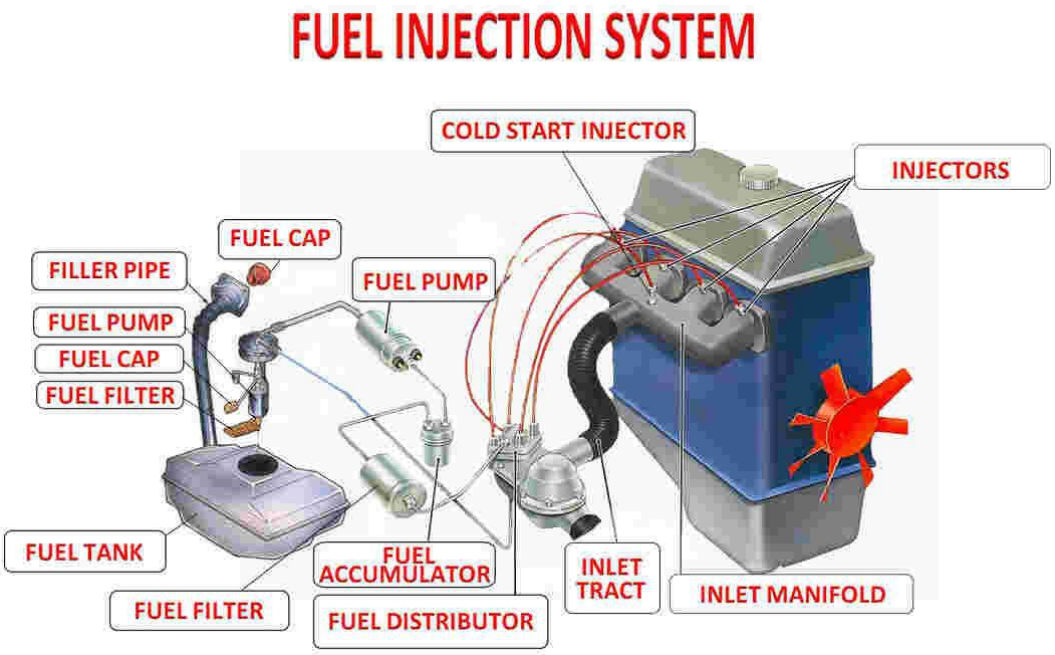
Advantages:

- This system can be easily used for all types of vehicles, from trucks and buses to cars.

Disadvantages:

- Placing a fuel pump is essential for these systems because, without the help of the pump, the petrol will not move. However, this increases the overall cost.

4. Fuel Injection System



This fuel supply system is most prevalent in modern cars. In this system, the air injector nozzle atomises fuel from the petrol tank and sends these particles into the air stream. Manufacturers sometimes use separate injectors for each cylinder or just one for all the cylinders.

Advantages:

- Fuel injection systems are advanced, and, as a result, they are the most accurate among all other systems.
- Such systems can quickly warm up and start a car's engine.
- Fuel injection system enables engines to develop high power.
- These consume less petrol in certain instances.

Disadvantages:

- Setting up this fuel supply system can be quite expensive initially.
- In some cases, petrol backflows can occur.

Carburetor:

A carburetor is a component in an automobile engine that is designed to take in the exact air and fuel needed for proper combustion. The part has been the heart of a vehicle's engine making it run smoothly and give better horsepower. Carburetors are so perfect that even at cold starting or running hot at high speed, getting the exact fuel/air mixture is the job of the mechanical gadget.

The working of this component is quite complex in car engines but let me explain. If you have enough atoms of oxygen to burn all your atoms of fuel, that is known as a stoichiometric mixture. The term is

used in chemistry to ensure there is enough of each ingredient before a recipe is cooked. In the case of an automobile engine, the ratio is usually around 14.7 parts of air to 1 part of fuel.

Although it's determined by what the fuel is made of. When an engine burns "lean" it's the cause of too much air and lesser fuel, while too much fuel and lesser air are called burning "rich." Note that having slightly too little air (a slightly rich mixture) will offer better performance. Slightly too much air (a slightly lean mixture) will give better fuel economy.

Too much air is not good for engines so having too little, so there should be a proper amount of air intake. So, a simple definition of the carburetor is that it is a device for mixing air with fuel in a system for proper burning of fuel. It's only seen in gasoline engine that works with spark ignition. Apart from a spark ignition engine, the carburetor is found in small engines for lawnmowers, generators, rototillers, and other equipment.

Functions of Carburetor

Below are the functions of a carburetor in an automobile engine as well as other equipment:

- As earlier mentioned, the primary function of a carburetor is to allow a suitable amount of air and fuel needed to produce power. It's done at the correct strength under all conditions of load and speed of the engine.
- It regulates the air-fuel ratio and also mixes the fuels.
- Controls the engine speed.
- According to the engine speed and load changes, carburetors increase or decrease the amount of mixture.
- It vaporizes the fuel and mixes the air into a homogeneous air-fuel mixture.
- Also, help to keep a certain head of fuel in the float chamber all the time.
- Helps the fuel to burn smoothly and properly without any problem.

Working of a simple Carburetor

The working of a carburetor is quite simple but complex depending on the design. However, the simplest is the one with a large vertical air pipe above the engine cylinders. It has a horizontal fuel pipe joined into one side. As airflow down the pipe, it passes through a narrow kink in the middle. This kink makes it speed up and causes its pressure to fall. The kink is known as venturi. The sucking effect that draws air in through the fuel pipe at the side is caused by the falling pressure of the air.

The airflow pulls the fuel along causing their mixture, which is its intended purpose. The mixture is caused in the carburetor by two swiveling valves which are located above and below the venturi. The valve at the top is called "Choke", it regulates the amount of air that flows in the carburetor. If this choke is closed, a little amount of air flows down through the pipe and the venturi sucks in more fuel. This caused the engine to get a rich fuel mixture which is helpful when the engine is cold, first starting up, and running slowly.

Below the venturi, the second valve is known as the “Throttle”. It determines the amount of air that enters the carburetor and the amount of fuel it drags in from the pipe to the side. As the throttle is opening the air and fuel flowing in makes the engine release more energy and makes more power making the vehicle move faster. Thus, the throttle makes the car accelerate. The throttle is connected to the accelerator pedal in a car and on the handlebar of a motorcycle.

Advantages:

Below are the benefits of carburetors in an automobile engine:

- Carburetor parts are less expensive when compared to that of fuel injector.
- The air and fuel mixture is perfectly done with the component.
- It has more power and precision than the air/fuel mixture.
- The engine component is not restricted by the amount of gas pumped from the fuel tank. This is to say; the cylinders may pull more fuel through the carburetor leading to greater power and denser mixture in the chamber.

Disadvantages:

Despite the great benefits of carburetors some limitations still occur. Below are the disadvantages of a carburetor in an engine:

- The mixture supplied at a very low speed is weak making the engine not perfectly ignite.
- The engine part can be affected by changes in atmospheric pressure.
- More fuel is consumed more fuel when compared with fuel injectors.
- More air emissions than fuel injectors.
- Higher maintenance than fuel injectors.

Air-Fuel Ratio:

The air-fuel ratio (AFR) is the mass ratio between the amount of air and fuel that are mixed together in the combustion chamber of a vehicle. This ratio needs to correct for the fuel to burn correctly and efficiently.

If the ratio is too rich or too lean, the engine will not burn optimally burn the air-fuel mixture which can cause performance issues or use up too much fuel. The ideal air-fuel ratio that burns all fuel without excess air is 14.7:1. This is referred to as the “stoichiometric” mixture. In this case you have 14.7 parts of air for every 1 part of fuel.

Types of air fuel ratios

- RICH air-fuel ratio: There is less air than the ideal AFR. This can be good for power but bad for fuel economy and emissions. (example: 13:1)
- LEAN air-fuel ratio: There is more air than the ideal AFR. This can be good for fuel economy and emissions but bad for power. (example: 16:1)

- IDEAL air-fuel ratio: There is the correct mixture of air to fuel for proper combustion. (example: 14.7:1)

Air-Fuel Ratios at different vehicle running conditions

Starting Up

When starting your car, all engine components such as the cylinder head, cylinder blocks, and intake manifold, are cold. Some extra fuel is needed to start the engine in this case so a rich fuel mixture is temporarily needed.

An easier way of describing this is that on older cars with carburetors, the choke was used to block off air so more fuel would be pulled into the engine to start the car.

When starting your engine, the air-fuel ratio can be as **low as 9:1**, making it very rich.

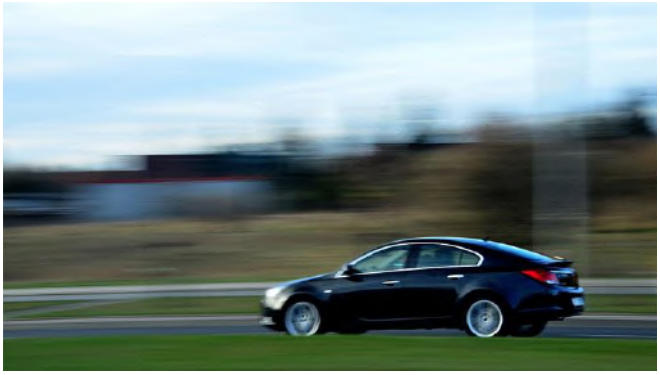
Warming Up (Idling)

After startup and while your engine is still idling, the coolant temperature is still low and more fuel than normal is still needed until the vehicle warms up to operating temperatures. So in this case, a rich AFR of **about 12:1** is necessary.

Accelerating

When the accelerator pedal is being depressed to gain speed, more air comes into cylinder to meet the extra power requirement so naturally more fuel is needed. At full throttle, the air-fuel ratio can be **around 11:1** (very rich) while moderate acceleration can mean about a **13:1** (rich) air-fuel ratio.

Cruising (Constant Speed)



In this condition, the engine is already warmed up, and the air-fuel mixture is near the stoichiometric ratio which is **about 14.7:1**. This allows for the best combination of fuel economy, emissions, and power.

Heavy Loads

Under heavy loads such as going uphill or if you are towing a trailer, the vehicle requires the engine to produce more power. This means a rich air-fuel ratio similar to accelerating is needed for the excess demands when under heavy loads. The AFR will be somewhere **around 12:1**.

Decelerating

Under this condition, the accelerator pedal is released, which means no power output is needed from the engine other than to it keep running. An air-fuel ratio of **about 17:1** (lean) will exist at this point as the fuel demands are very low at this point. At this stage, the exhaust gases are cleared out as well.

Carburetor System

In order to mix fuel and regulate speed, the carburetor has a series of fixed and variable passages, jets, ports, and pumps, which make up the fuel metering systems or circuits. There are six basic systems common to all carburetors :

(i) Float system

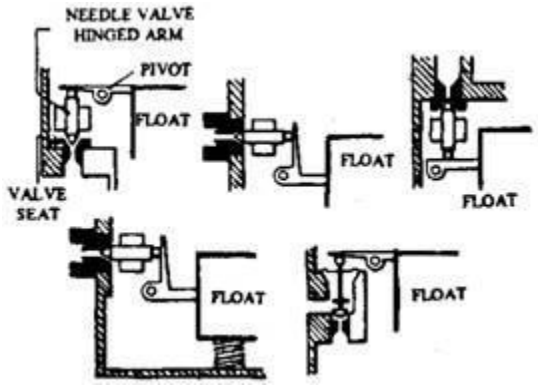
(ii) Idle and low speed system

(iii) High speed, or main metering system
(iv) Power system
(v) Acceleration pump system
(vi) Choke system

(i) The Float System

Gasoline from the fuel tank is delivered by the fuel pump to the carburetor fuel bowl (main well), where it is stored. The gasoline must be kept in the fuel bowl at a precise, nearly constant level. This level is critical, because it sets the fuel level in all the passages and circuits within the carburetor. High fuel level produces a rich fuel mixture causing high fuel consumption and high emission level. Low fuel level produces a lean mixture, which leads to engine surge and misfiring. Because of these problems, fuel level is one of the most critical adjustments needed on a carburetor.

The main fuel discharge nozzle for the high-speed system is directly connected to the bottom of the fuel bowl. The fuel level in the bowl and the nozzle is the same. The float assembly has a light weight hollow brass or a foam plastic pontoon with a hinge and tang. As the fuel level in the bowl rises, the pontoon floats higher. It pivots on the hinge to move the tang against the needle valve. The needle valve is pushed against the seat by the float assembly tang to stop the incoming fuel into the bowl when the float reaches the set fuel level. The float lowers as the fuel level drops due to use, allowing the needle valve to leave the seat to refill the bowl with the fuel supplied by the fuel pump. During operation while fulfilling many operating conditions, fuel flow into and out of the fuel bowl is almost equal. The needle valve stays in a partially open position to maintain the required flow rate. Fuel level is controlled and is maintained nearly constant by the float and the inlet needle valve. An air space is provided above the fuel in the bowl. The pressure in the bowl is atmospheric due to the vent to the carburetor air horn. The atmospheric pressure of fuel in the bowl provides the pressure differential needed for precise fuel metering into the venturi vacuum area of the carburetor barrel.



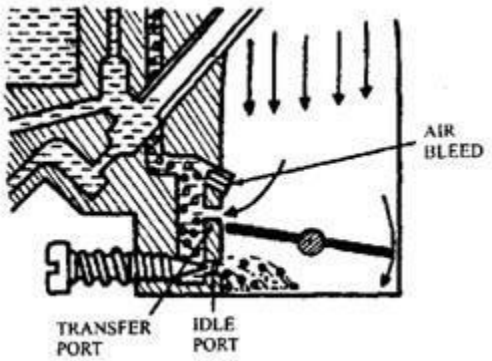
Float and needle valve design.

Float and needle valve design and location in the fuel bowl vary with different carburetor designs. Small springs are attached to some floats to keep them from bobbing up and down when the car travels over rough roads. Many fuel bowls have baffles to keep the fuel from sloshing on rough roads and sharp turns. The needles and seats in most carburetors are made of brass, and the needles often have plastic tips that conform to any rough spots on the seat and still provide a good seal when the valve is closed. When the engine is shut-off, engine heat evaporates the fuel in the bowl. The amount of evaporation from a large bowl system can easily overload the canister used in emission control. Therefore, the modern carburetors incorporate a somewhat small float bowl of moulded plastic. Other installs an insulator between the carburetor and intake manifold to reduce heat.

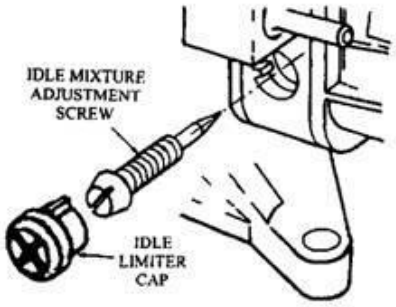
(ii) The Idle and Low Speed System

This system completely controls supply of petrol during idle and light load speeds up to 32 km/h. At low speeds, a very small amount of air flows through the venturi causing slight venturi effect and consequently the throttle is nearly closed. This is not sufficient to produce fuel flow in the main metering jet system. Therefore carburetors are equipped with an idle system, illustrated in Fig, which picks up fuel from the main well and carries it through restrictions to an elevation above the fuel level where air enters the fuel system through idle air bleeds, producing a mixture of fuel and air. This mixture follows another passage to an opening just below the throttle plate where the mixture flows through a manually adjustable idle port and discharges into the air stream. The idle mixture, which provides idle smoothness, is controlled by turning a manually adjustable needle screw, called the idle mixture adjuster screw.

One adjustment screw generally is used for each primary barrel. The screw tips stick out into the idle system passages and are turned inward (clock wise) to create a lean mixture, or outward (counter clockwise) for a rich mixture. Some carburetor mixture screws have plastic limiter caps. These caps restrict the amount of adjustment to prevent excessively rich idle mixtures. Idle speed is the result of the amount of air going through the carburetor, which is controlled by throttle position. The throttle position is set by an idle air adjustment screw. Additional small openings called transfer ports are located just above the closed throttle plate in the carburetor barrel. At idle, the transfer ports suck air from the barrel, which is at atmospheric pressure, into the fuel flow in the idle system. When engine is under slight acceleration, the engine needs more fuel than the idle port alone can provide and hence the transfer port comes into operation as the low speed system. As the throat opens, the transfer port is exposed to the intake vacuum and flow reverses in the transfer port. Extra fuel flows out of the transfer port to meet the engine's need during the switch over from idle to low speed operation. Fuel continues to flow from the idle port, but at a reduced rate. This permits an almost constant air-fuel mixture during this transition period.

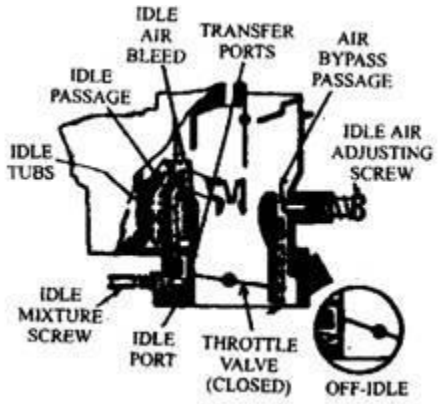


Typical idle circuit.

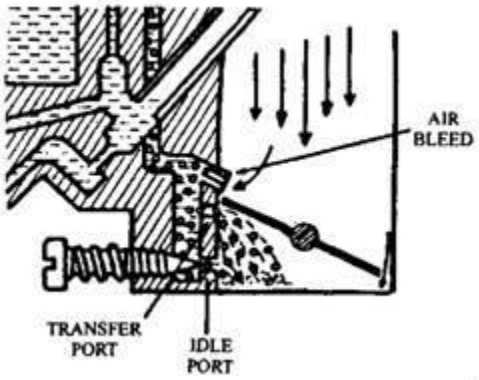


Idle limiter caps.

The most common problem in the idle system is plugging of idle restrictions and air bleeds, needing through cleaning. This is noticed when a change in the mixture screw adjustment has no effect on engine idle.



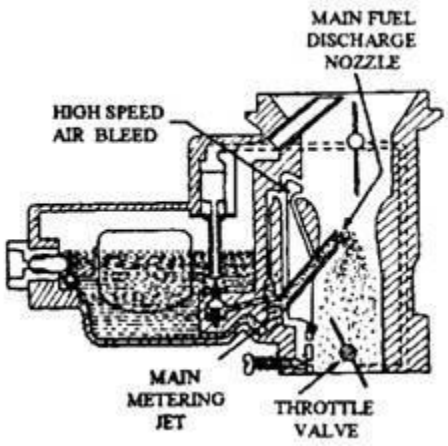
Idle air adjusting screw.



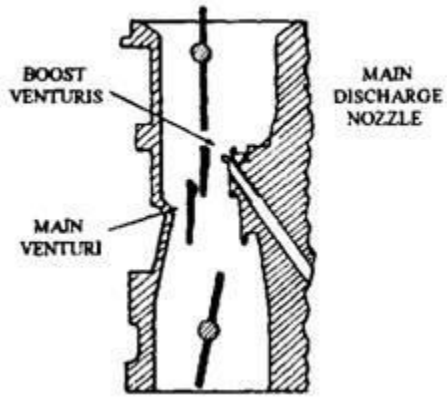
Low-Speed operation.

(iii) The Main Metering or High Speed System

As the vehicle speed reaches more than 32 km/h the throttle is opened, wide enough, to provide sufficient air flow to create pressure slightly less than atmospheric at the tip of main discharge nozzle. At the same time, the partial vacuum area of the intake manifold moves up in the carburetor barrel. The air flow and pressure change strengthen the venturi effect, causing gasoline to flow from the main discharge nozzle. With further increase in speed the main metering system continues to cut in till it takes over the entire load while the idle system cuts out. The main metering system ensures supply of sufficient petrol for the operation of engine above idle running to a maximum speed when the throttle is almost completely open.



High Speed or main metering system.



Multiple venturi system.

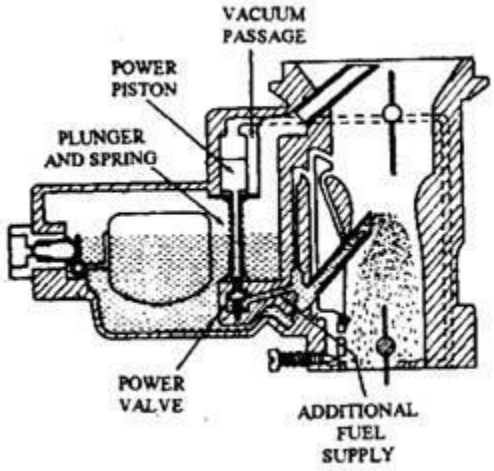
For better mixing of the fuel and air, most carburetors have multiple, or boost, venturies placed one inside another. The main discharge nozzle is located in the smallest venturi to increase the partial vacuum effect on the nozzle. Fuel flows from the bowl, through the main jet and main passage, and into the discharged nozzle. A high-speed air-bleed mixes air into the fuel before it is discharged from the nozzle.The primary or upper venturi produces vacuum, which causes the main discharge nozzle to spray fuel. The secondary venturi creates an air stream, which holds the fuel away from the barrel walls where it has a chance to slow down and condense. This results in air turbulence, which causes better mixing and finer atomisation of the fuel.

(iv) The Power System

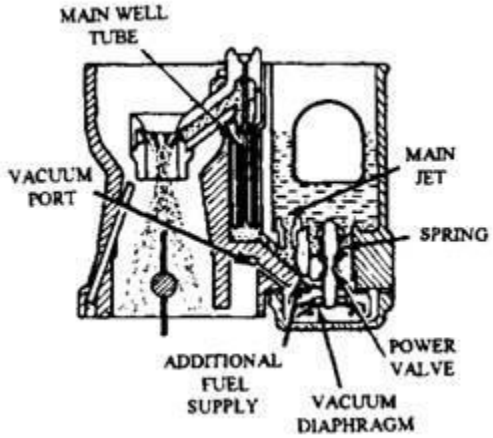
The high-speed system delivers the leanest air-fuel mixture to all the carburetor systems. When engine load increases during high-speed operation, this mixture is too lean to deliver the necessary power required by the engine. The extra fuel needed is provided instead by another system called the power system, or power valve. It supplements main metering fuel delivery. The power system or valve can be operated by vacuum or mechanical linkage. The exact type of power valve differs according to carburetor design, but all provide a richer air-fuel mixture. One type of power valve is located in the bottom of the fuel bowl with an opening to the main discharge tube. A spring holds the small poppet

valve closed, while a vacuum piston holds a plunger above the valve. Since manifold vacuum decreases as the engine load increases, a large spring moves the plunger downward. This opens the valve and allows more fuel to the main discharge nozzle.

Another type of vacuum-operated power valve uses a diaphragm. Manifold vacuum operates the diaphragm which holds the valve closed. As vacuum decreases under an increased load, a spring opens the valve, which sends more fuel through the power system to main discharge nozzle. Metering rods also can be used as a power system, which is controlled by vacuum pistons and springs, or by mechanical linkage connected to the throttle. The ends of the rods are tapered or stepped to increase the extra fuel flow gradually and are installed in the main jet opening. The rods restrict the area of the main jet and reduce the amount of fuel that flows through them during light load operation of the main metering system. Extra fuel for full throttle power is provided by moving the rods out of the jets to increase the flow through the jets.



Power system operated by vacuum controlled piston



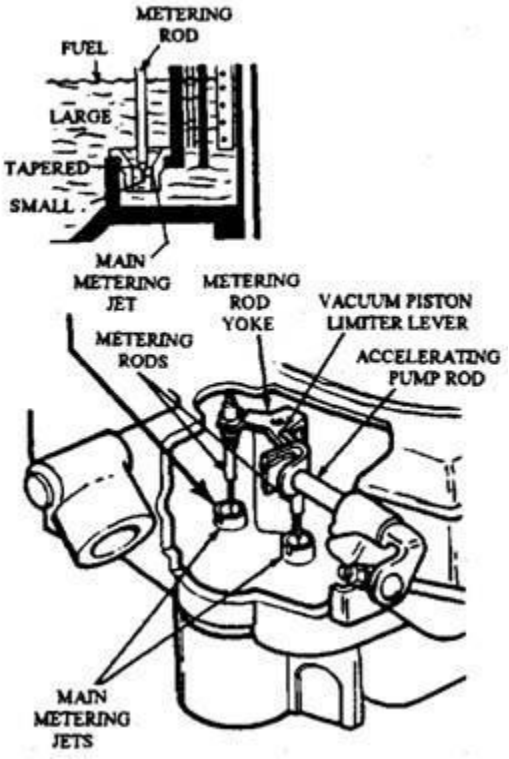
Power system operated by vacuum controlled diaphragm.

Vacuum controlled metering rods, also called step-up rods, are held in the jets by manifold vacuum applied to pistons attached to the rods. When vacuum drops under heavy load, springs, working against the pistons, move the rods out of the jets. Mechanically operated metering rods are controlled directly by mechanical linkage connected to the throttle linkage.

(v) Accelerator Pump System

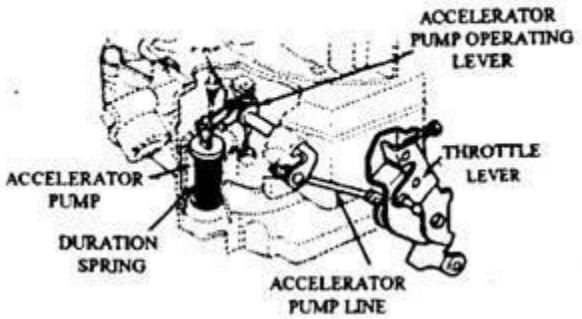
The system provides additional fuel for some engine operating conditions. If the throttle is opened suddenly from a closed position, or nearly closed position, air flow increases more rapidly than fuel flow from the main discharge nozzle. This dumping of air into the intake manifold reduces manifold vacuum suddenly and causes a lean fuel mixture. This excessively lean mixture results in a stumble, sometimes called a flat spot. For enough richness of the mixture, extra fuel is provided by the accelerator pump.

The accelerator pump is a plunger or diaphragm in a separate chamber in the carburetor body. It is operated by a linkage connected to the carburetor throttle linkage. When the throttle closes; the pump

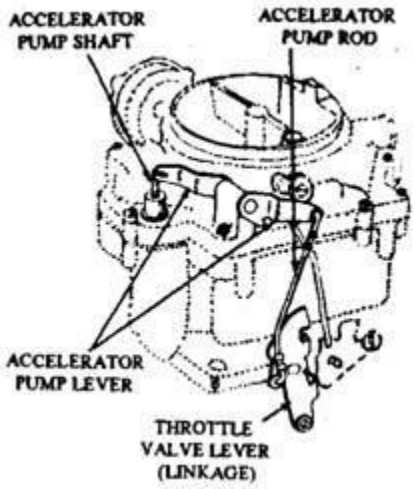


Metering rods based power system operated by mechanical or vacuum linkage.

draws fuel into the chamber through an inlet check valve, shown in Fig., and an outlet check valve closes so that air is not drawn through the pump nozzle. The pump moves down, or inward, when the throttle is opened quickly, to deliver fuel to the nozzle in the barrel through outlet check valve. During delivery of fuel inlet check valve closes. The pump outlet check valve may be a steel ball or plunger and the inlet check valve is a steel ball, rubber diaphragm, or part of the pump plunger.



Typical plunger-type accelerator pump.

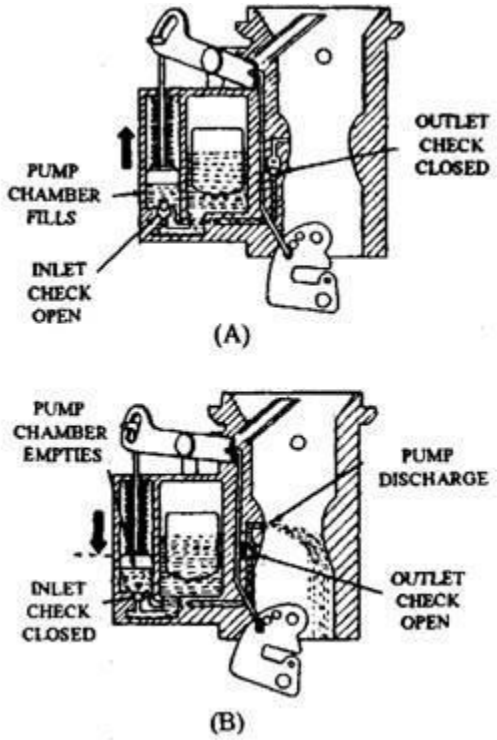


Accelerator pump linkage.

Most pump plunger or diaphragms are operated by a duration spring. The throttle linkage holds the pump in the returned position. When the throttle opens, the linkage releases the pump, and the spring moves the plunger for a steady and uniform fuel delivery. The accelerator pump operates during the first half of the throttle travel from the closed to the wide-open position.

During high-speed operation, the vacuum at the pump nozzle in the carburettor barrel may be strong enough to unseat the outlet check and siphon fuel from the pump. This is called pump pullover or siphoning. In most carburettors, air bleeds are placed in the pump discharge passages to prevent the siphoning. In some carburettors, an extra weight is added to the outlet check to resist the siphoning. The pump plungers in some carburettors have anti-siphon check valves.

Acceleration system problems cause engine stumble or hesitation which is due to damaged synthetic rubber piston or

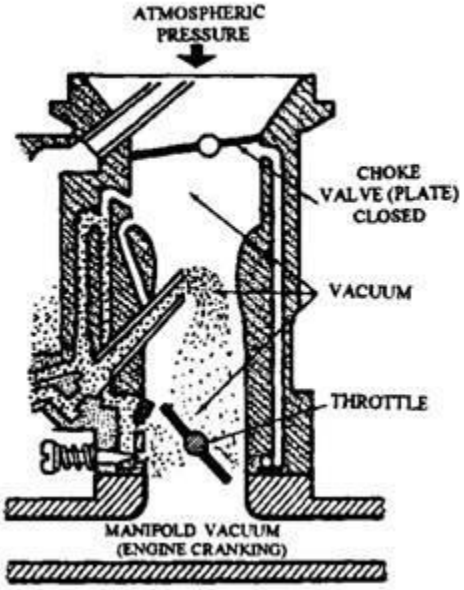


Accelerator pump operation. A. Pump intake stroke B. Pump discharge stroke

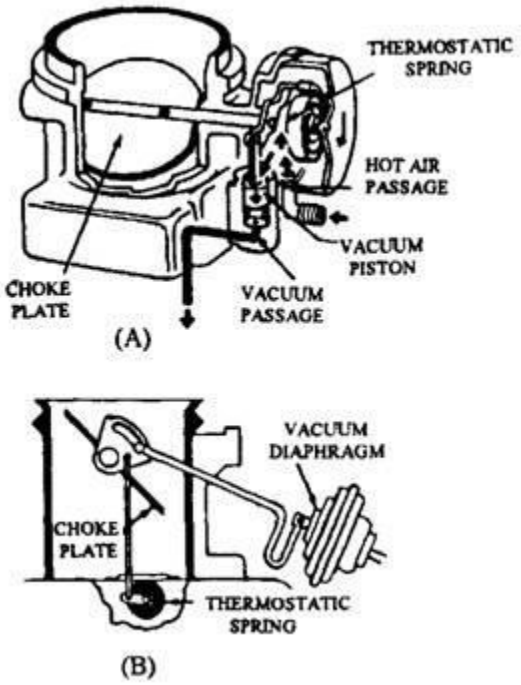
diaphragm requiring replacement. Sometimes dirt gets on the check valve seat or plungs the discharge nozzle requiring cleaning or replacement.

(vi) The Choke or Starting System

During cold start, only the light, volatile part of the fuel vaporises at low temperature. Cold manifold walls cause gasoline to condense from the air-fuel mixture, and less vaporised fuel reaches the combustion chambers. A choke system is used during cold start to supply a large amount of fuel to the carburetor barrel. The choke plate (valve) is located in the air horn above the main discharge nozzle and venturi as shown in Fig.. The choke plate can be tilted at various angles to restrict air flow. Cranking the engine with the choke plate in closed position creates a partial vacuum throughout the carburetor barrel below the plate. This airflow reduction and partial vacuum area work together to allow more fuel to be drawn into the mixture.



Choke system.



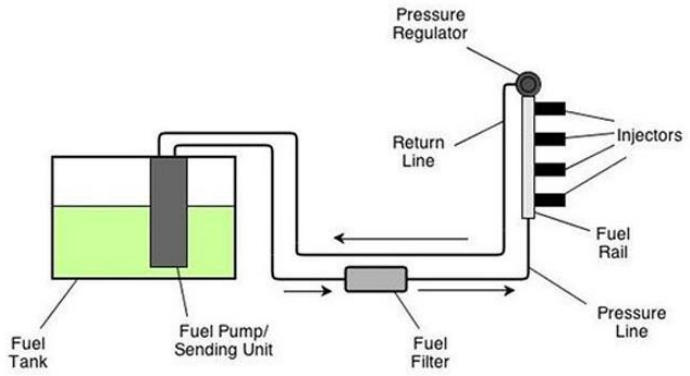
Automatic choke system. A. Integral choke. B. Remote choke.

The choke plate can be operated manually by a cable running to the driver's compartment or automatically by a thermostatic spring. The choke plate shaft is connected to spring by linkage. The bimetal thermostatic spring is normally located in one of the two places. In one type, it is placed in a round housing on the carburetor air horn. This is called an integral, or piston type choke. On the other type, it is located off the carburetor in a well on the intake manifold. This is called a remote, a well type,

or a vacuum-brake choke. Regardless of type and location, the thermostatic spring closes the choke when the engine is cold. When the cold engine is cranked, the choke is completely closed. As soon as the engine starts, the choke is opened slightly for sufficient air flow. The manifold vacuum pulls the diaphragm or piston, which opens the choke slightly. As the engine warms, the choke thermostatic spring gradually relaxes its tension, allowing vacuum to slowly open the choke as well as slowly release the fast idle cam. When the engine is warm, the choke is fully released. The choke shaft is offset to give another opening force. If the throttle is suddenly opened on a cold engine, the offset choke plate tip opens allowing more air to enter the carburetor. The thermostatic spring for remote choke is located either at the intake manifold exhaust crossover or on the exhaust manifold where it quickly senses heat. In case of integral choke, heat is transferred from a manifold stove through an insulated tube to heat the thermostatic spring.
A sticky choke plate shaft, a stuck vacuum piston, bent linkages, improper adjustment, and plugged or a burned choke heat tube usually cause problems in the choke system requiring replacement of damaged parts, cleaning of shaft and bushings, and correct adjustments.

Multi-Point Fuel Injection – MPFi

MPFi system was initially only manufactured for airplane engines. Currently, it is being used in commercial vehicles as well. It is known as the most advanced gasoline injection system in the automobile industry.



Multi-Point Fuel Injection is a compilation of electrical engineering with mechanical, electronics, and computers, making the systems more efficient and advanced. Let's compare MPFi with single-point fuel injection. It is seen that single-point fuel injection has only a single fuel injector location in the middle, which supplies fuel to several cylinders available in the engine. At the same time, a multi-point fuel injection system has separate fuel injectors that supply fuel to the cylinders from the fuel storage tank.

In the MPFI system, an electronic fuel pump sprays the fuel into the engine intake manifold to deliver an accurate air/fuel ratio. Engine sprays the fuel to the cylinder with the help of suctions pressure (Vacuum technique is used to provide fuel in Carburetor). Each of the fuel injectors receives the fuel equally by using the electric fuel pump, and this process happens for each injector once in every cycle.

Types of MPFI System

- **D-MPFI System** refers to a manifold fuel injection system.
- **L-MPFI System** refers to a port fuel injection system.

Following are the components used in the MPFI system

- Air Filter, which removes the solid particles from the air.
- E-Sensors help to measure coolants, gas, and exhaust temperature as well as throttle and speed positions.
- The electronic control unit – ECU controls the quality of fuel and ignition timing.
- Solenoid Injectors.

Advantages

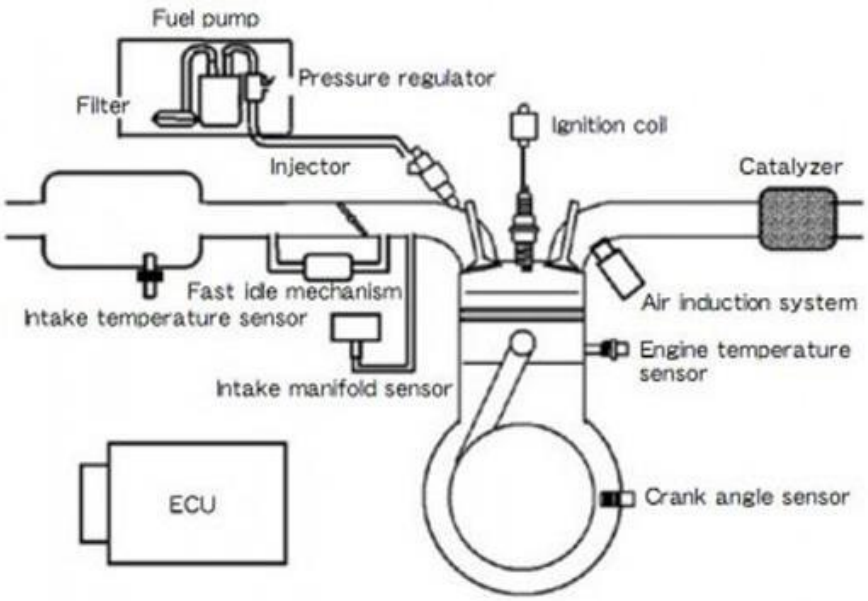
- It improves the engine's volumetric efficiency
- It generates more power than the carburetion system.
- It enhances the life of the engine as vibration is very less in MPFI equipped engines.
- The response is very quick in case of sudden deceleration or acceleration.
- It improves mileage and minimizes fuel consumption.

Disadvantages

- It needs more room/space to fit in.
- Complex and costly.

Electronic Fuel Injection – EFI

Electronic control unit – ECU is placed in the electronic fuel injection to deliver adequate fuel pressure, various sensors, and fuel injectors. Fuel injectors and multiple types of sensors vary due to the system's complexity, the number of cylinders, and the engine's configuration. With the help of intake and exhaust, these sensors in the machine provide the information to the ECU of air and water temperature, shaft and crank position, throttle position, and gas composition.



Measuring airflow is an important aspect of the engine, and it can be gauged by a pressure sensor or mass airflow sensor. ECU has a task to evaluate the data received and matches it with the available data table, referred to as a "MAP." It will show the fuel needed in a particular situation and adjust the fuel supply using the injectors according to the requirement.

The Carburetor seems to struggle with fine-tuning the mixture for the load and conditions on various occasions. At the same time, EFI does this job efficiently on the other hand. One fuel injector is mostly for the single cylinder and positioned in the inlet runners, leading to the cylinder.

It sprays a small amount of fuel through the nozzle to create a spark, and it is easily mixed with air in the intake. Most of the ECUs control the other parts of the engine, including the valve train and ignition system, to improve efficiency, performance, and drivability.

Advantages

- Variation of fuel/air ratio is quite less, and it enhances the performance of the engine.

- It eliminates manifold wetting due to direct fuel injection to the cylinder.
- It eliminates the ice formation at the throttle plate.
- Reduces the height of the engine as the injection unit is not big.
- Almost minimize the knocking due to improved vaporization and atomization system.
- It improves the engine's volumetric efficiency
- Even at low speed, it provides good atomization.

Disadvantages

- There is a possibility of a breakdown of sensors
- Complexity in servicing.
- Costly maintenance.

Types of Carburetors

Following are the different types of carburetors:

1. **According to the arrangement of the float chamber:**
    1. Eccentric
    2. Concentric
2. **According to the direction of air flow:**
    1. Downdraft.
    2. Side draft.
    3. Up draft.
    4. Semi-down draft.
3. **According to the number of units:**
    1. Single
    2. Dual
    3. Four-barrel.
4. **According to the type of metering system:**
    1. Air-bleed jet.
    2. Metering rod type.
5. **According to the types of venturi:**
    1. Plain venturi.
    2. Double venturi
    3. Vane venturi
    4. Nozzle-bar venturi
    5. Triple venturi.
6. **According to the pressure above the fuel in the float chamber:**
    1. Unbalanced.

2. Balanced.

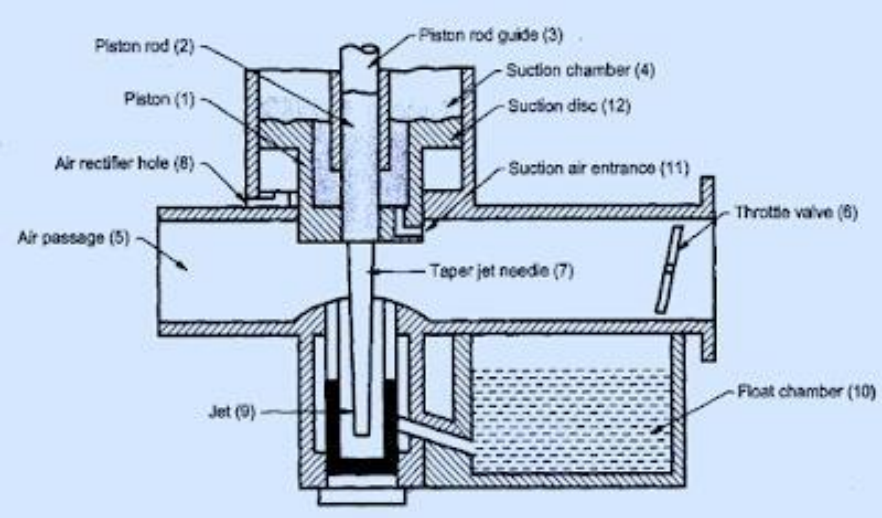
7. **According to the type of power system:**
    1. Manually operated
    2. Vacuum controlled
8. **According to the method of varying the mixture strength:**
    1. Constant choke carburetor.
    2. Constant vacuum carburetor.
9. **Typical Carburetors**
    1. SU Carburetor
    2. Solex Carburetor
    3. Zenith Carburetor
    4. Carter Carburetor

S.U Carburetor

SU carburetor full form is **Skinners Union carburetor.** Skinners Union is a carburetor company established in London in 1910. SU carburetor is a constant depression or constant vacuum type of carburetor. It has an automatic variable choke rather than a simple choke.

S.U Carburetor Construction

- S.U Carburetor consists of a sliding piston and the tapered needle inserted into the main jet.
- Along with the piston upward and downward movement, the needle and the main jet also moves.
- There is a suction disc attached to the upper end of the piston.
- Piston rod and the piston rod guide help to guide the piston and the suction disc as shown in the schematic diagram.
- The piston is loaded with the helical spring.



- There is this portion above the suction disc is called the suction chamber which will be connected by the air passage by means of a slot provided in the piston.
- And there is an ordinary butterfly throttle valve as shown in the above fig.

- There is an air rectifier hole provided at the lower portion of the suction disc and the upper portion of this disc will be connected to the throttle air passage.

S.U Carburetor working principle

This Carburetor does not have different engine operating condition such as the idling and the slow running (cruising), normal running, accelerating.

As the piston is loaded with the helical spring and the weight of the piston will be also supported by the vacuum in the suction chamber. The position of the piston will be balanced by maintaining the constant vacuum in the suction chamber. If any deviation occurred, the piston gets moved up/down.

There will be a lever attached to the main jet to control the fuel flow while the engine needs to start. Because the engine starting needs a richer mixture.

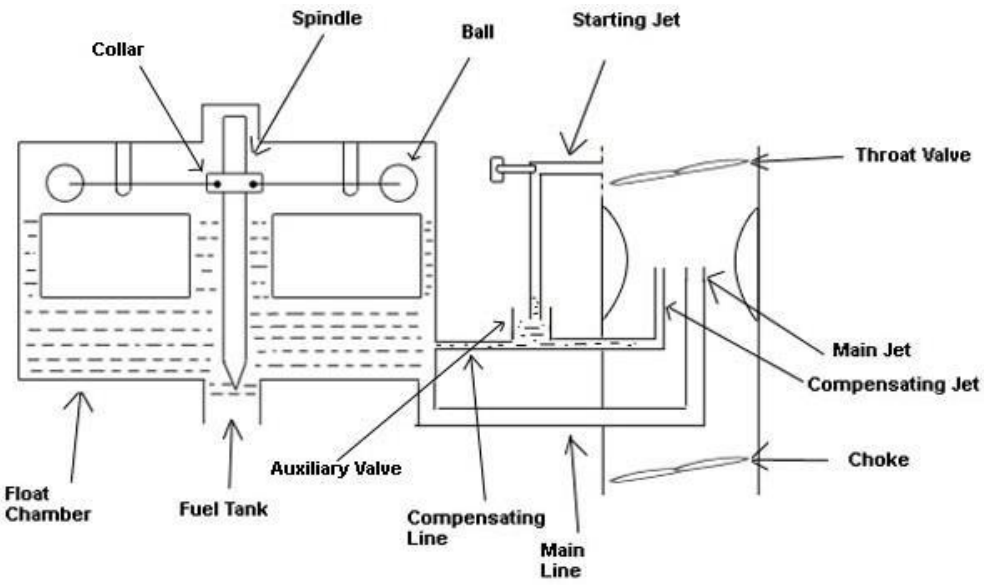
The throttle is opened more the more air is allowed to pass thru through the inlet due to the upward movement of the piston. the upward movement of the tapered needle also ensures the more fuel flow from the main jet. This is how the air and the fuel passages are varied with the different engine speeds and velocities of the fuel and the air remains constant in this system.

Zenith Carburetor

Zenith Carburetor is a British carburetor which is used by many popular companies. It is produced by Zenith Carburetor Company and was founded in 1910.
In this carburetor there is no starting problem and also this carburetor provides rich mixture during high speed.

Zenith Carburetor Construction

In this carburetor, Float Chamber is connected to the Venturi via a Main Line. Main function of fuel chamber is to take fuel from the fuel tank. This fuel chamber has two balls, two floats and a spindle. There is choke which when closed restricts the air flow to the carburetor. A throttle Valve is a valve between the carburetor and the engine which opens when fuel is needed by the engine. Fuel from main line enters to form air fuel mixture through Main Jet. Apart from main jet, there is a compensating jet also which compensate when more fuel is needed by engine at high speed. This compensating jet gets fuel from reservoir or auxiliary valve. Apart from compensating jet, it also has starting jet which aids engine at time of starting. It also gets fuel from reservoir or auxiliary valve.



Zenith Carburetor working principle

At first fuel from fuel tank enters into Float Chamber through a passage which is blocked by a spindle present in the float chamber when fuel is not needed. This spindle moves up and down to block and unblock the fuel supply to fuel chamber.

When the fuel supply to fuel chamber decreases the two floats come down and the two balls also come down with them. As the balls and the spindle are connected like a Seesaw, so when the balls come down the spindle comes up and fuel passage to fuel chamber is unblocked.

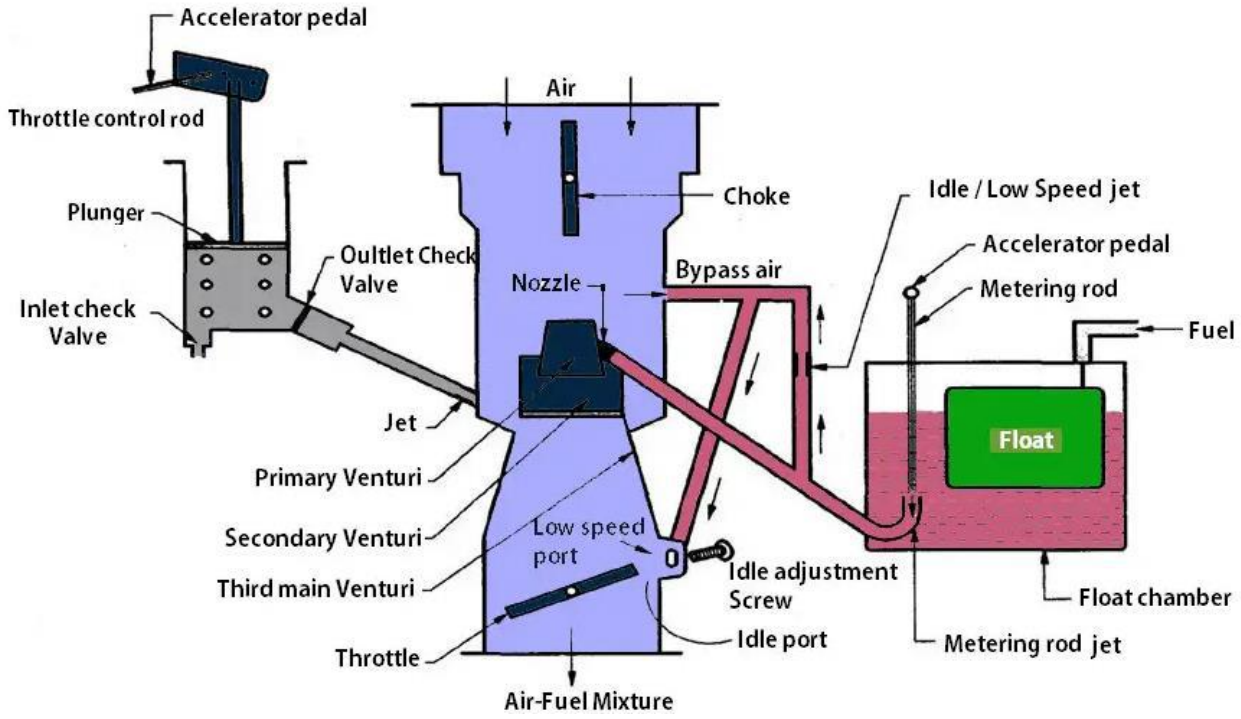
On other hand, when the fuel supply increases in the fuel chamber the two floats come up and the balls also come up. As the balls come up , the spindle comes down due to Seesaw connection between the balls and the spindle. When spindle comes down the passage is blocked and the fuel supply to fuel chamber stops.

Carter Carburetor

It was first founded by William Carter for the jeeps run by four-cylinder engines.

Carter Carburetor is a downdraught type Carburetor. It is having multiple jets, a plain tube with only one adjustment for the idling or low speed running of the engine.

Carter Carburetor Construction & Working Principle



The gasoline is injected into the float chamber. During normal operation, air enters the carburetor from the top, and the choke valve in the channel remains open. There are three vents in this carburetor. The principal venturi, which is the smallest, is located above the fuel level in the float chamber. Other than that, two ventures are located below the fuel level and one is located below the other. The primary venturi's suction is sufficient to extract petrol at very low speeds. The nozzle enters the primary venturi at an angle, atomizing the fuel and sending it upward against the air stream. The mixture from the primary venturi enters the secondary venturi, which is encircled by an air stream, and eventually flows to the final venturi.

The fresh air supply insulates the stream from the second venturi once again in the main venturi. The mixture is ill atomized when it enters the engine. Multiple ventures allow for greater mixture formation at low speeds, resulting in stable and smooth functioning at both low and high speeds.

Unit-III

Ignition System

The ignition system is one of the most important systems used in the I.C engines. The spark-ignition engine requires some device to ignite the compressed air-fuel mixture. The ignition takes place inside the cylinder at the end of the compression stroke; the ignition system serves this purpose.

It is a part of the electrical system which carries the electrical current to a current plug. It gives the spark to ignite the air-fuel mixture at the correct time.

Types of Ignition System

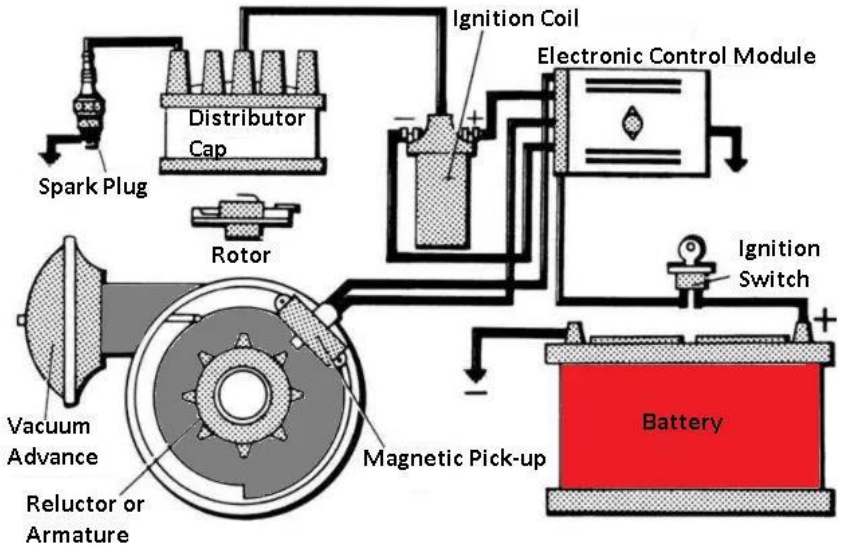
Following are the types of ignition system:

1. Battery ignition system or coil ignition system
2. Magneto ignition system.
3. Electronic Ignition System.

Electronic Ignition System

An electronic ignition system is a type of ignition system that uses a transistor to make an electronic circuit work. A sensor controls this transistor to create an electrical pulse, generating a high voltage spark that can burn the lean mixture and provide a better economy and lower emissions.

The role of the electronic ignition system remains the same as it generates a high voltage spark to ignite the air-fuel mixture to the spark plug. Since sensors are used in the system, it improves reliability and mileage and also reduces emissions.



Components of Electronic Ignition System

Following are the important components of an electronic ignition system:

1. Battery
2. Armature
3. Ignition switch
4. Electronic control module (ECU)
5. Ignition coil
6. Ignition distributor
7. Spark plug

1 Battery

The battery is the primary power source for the ignition system because it transfers the energy to the system when the ignition switch is turned on. The function of a battery is to store charges and release them when needed.

It has two terminals: positive (+) and negative (-). The positive terminal is connected to the ignition switch (key), while the negative terminal is connected to the ground.

2 Armature

Unlike battery ignition systems with contact breaker points, this is being replaced by an armature in an electronic ignition system. The armature is used to generate the magnetic field in the system.

It consists of a retractor (moving part) with teeth, a vacuum advance, and a pickup coil to capture voltage signals. The ECU receives voltage signals from the armature so that circuits can be made and broken. This accurately determines the timing of the current supply to the distributor's spark plugs.

3 Ignition Switch

It's the power button that turns the system on and off. When the switch is turned on, the current from the battery runs directly to the coil and into the ignition system. Similarly, when the switch is turned off, the current from the battery will be terminated, so even if the engine is cranked, it will not run.

4 Electronic Control Module (ECU)

It is the essential part of the electronic ignition system in which electronic work starts as it switches the primary current on and off. This is known as the brain or programmed instructions given to the electronic ignition system.

It also called as control unit. Which is automatically monitors and controls the timing and intensity of sparks. It receives the voltage signal from the armature and turns the primary coil on and off. These are kept separately outside the distributor or the vehicle's electronic control unit box.

5 Ignition Coil

An ignition coil in the system is beneficial as it helps the spark plug to generate a higher voltage up to 12 V to 20 KV. It uses the electromagnet induction method, which acts as a step-up transformer.

This transformer produces a low flame or high voltage spark for combustion. There are two sets of ignition coil windings: primary winding (outer winding) and secondary winding (inner winding).

6 Ignition Distributor

Despite the magneto ignition system, electronic ignition systems also have an ignition distributor. This is because, in electronic ignition, only the primary current termination method differs and the rest is the same. It distributes the current to the spark plugs of a multi-cylinder engine.

7 Spark Plug

The spark plug generates the spark inside the cylinder by using the high voltage ignition coil to ignite the fuel-air mixture. It usually works by using the gap between two conductors. One is the spark electrode which is positively charged, and the other is the ground which is negatively charged.

Working of Electronic Ignition System

The above figure shows you a simplified diagram of an electronic ignition system. In the electronic ignition system, a timer is employed in the distributor of the electronic ignition system.

The timer sends the electrical pulses to an electric control unit (ECU) which switches off the flow of current to the primary winding. As a result, a high voltage is induced in the secondary winding which is then distributed to the spark plugs as in the case of a breaker point ignition system.

The electronic control unit later switches on the flow of current to the primary circuit so that the primary circuit can be built up for the next cycle. The timer may be a pulse generator or Hall effect sensor.

Advantages

1. It has no moving parts. Solid-state electronics control all operations of the ignition system.
2. The system does not rely on a range of factors to be mechanically timed by the system for the timing of spark plug activation.
3. Electronic ignition systems provide better environmental benefits than mechanically timed ignition.
4. Since the system has fewer moving parts, it increases its efficiency.
5. The use of this system will increase fuel efficiency as well as generate fewer emissions.

Disadvantages

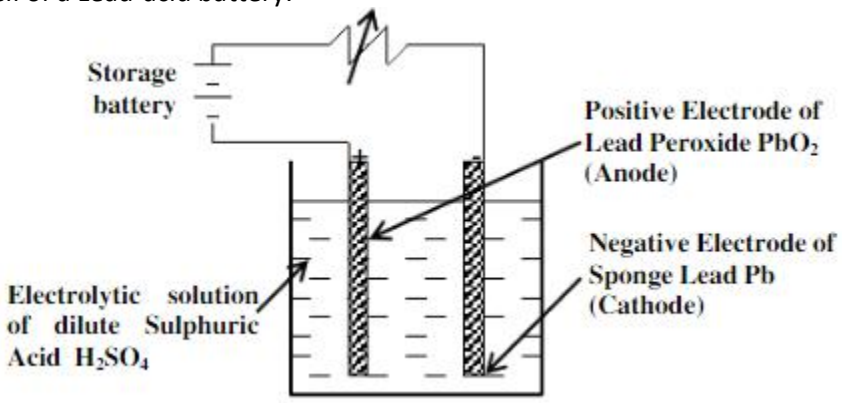
Despite the advantages of electronic ignition systems, there is still one drawback. The main disadvantage of electronic ignition systems is that not all vehicles can tolerate this type of ignition system.

Application

Electronic ignition is mostly used in modern supercars like Audi A4, Mahindra XUV-500, etc., and bikes like KTM Duke 390 cc, Ducati Super Sports, etc., to meet the need for high reliability and performance. It is also used in aircraft engines due to its superior reliability and low maintenance.

Storage battery

Storage battery is a device, which can be used repeatedly for storing energy at one time in the form of chemical energy during charging process for use at another time in the form of electrical energy during discharging process. A storage battery may consist of a single or a group of storage cells electrically interconnected. A storage cell consists of positive plate (or anode) and negative plate (or cathode) bearing the necessary electrochemically active materials immersed in an electrolyte solution. Figure shows a storage cell of a Lead-acid battery.



Charging a battery consists of connecting the two plates to a dc supply of proper polarity for a sufficient length of time. Electrical energy is delivered by the dc supply to the battery, in which it produces certain chemical reactions so that the energy is converted into chemical energy. If a charged battery has its two terminals connected through a closed external electric circuit, the active materials of the plate will react chemically with the electrolyte, producing a flow of current in the circuit. This conversion of chemical energy into electrical energy is called discharging the battery.

Battery rating

Rating of a battery is determined by the current it can produce and the time for which it can sustain this current. Batteries are rated in many ways the most important of which are:

- **Ampere Hour capacity:** It represents the lasting power of a battery on small load. It represents the rate of current a battery can deliver continuously for 20 hours after which the cell voltage should not drop below 1.75V at 80 °F.
- **Twenty minute rate:** It represents the rate of current a battery can deliver continuously for 20 minutes the cell voltage not dropping below 1.5V at 80 °F.

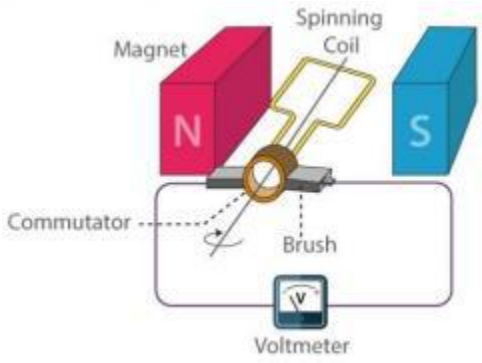
- **Reserve capacity:** RC is a battery's ability to sustain a minimum stated electrical load; it is defined as the time (in minutes) that a lead-acid battery at 80 °F will continuously deliver 25 amperes before its voltage drops below 10.5 volts.
- **Cold cranking amps:** CCA is a measure of a battery's ability to start a car in cold weather, when thickened engine oil and slowed chemical reactions make starting hardest. CCAs denote how much current the battery can deliver to the starter at 0° F. It represents the current in amperes which the battery can supply continuously for 30 sec or 1minute without cell voltage dropping below 1.4V.

Dynamo:

1. A dynamo is an electrical generator that utilizes a commutator to generate direct current.
2. Dynamo is a device that converts mechanical energy into electrical energy.
3. Dynamos were the first electrical generators utilized just to supply power to industry, as well as they served as the platform for several subsequent electric-power conversion types of equipment, such as the alternating-current (AC) alternator, electric motor, as well as a rotary converter.

Working of Dynamo:

1. The image below shows a basic dynamo with such a coil constructed of conducting wires that are positioned between the North pole and South pole of two permanent magnets.
2. Whenever the coil is to be motionless, no voltage is produced. The magnetic field changes as the coil spins, causing a voltage to be generated within the coil.



3. The left side of the coil travels from the North Pole of such a left magnet during the first half of the revolution. The coil travels from the South Pole of the right magnet throughout the second part of the revolution.

Alternator

An alternator is a device that converts mechanical energy into AC electrical energy. The alternator actually generates power for the vehicle. As the alternator rotates, it creates a DC voltage primarily to charge the vehicle battery. The battery provides the huge current required to start the vehicle engine. Once the vehicle is running, the alternator assists by providing power to run the vehicle’s electrical systems.

Parts of an alternator

The components of an alternator are geared toward providing the right type and right amount of power to the vehicle. Your car's charging system contains many parts, but these are the main components and their functions:

Rotor and stator

The rotor and stator are the electricity-producing components of an alternator. The rotor, a cylindrical piece surrounded by magnets, spins inside of the stator, which holds a fixed set of conductive copper wiring. The movement of the magnets over the wiring is what ultimately creates electricity.

The stator is attached to the alternator's shell and does not move. It consists of the outer frame, stator core and stator winding. The stator, unlike the rotor, is highly insulated due to the high voltage that it creates.

Voltage regulator

The voltage regulator oversees the power the alternator makes. It monitors the level of voltage that is output to the battery and delivers power to the rest of the vehicle.

Diode rectifier

The diode rectifier converts the voltage from the alternator into a form that can be used by the battery to recharge.

Cooling fan

Alternators give off a lot of heat and need to be cooled to operate efficiently. While they're built with vents and aluminum casing to better release heat, they're also equipped with rotating fans for added cooling. New alternator models have internal cooling fans, whereas older versions tend to have external fan blades.

Working of an Alternator

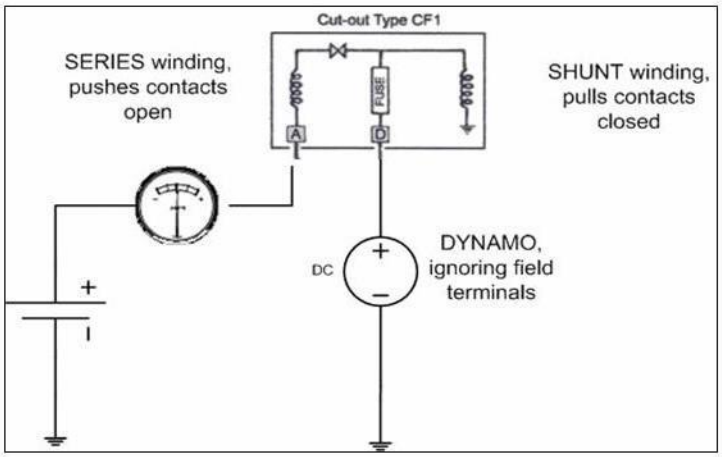
– The Ignition switch allows the battery to energize the rotor
– The Rotor spins faster as the engine revs up…
– The stator voltages rise
– The Rectifier output battery charge voltage rises
– The Voltage regulator senses the battery voltage rise
– The Voltage regulator reduces electromagnet energizing voltage, and
– The Stator voltages drop

Difference between Dynamo Vs Alternator

Parameters of Comparison	Dynamo	Alternator
Definition	Dynamo is a machine that produces direct current flowing in the same direction.	An alternator is a machine that produces alternating current flowing in different directions.
Magnetic field	Stationary	Rotating
Input supply	Takes input supply from the rotor	Takes input supply from the stator
Energy efficiency	It is less energy efficient	It is highly energy efficient
Range of Rotations Per Minute (RPM)	Supports less range of RPM	Supports a wide range of RPM
Brush durability	It has less brush durability	It has high brush durability
Charging dead battery	It can be used to charge a dead battery	It cannot be used to charge a dead battery
Maintenance	It has high maintenance charges	It has low maintenance charges

Cut-outs

The charging system of the Austin Seven primarily consists of a dynamo to produce an electric current and a battery in which to store the charge. In between these two is an automatic switch, known as a Cut-out. Without the cut-out, the battery would be charged whenever the dynamo is rotated sufficiently fast by the engine, but would be rapidly discharged by trying to operate the dynamo as a motor when the engine revs are not high enough – particularly when the engine is stationary. Note that the ignition switch does NOT disconnect the dynamo from the battery; it only disconnects the ignition circuit itself, (plus a few auxiliary devices such as stop lights). The ignition switch is therefore not relevant to the cut out operation or charging circuit.



With the engine stationary, it is necessary for the battery to be disconnected from the dynamo, to prevent the “motor” action described above. Hence, the contacts must be open. This is the resting state of the cut-out.

Voltage Regulators

Voltage regulator is electrical or electronic device that maintains the voltage of a power source within acceptable limits. The voltage regulator is needed to keep voltages within the prescribed range that can be tolerated by the electrical equipment using that voltage. Such a device is widely used in motor vehicles of all types to match the output voltage of the generator to the electrical load and to the charging requirements of the battery. Voltage regulators also are used in electronic equipment in which excessive variations in voltage would be detrimental.

In motor vehicles, voltage regulators rapidly switch from one to another of three circuit states by means of a spring-loaded, double-pole switch. At low speeds, some current from the generator is used to boost the generator's magnetic field, thereby increasing voltage output. At higher speeds, resistance is inserted into the generator-field circuit so that its voltage and current are moderated. At still higher speeds, the circuit is switched off, lowering the magnetic field. The regulator switching rate is usually 50 to 200 times per second.

Electronic voltage regulators utilize solid-state semiconductor devices to smooth out variations in the flow of current. In most cases, they operate as variable resistances; that is, resistance decreases when the electrical load is heavy and increases when the load is lighter.

Voltage regulators perform the same function in large-scale power-distribution systems as they do in motor vehicles and other machines; they minimize variations in voltage in order to protect the equipment using the electricity. In power-distribution systems the regulators are either in the substations or on the feeder lines themselves. Two types of regulators are used: step regulators, in which switches regulate the current supply, and induction regulators, in which an induction motor supplies a secondary, continually adjusted voltage to even out current variations in the feeder line.

Current regulator

A current regulator is at work each time a cell phone is recharged, a car is started, a computer is plugged in, or a small electrical appliance is turned on. Sometimes called voltage regulators, current regulators reduce and limit the amount of electricity to a level that is required for the electrical device to operate.

Generally, a current regulator is a form of step-down transformer that allows only a set amount of current to pass through to the device. For example, computers typically require only 20 volts to operate and cell phones require only 3 volts. Current regulators in both cases are usually part of the cord that is plugged into the wall and then into the device.

Most all current regulators for consumer appliances include circuitry for constant current regulation. This circuitry keeps the current going to the device at a constant level to avoid damage. Since household voltage can fluctuate slightly due to variations in overall utility capacity or drains on the building's electrical system, this kind of fluctuation can cause sensitive devices to malfunction or cease to operate. The constant current circuit takes the available voltage and stabilizes it to a constant and reliable low-voltage level.

Starter motor

A starter or starter motor is an electrical device that is used to rotate (crank) internal combustion engines so as to initiate the engine's operation under its own power. As soon as the engine begins to

run, it got disconnected from the engine, which now relies on the combustion process. The component is mounted on the engine's gearbox housing, and the starter motor gear meets the flywheel's teeth.

Being an electrical component, a starter consists of a powerful DC (Direct Current) electric motor and a solenoid. The solenoid receives positive power direct from the battery and heart current from the engine body. In order to turn the engine, a 12-volt battery must be used to run the starter. This means the battery has to be sufficient enough to power the device. In most situations where the starter motor clicks but won't start, the issue is either from the battery or the starter itself.

Parts of the Starter Motor

Below are the starter motors parts and their functions:

Armature:

An armature is an electromagnet component that is mounted on the driveshaft or bearings for a guide. It is made of a laminated soft iron core which is wrapped with numerous conductor loops or windings.

Commutator:

A commutator is a section of the shaft at the rear of the housing on which brushes run to conduct electricity. It is made of two plates mounted to the axle of the armature; the plates provide connections for the coil of the electromagnet.

Brushes:

Brushes are parts that run on a section of the commutator at the rear of the housing. it rubs the commutator and conducts electricity.

Solenoid:

The solenoid features two coils of wire that are wrapped around the core. This solenoid serves as a switch that connects and closes the electrical connection between the starter motor and the vehicle's battery.

Plunger:

The function of a plunger in a starter motor is to push forward so the pinion can be engaged.

Lever Fork:

The lever fork is connected to the plunger which makes them push forward together to engage the pinion.

Pinion:

A pinion is a small mechanism containing gear and springs. It engages immediately after the engine started, by extending the gear to the flywheel teeth. The flywheel is the source of engine rotation.

Field Coils:

The field coils are held in housing with screws as it consists of two or more coils connected in series. These coils receive power from the battery that converts them into an electromagnet that turns the armature. This creates a magnetic field around the armature.

Working Principle of starter

The working of a starter is quite easy and interesting, but most drivers really don't know the secret behind motor cranking. When the ignition key or bottom is pressed, the transmission should be in the park or neutral state. The battery voltage goes through the starter control circuit to activate the solenoid.

The starter motor is powered by the solenoid, which helps to push the starter gear forward to mesh with the engine flywheel. This flywheel is mounted on the engine crankshaft, so as the starter motor spins it turns the flywheel so as the crankshaft. As soon as the engine start, the system disengages from the flywheel.

Note in an automatic transmission, starter motors can only be operated when the vehicle is in a park or neutral position. And in manual transmission, the clutch pedal must be depressed.

The working inside the starter motor, there are four field windings attached to the housing from inside. The armature (rotating parts) is connected through the carbon brushes in series with the field coils. But remember in some starters field coils are replaced with magnet fields. There is a small gear at the front of the armature attached with an overrunning clutch.

Hot Spark Plugs

Found in many passenger vehicles, hot spark plugs have more insulation to transfer the heat slowly, which keeps the temperature high enough to burn off carbon deposits and avoid premature fouling. This helps allow for more time between spark plug changes.

Characteristics of hot spark plugs:

- Longer insulator nose
- Transfers heat slowly
- Tip remains hot longer
- Burns off carbon deposits

Cold Spark Plugs

Cold spark plugs are good for high RPM engines and other situations where the engine operates at a high temperature. Because they transfer heat faster, cold spark plugs can get dirty and become fouled sooner because they don't get hot enough to burn off carbon deposits.

Characteristics of cold spark plugs:

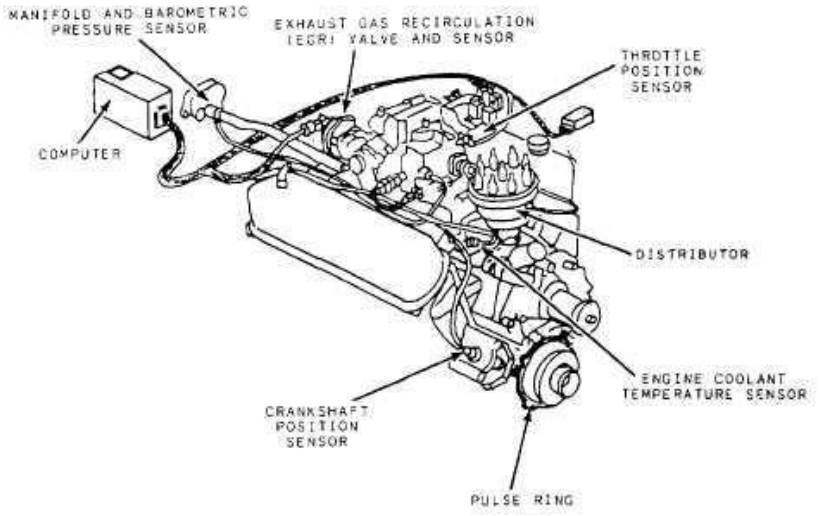
- Shorter insulator nose
- Transfers heat faster
- Tip remains cooler longer

Computer controlled coil Ignition sensors:

Today, minicomputers are being used to control many modern automotive systems. One example is Ford's electronic engine control system (EEC). This system consists of an electronic control assembly (ECA), seven monitoring sensors, a Dura Spark II ignition module and coil, a special distributor assembly, and an EGR system designed to operate on air pressure.

The ECA is a solid-state microcomputer consisting of a processor and a calibration assembly. The processor continuously receives inputs from the seven sensors and converts them into usable information that is received by the calculating section of the computer. The processor assembly also performs ignition timing, does Thermactor and EGR flow calculations, processes this information, and sends out signals to the ignition module and control solenoids to adjust the timing and flow of the systems accordingly. The calibration assembly contains the memory and programming for the processor.

Processor inputs come from sensors that monitor manifold pressure, barometric pressure, engine coolant temperature, inlet air temperature, crankshaft position, throttle position, and EGR valve position.



Manifold Absolute Pressure Sensor

This sensor detects changes in intake manifold pressure that are caused by variances in engine speed, engine load, or atmospheric pressure.

Barometric Pressure Sensor

Barometric pressure is monitored by a sensor mounted on the fire wall. Measurements taken are converted into a usable electrical signal. The ECA uses this reference for altitude-dependent EGR flow requirements.

Coolant Temperature Sensor

This sensor is located at the rear of the intake manifold and consists of a brass housing that contains a thermistor. When reference voltage (about 9 volts, supplied by the processor to all sensors) is applied to the sensor, the resistance can be measured by the resulting voltage drop. Resistance is then interpreted as coolant temperature by the ECA. EGR flow is cut off by the ECA when a predetermined temperature is reached. If the coolant temperature becomes too high (due to prolonged idling), the ECA will advance the initial ignition timing to increase the idle speed. The increase in engine rpm will increase coolant and radiator airflow, resulting in a decrease in coolant temperature.

Inlet Air Sensor

Inlet air temperature is measured by a sensor mounted in the air cleaner. It operates in the same manner as the coolant sensor. The ECA uses its signal to control engine timing. At high inlet temperatures (above 90°F), the ECA modifies the engine timing to prevent spark knock.

Crankshaft Position Sensor and Metal Pulse Ring

The crankshaft is fitted with a four-lobe metal pulse ring. Its position is constantly monitored by the crankshaft position sensor. Signals are sent to the ECA representing both the position of the crankshaft and the frequency of the pulses (engine rpm).

Throttle Position Sensor

The throttle sensor is a rheostat connected to the throttle plate shaft. Changes in the throttle plate angle varies the resistance of the reference voltage that is supplied by the processor. Signals arc interpreted by the ECA in one of the following three ways:

1. Closed throttle (idle or decelcration)

2. Part throttle (cruise)

3. Full throttle (maximum acceleration)

EGR Valve and Sensor

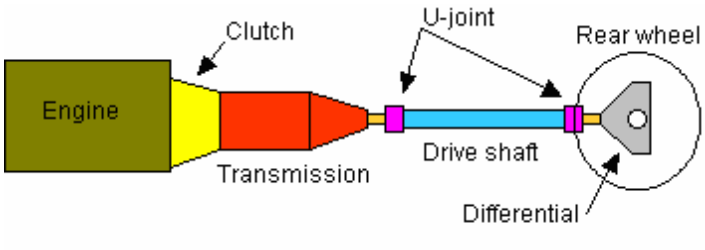
A position sensor is built into the EGR valve. The ECA uses the signal from the sensor to determine the position of the valve. The EGR valve and position sensor are replaced as a unit.

UNIT-IV

Transmission System, Gearbox & Differential

Transmission system

Chief function of the device is to receive power at one torque and angular velocity and todeliver it at another torque and the corresponding angular velocity.



Layout of automobile power transmission system

Requirements of transmission system

1. To provide for disconnecting the engine from the driving wheels.

2. When the engine is running, to enable the connection to the driving wheels to be made smoothly and without shock.

3. To enable the leverage between the engine and driving wheels to be varied.

4. It must reduce the drive-line speed from that of the engine to that of the driving wheels in a ratio of somewhere between about 3:1 and 10:1 or more, according to the relative size of engine and weight of vehicle.

5. Turn the drive, if necessary, through 90° or perhaps otherwise re-align it.

6. Enable the driving wheels to rotate at different speeds.

7. Provide for relative movement between the engine and driving wheels.

CLUTCH

The clutch is housed between the engine and transmission where it provides a mechanical coupling between the engine's flywheel and the transmission input shaft. The clutch is operated by a linkage that extends from the passenger compartment to the clutch housing. The purpose of the clutch is to disconnect the engine from the driven wheels when a vehicle is changing gears or being started from rest.

Disengaging the clutch separates the flywheel, the clutch plate and the pressure plate from each other. The flywheel is bolted to the end of the crankshaft and rotates with it. The clutch plate is splined to the gearbox in order for both to rotate together and the pressure plate clamps the clutch plate to the flywheel. When the pressure is released by depressing the clutch pedal, the crankshaft and gearbox input shaft rotate independently. When the foot is taken off they rotate as one.

REQUIREMENTS OF A CLUTCH

The clutch must

1. Pick up its load smoothly without grab or clatter.

2. Have a driven disc of low moment of inertia to permit easy shifting.

3. Damp out any vibration of the crankshaft to prevent gear clatter.

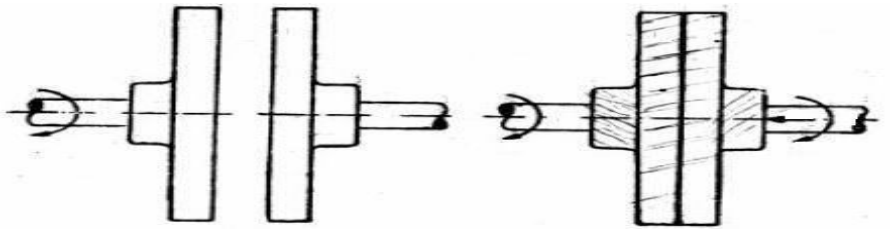
4. Require little pedal pressure to operate it.

5. Be easy to adjust and service.

6. Be cheap to manufacture.

BASIC PRINCIPLE OF THE FRICTION TYPE CLUTCH

To understand the working principle of clutch, let's take two sanding discs, first one driven by a power drill corresponds to the flywheel of a car, driven by the engine. If a second sanding disc is brought into contact with the first, friction makes it revolve too but more slowly. But when the second disc pressed against the first disc which is connect to the power drill, as the pressure increases the two discs revolve as one. This is how a friction clutch works.



Single plate clutch construction

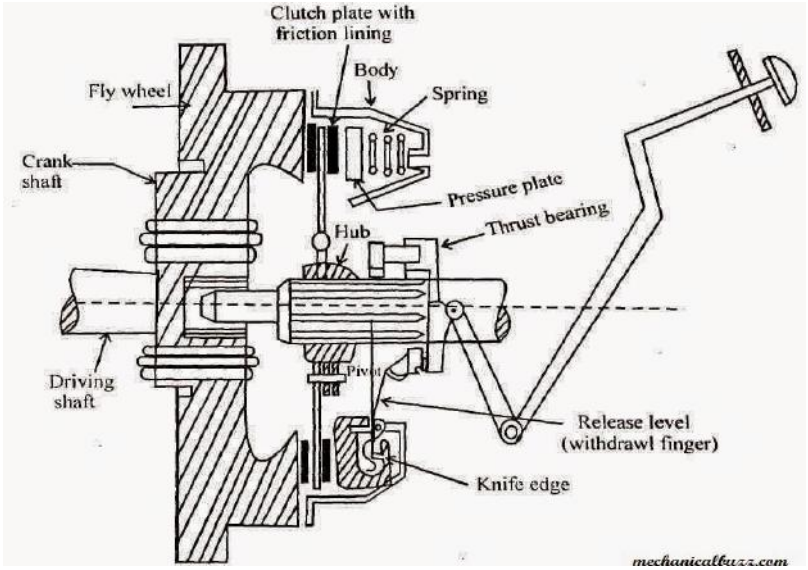
A typical clutch actuated by a number of coil springs on a pitch circle nears the periphery is shown. The driven shaft which normally is a forward extension of gearbox primary shaft is supported at its front end in ball bearing in a hole in the centre of flywheel web, which is spigot and bolted on to a flange at the

rear end of the crankshaft.

In this clutch, the coil springs force the pressure plate forwards to clamp the driven plate between it and the rear face of the flywheel. Three lugs extend rearwards from periphery of pressure plate both to rotate the pressure plate and to cause it to rotate with the rest of the assembly. The driven plate of course is splined onto the shaft. here are three release levers pressing the coil springs at the outer end. The inner ends of the levers can be forced forward by means of thrust bearing made of graphite and slide along the clutch shaft when clutch pedal is depressed. The driven plate mounted between flywheel and pressure plate makes the clutch shaft to rotate to transmit power. It has the clutch facing made of friction materials around the periphery of disc.

Working

When the clutch is engaged, the clutch plate is gripped between the flywheel and pressure plate. The friction linings are on both sides of clutch plate. Due to friction between flywheel, clutch plate and pressure plate, the clutch plate revolves with the flywheel. As clutch plate revolves the clutch shaft also revolves. Thus, engine power is transmitted to the clutch shaft. When the clutch pedal is pressed the pressure plate moves back against the spring force and clutch plate becomes free between flywheel and pressure plate. Thus flywheel remains rotatingas long as the clutch pedal is pressed, the clutch is said to be disengaged and clutch shaft speed reduces slowly and finally it stops rotating.



Advantages:

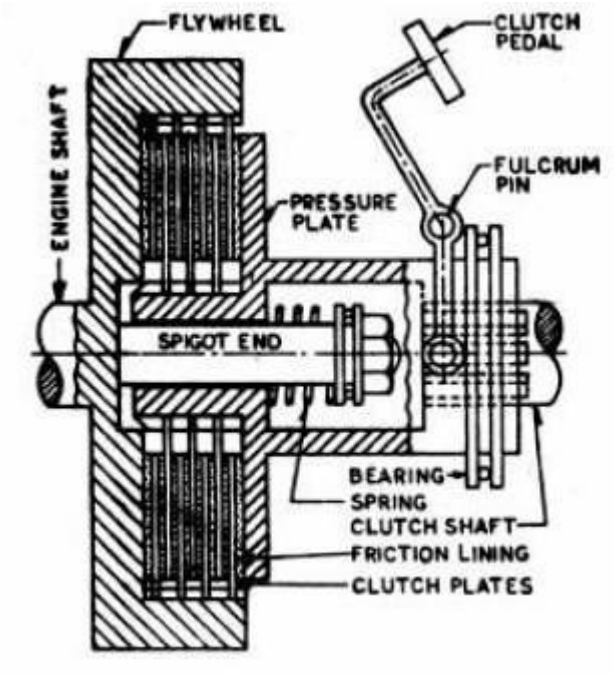
- The Working engagement is smooth
- It Consume less power
- It has No require of cooling oil used
- Quickly operated & respond fast

- It is Easy to change the gear

Dis-advantages:

- High wear & tear rate
- Less Torque transmission capacity
- High Maintenance charges
- It required space to accommodate Clutch

MULTIPLATE CLUTCH



The multi-plate clutch is an extension of single plate type where the number of frictional and the metal plates are increased. The increase in the number of friction surfaces obviously increase capacity of the clutch to transmit torque, the size remaining fixed. Alternatively, the overall diameter of the clutch is reduced for the same torque transmission as a single plate clutch. This type of clutch is, used in some heavy transport vehicles, in epicyclic gearboxes and racing cars where high torque is to be transmitted. Besides, this finds applications in case of scooters and motorcycles, where space available is limited.

Extension of flywheel is a drum; which on its inner circumference is splined to carry a number of thin metal plates. These must consequently revolve with drum but are able to slide axially. Interleaved with these outer plates are a number of inner plates that are splined to an inner drum which is coupled rotationally to the gearbox shaft.

This drum is supported on a spigot extension of crankshaft. Between the web of inner drum andsleeve in

inner drum is a strong coil spring. The inner drum is thus pressed to left being provided with a flange it squeezes the inner and outer plates together so that friction between them transmits driving torque from outer to inner drum.

The clutch is disengaged by pulling inner drum right against spring force. The plates of multi- plate clutch were at one time made alternately of steel and phosphor bronze but now are all of steel or one set may be lined with a friction material. With metal contact lubrication is essential and so clutch is made oil-tight and partly filled with oil. The oil tends to make the plates drag when clutch is disengaged and so some mean should be provided to avoid this drag.

DRY MULTIPLATE CLUTCH

Multi plate clutches are also made to work dry, without any oil. The driving plates are then lined on each side with a friction fabric. In such clutches, the driving plates are sometimes carried on a number of studs screwed into the web of flywheel in the same way as the outer plate of a Single Plate Clutch is carried. This construction is inconvenient when oil is used. Several small springs can be used instead of a single spring.

AUTOMATIC CLUTCH

Many attempts have been made to produce motor vehicles that can be controlled by the accelerator pedal and brakes only. This can be done in several ways. A centrifugal clutch which automatically disengages itself when the speed falls below and which re-engages when the speed rises above some predetermined values may be used. Alternatively, a fluid coupling, fluid torque converter may be employed.

Advantages

- Decreases the weight of the Clutch
- Comes with the compact Size
- The amount of Torque transmission increases.
- It decreases the moment of inertia of the Clutch

Dis-advantages

- Heat up quickly.
- They are Costly.
- They are heavy Weighted.

CENTRIFUGAL CLUTCH

In this type of clutches the springs are eliminated altogether and only the centrifugal force is used to apply the required pressure for keeping the clutch in engagement position.

The advantage of the centrifugal clutch is that no separate clutch pedal is required. The clutch is operated automatically depending upon the engine speed. This means that car can be stopped in gear without stalling the engine. Similarly while starting, the driver can first select the gear, put the car into the gear and simply press the accelerator pedal. This makes the driving operation very easy.

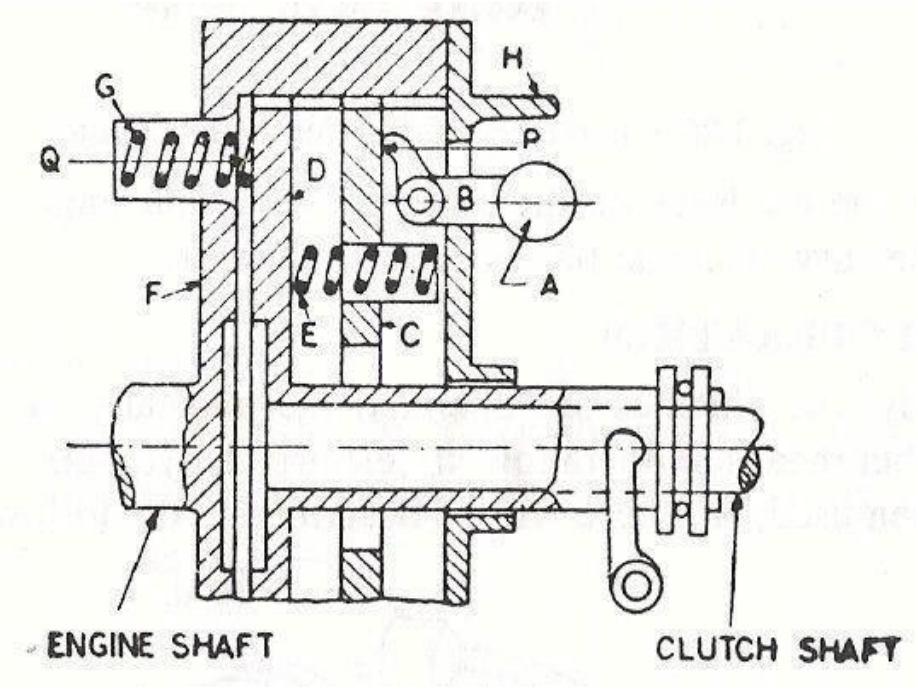


Figure shows a schematic diagram of a centrifugal clutch. As the speed increases, the weight A fly off, thereby operating the bell crank lever B that presses the plate C. This force is transmitted to the plate D by means of springs E. The plate D containing friction lining is thus pressed against the flywheel F thereby engages the clutch. Spring G serves to keep the clutch disengaged at low s peed say 500 rpm. The stop H limits the amount of centrifugal force.

The operating characteristics of this type of clutch will be then as shown in figure. Force P is proportional to the centrifugal force at a particular speed, while force Q exerted by spring G is constant at all speeds. The firm line in the figure shows that net force on the plate D for various engine speeds. At the upper end the curve is made f lat by means of stop H.

Advantages of centrifugal clutch:

1 It is easier for the driver since the operation becomes simpler.
2) It is low in price.
3) It requires very little maintenance.
4) It is safer for both the user and the system since huge loads won't stall the engine and letting the throttle free disengages the driving shaft almost immediately.
5) The engaging speed can be preciously controlled by selecting springs.

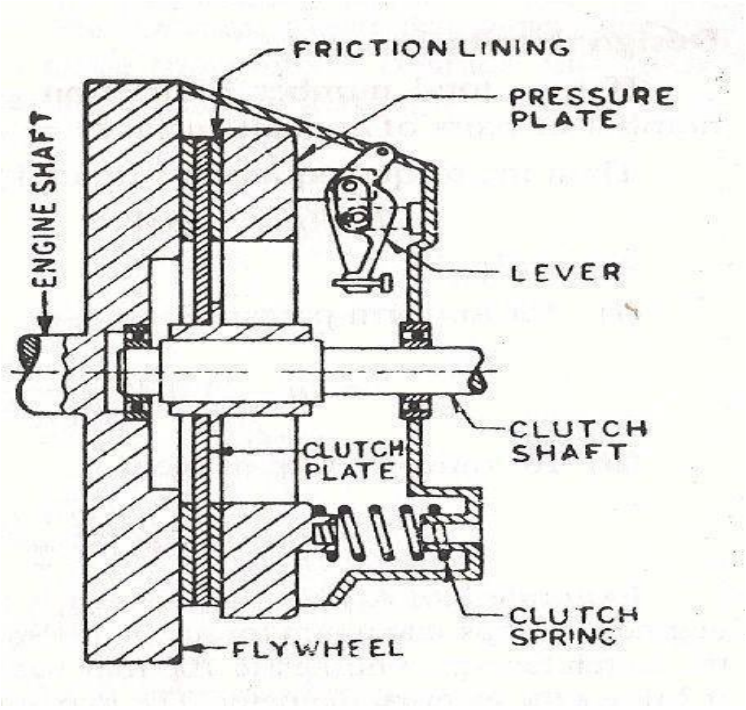
6) If optimized in conjunction with a particular engine, the overall operation can become extremely efficient and effective.

Disadvantages of Centrifugal clutch:

1 Power transmission is limited due to slippage.
2) Overheating problem due to friction between the drum and shoes. If taken too far due to bad driving/usage habits, permanent damage may completely destroy the clutch.
3) There is a need for frequent oiling of centrifugal clutch arrangement so as to keep the temperature at a safe level.
4) It cannot be used to transmit a high amount of torque.
5) The power transmission is totally dependent on controlling speed.
6) There will be always a power loss due to friction and slipping.

SEMI CENTRIFUGAL CLUTCH

It uses both centrifugal and spring force for keeping it in an engaged position. The springs are designed to transmit torque at normal speed, while centrifugal force assists in torque transmission at high speed. This clutch consists of three hinged and weighted levers and three clutch springs alternately arranged at equal spaces on the pressure plate. At low speeds the springs keep the clutch engaged and the weighted levers do not have any pressure on pressure plate. At high speeds when power transmission is high, weights fly off and the levers also exert pressure on plate, keeping the clutch firmly engaged.



When the speed decreases the weights do not exert any pressure on the pressure plate. Only spring

pressure is exerted on pressure plate which keeps the clutch engaged. An adjusting screw is provided at the end of the lever by means of which the centrifugal force on pressure plate can be adjusted. At low speeds pressure on the spring is sufficient to transmit the torque required. However at high speeds, the centrifugal force due to weight moves about the fulcrum thereby pressing the pressure plate. The centrifugal force is proportional to the square of speedso that adequate pressure level is attained.

Advantages of semi centrifugal clutch:

- Less stiff clutch springs are used as they operate only at low speeds
- Driver will not get strained in operating the clutch

Single Plate Clutch	**Multi Plate Clutch**
Single Plate Clutch has only a single frictional clutch plate.	Multi Plate Clutch consists of a number of frictional clutch plates.
Single Plate Clutch provides less torque carrying capacity compared to multiple clutch.	Multi Plate Clutch provides the increased torque carrying capacity.
Single Plate clutch is less smooth and easier to operate.	Multi plate clutch is smoother and easier to operate
Single Plate Clutch requires more space.	Multi Plate Clutch requires less space.
Coefficient of friction is high in single plate clutch	coefficient of friction is low in multi plate clutch
Dry-type clutch	Wet type clutch
Used in a light vehicle like Car etc.	Used in a heavy vehicles like military and agricultural vehicles.

Difference between Centrifugal & Semi-Centrifugal Clutches

Talking about the semi-centrifugal clutches, these are not automatic clutches.

- Semi-centrifugal clutches are part of manual clutches that needs a clutch pedal to activate.
- Whereas the centrifugal clutches are automatic and do not need any pedal-operated force.
- The semi-centrifugal clutches operation is easy and there are less stiff clutch springs and operate only at low speeds.
- Whereas centrifugal clutches are suitable for higher speeds and they struggle at certain speeds.
- The semi-centrifugal clutches are used in high-powered engine and racing cars, where the efforts of drivers are needed to operate the clutches and control the vehicles.

Gearbox

A gearbox is a mechanical device used to transmit and control mechanical power from one rotating shaft to another. The specific requirements of a gearbox can vary depending on its intended application, but here

are some general requirements and considerations that are common for designing and selecting gearboxes:

Torque and Power Transmission: The gearbox must be designed to handle the required torque and power levels for the application. This involves selecting appropriate gear sizes, materials, and manufacturing methods to ensure that the gearbox can transmit power efficiently without failure.

Gear Ratios: The gearbox should provide the necessary gear ratios to match the speed and torque requirements of the driven components. Different gear ratios are achieved by using various combinations of gear sizes (number of teeth).

Efficiency: Gearboxes introduce mechanical losses due to friction, meshing, and other factors. Designing for high efficiency is important to minimize energy wastage during power transmission.

Load Capacity: The gearbox should be capable of handling the anticipated loads and shocks that the application may subject it to. This includes static and dynamic loads as well as intermittent peak loads.

Durability and Reliability: Gearboxes should be designed to withstand the expected service life of the application. Proper material selection, heat treatment, and quality control are essential to ensure longevity and reliability.

Noise and Vibration: The design should consider minimizing noise and vibration, which can be generated due to gear meshing and other mechanical interactions.

Cooling and Lubrication: Adequate cooling and lubrication systems are important to prevent overheating, reduce wear and friction, and extend the gearbox's lifespan.

Space Constraints: The physical size of the gearbox should fit within the available space in the application.

Environmental Conditions: The gearbox may be exposed to various environmental conditions such as temperature extremes, humidity, dust, or corrosive agents. These factors should be considered in the design and material selection.

Maintenance and Serviceability: The design should facilitate easy maintenance, inspection, and repair. This includes access to components, replaceable parts, and clear documentation.

Compatibility: The gearbox should be compatible with the other components of the system, including input and output shafts, coupling methods, and mounting arrangements.

Cost and Manufacturing: The design should balance performance requirements with manufacturing costs. Complex designs may offer superior performance but could be more expensive to manufacture.

Safety: Gearboxes should be designed to minimize the risk of accidents, such as gear disengagement, gear tooth failure, or oil leakage.

Regulations and Standards: Depending on the industry and application, there may be specific regulations or

industry standards that the gearbox must comply with.

Application-Specific Considerations: Different applications may have unique requirements. For example, automotive gearboxes have different requirements compared to industrial machinery gearboxes.
A gear selecting mechanism, often found in vehicles like cars, motorcycles, and bicycles, is responsible for engaging and disengaging different gears in the transmission system. Gears are used to control the speed, torque, and power distribution between the engine and the wheels. The gear selecting mechanism allows the driver or rider to choose the appropriate gear ratio based on the driving conditions.

There are several types of gear selecting mechanisms, depending on the type of vehicle and transmission system:

Manual Transmission:
In manual transmissions, the driver uses a gear shift lever to manually select the desired gear. The most common type of manual transmission is the "H-pattern" gearbox, where gears are arranged in a pattern resembling the letter "H". To change gears, the driver moves the gear shift lever in specific directions and positions, corresponding to the desired gear.

Automatic Transmission:
Automatic transmissions use a complex hydraulic and electronic system to automatically select gears based on the vehicle's speed, load, and other factors. The gear selection is handled by the transmission control unit (TCU), which uses sensors to determine the best gear for the current driving conditions. Drivers usually have the option to select between different driving modes (e.g., "Drive," "Sport," "Manual"), allowing some level of control over gear selection.

Semi-Automatic Transmission:
Semi-automatic transmissions combine elements of both manual and automatic transmissions. They typically allow the driver to manually shift gears without using a clutch pedal. Some systems use paddle shifters mounted on the steering wheel to facilitate quick gear changes.

Continuously Variable Transmission (CVT):
CVTs offer an infinite number of gear ratios within a certain range, providing smooth acceleration without distinct gear shifts. They use a system of belts or chains to vary the effective diameter of pulleys, adjusting the gear ratio as needed.

Dual-Clutch Transmission (DCT):
DCTs have two separate clutches for odd and even gears, allowing for quick and seamless gear changes. While one clutch engages one gear, the other clutch pre-selects the next gear. This results in very fast and smooth gear shifts.

The gear selecting mechanism is a crucial component of any vehicle's drivetrain, as it determines how power is transferred from the engine to the wheels. The mechanism's design and operation can vary significantly based on the type of transmission and the vehicle's intended use.

SLIDING MESH GEAR BOX

It is the simplest and oldest type of gear box.

1. The clutch gear is rigidly fixed to the clutch shaft.

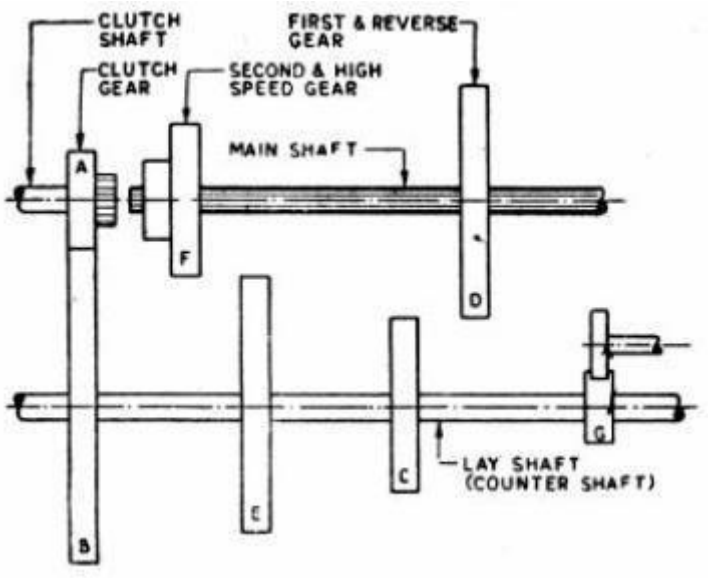
2. The clutch gear always remains connected to the drive gear of countershaft.

3. The other lay shaft gears are also rigidly fixed with it.

4. Two gears are mounted on the main shaft and can be sliding by shifter yoke when shifter is operated.

5. One gear is second speed gear and the other is the first and reverse speed gears. All gears used are spur gears.

6. A reverse idler gear is mounted on another shaft and always remains connected to reverse gear of counter shaft.



FIRST GEAR

By operating gearshift lever, the larger gear on main shaft is made to slide and mesh with first gear of countershaft. The main shaft turns in the same direction as clutch shaft in the ratio of 3:1.

SECOND GEAR

By operating gear shift lever, the smaller gear on the main shaft is made to slide and mesh with second

gear of counter shaft. A gear reduction of approximately 2:1 is obtained.

TOP GEAR

By operating gearshift lever, the combined second speed gear and top speed gear is forced axially against clutch shaft gear. External teeth on clutch gear mesh with internal teeth on top gear and the gear ratio is 1:1.

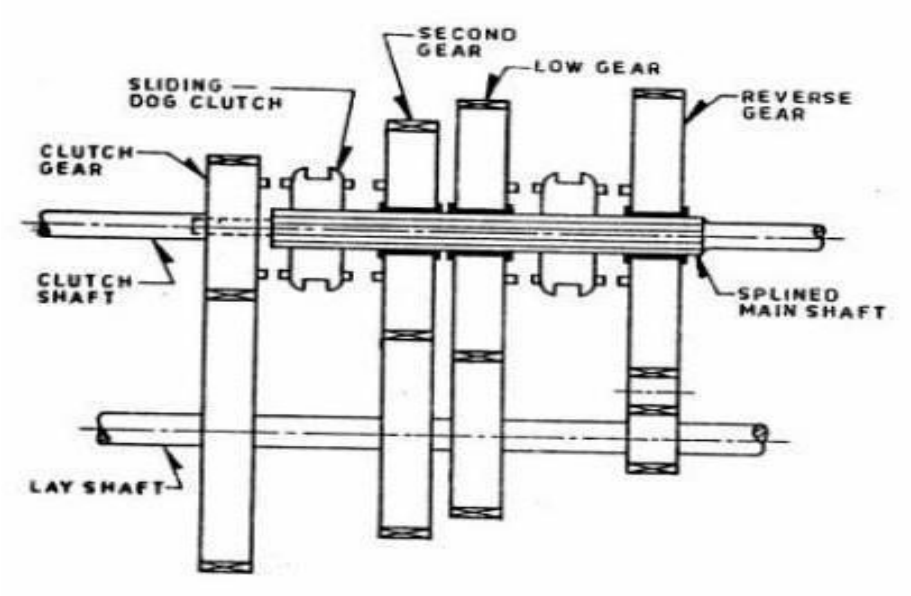
REVERSE GEAR

By operating gearshift lever, the larger gear of main shaft is meshed with reverse idler gear. Thereverse idler gear is always on the mesh with counter shaft reverse gear. Interposing the idler gear, between reverse and main shaft gear, the main shaft turns in a direction opposite to clutch shaft.

NEUTRAL GEAR

When engine is running and the clutch is engaged, clutch shaft gear drives the drive gear of the lay shaft and thus lay shaft also rotates. But the main shaft remains stationary as no gears in main shaft are engaged with lay shaft gears.

CONSTANT MESH GEARBOX



In this type of gearbox, all the gears of the main shaft are in constant mesh with corresponding gears of the countershaft. The gears on the main shaft which are bushed are free to rotate. The dog clutches are

provided on main shaft. The gears on the lay shaft are, however, fixed.

When the left Dog clutch is slid to the left by means of the selector mechanism, its teeth are engaged with those on the clutch gear and we get the direct gear. The same dog clutch, however, when slid to right makes contact with the second gear and second gear is obtained. Similarly movement of the right dog clutch to the left results in low gear and towards right in reverse gear. Usually the helical gears are used in constant mesh gearbox for smooth and noiseless operation.

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. 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.

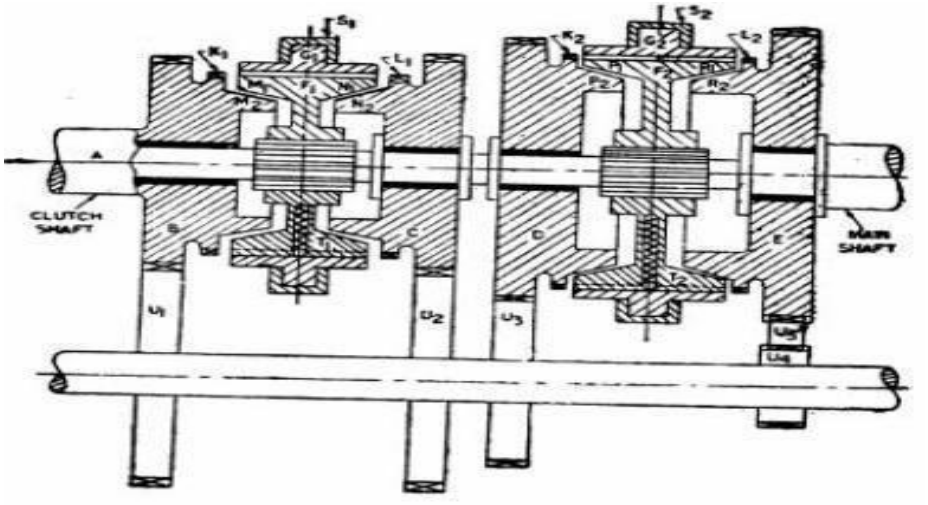
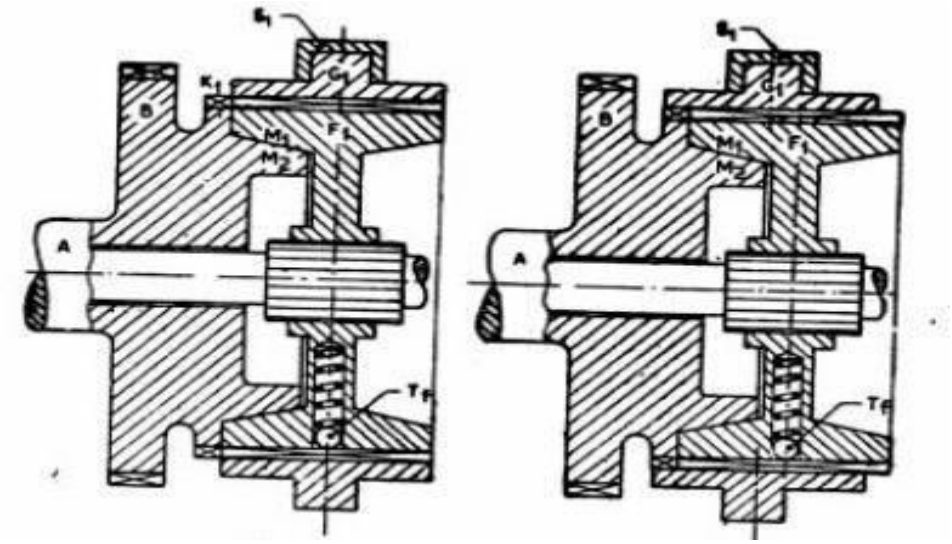


Figure shows the construction and working of a synchromesh gearbox. In most of the cars, however, the synchromesh devices are not fitted to all the gears as is shown in this figure. They are fitted only on the high gears and on the low and reverse gears ordinary dog clutches are only provided. This is done to reduce the cost. In figure A is the engine 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. 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 slid towards left till cones M1 and M2 rub and friction makes their speed equal. 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. Similarly for second gear the members F1 and G1 are slid 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.

A synchro's purpose is to allow the collar and the gear to make frictional contact before the dog teeth make contact. This lets the collar and the gear synchronizes their speeds before the teeth need to engage, like this: The cone on the blue gear fits into the cone-shaped area in the collar, and friction between the cone and the collar synchronize the collar and the gear. The outer portion of the collar then slides so that the dog teeth can engage the gear.

Propeller shaft

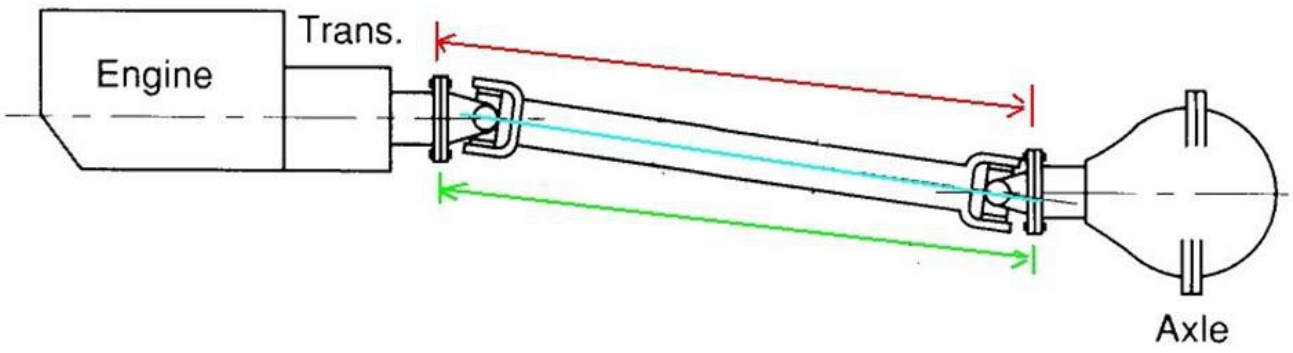
1. This is the shaft which transmits the drive from the gear box to the bevel pinion or worm of final drive in front engine rear drive vehicle.
2. Also called drive shaft
3. It consists of three parts.

1) Shaft: As this has to withstand mainly torsional loads, it is usually made of tubular cross section

2) One or two universal joints, depending upon the type of the rear axle drive used. The universal joints act for the up and down movements of rear axle when the vehicle is running.

3) Slip joint -Depending upon the type of drive one slip joint may be there in the shaft. This serves to adjust the length of the propeller shaft when demanded by the rear axle movement.

4. Fig shows a propeller shaft with two universal joints at end and a slip or sliding joint, Slip joint is formed by the internal splines on the sleeve attached to the left universal joint and external splines on the propeller as shown.



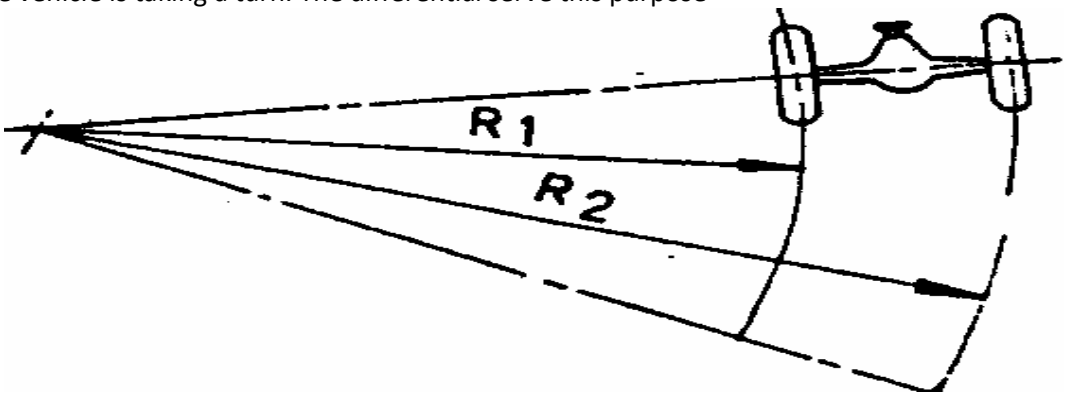
5. In vehicles with large wheel base, the long propeller shaft would tend to sag and whirl.
6. Whirl is like the action of a rope that is in an arc while held at both ends.
7. At certain speed the whirling becomes critical and the shaft vibrates violently. This also sets up sympathetic resonant vibrations in the vehicle body.

Differential

1.If a vehicle travels in a straight line, the two rear wheels turn on the road exactly at same speed. There is no relative movement between the two rear wheels. But when the
vehicle takes a turn, the outer wheel travels on a longer radius than the inner wheel.

2 The outer wheel turns faster than the inner wheel, that is, there is a relative movement between the two rear wheels. If the two rear wheels are rigidly fixed to a rear axle the
Inner wheel will slip which will cause rapid tyre wear, steering difficulties and poor roadholding.

3 Therefore there must be some devices to provide relative movement to the two rear wheels when the vehicle is taking a turn. The differential serve this purpose



When the car is taking a turn, the outer wheels will have to travel greater distance as compared to inner wheels at same time.

4 If therefore, the car has a solid rear axle only and no other device , there will be tendency for vehicles to skid.

5 Hence , if the wheel skidding is to be avoided , some mechanism must be incorporated in the rear axle, which should reduce the speed of the inner wheels and increase the speed of outer wheels when taking turns.

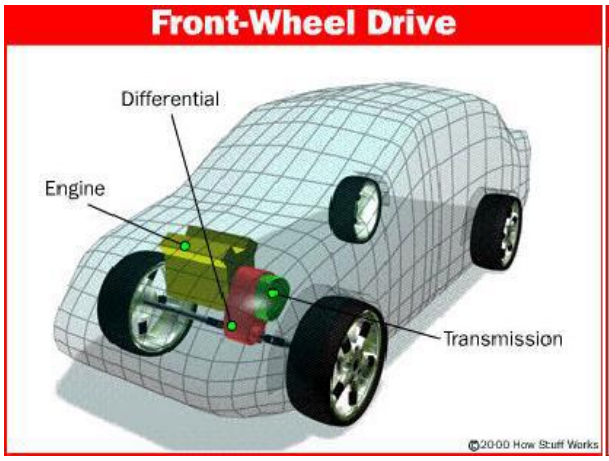
6 It should at the same time keep the speeds of all the wheels same when going straight ahead, Such a device which serves the above function is called **Differential** The function of the differential is to allow each rear wheel to rotate at different speeds during running but at the same time transmit equal torque to each wheel when both wheels have equal traction.

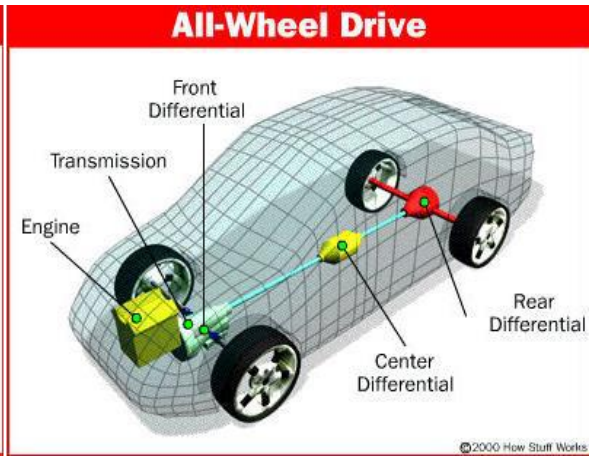
Working of differential

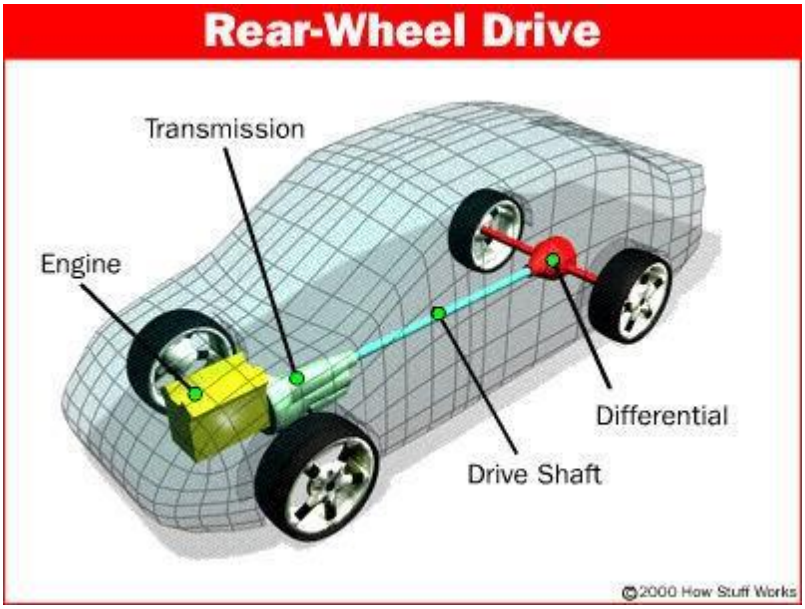
1 When the vehicle is moving on straight level road and the resistance affecting both the driving wheels is the same, there is no relative movement among the differential gears. The whole arrangement meshed together moves as one unit and both the half shafts in the driving wheel rotate at the same speed.

2 When the front wheels are turned to any directions to take a turn, a binding force acts on the inner wheel being nearer to the point around which wheels move in a circle. The sun gear of the side is held slow in relation to the movement of the complete cage or crown wheel While taking a turn when the bonding acts on the inner side sun gear and its speed is slowed down, the star pinion rotate the other side sun gear at a speed as a result of loss on the inner side and gain on the outer side plus the speed at which the complete differential assembly is rotating.

3 This results in a faster movement of the outer wheel than the inner one.







Types of Axles :- The axle is a shaft used for rotating and supporting the wheels of an automobile. Axle plays very important role in automobile. On one side, the axle is attached to a differential via sun gear and on the other side it is connected to the wheels.

In some cases, the axles are fixed to the wheels and rotate with wheels while in some cases axle is fixed to vehicles and only wheels can rotate with respect to the axle. Bearings are used to for the second case .

Types of Axle

Axles are classified into three categories:

1. Front axle

2. Stub axle

3. Rear axle

1. Front Axle: (Types of Axles)

Front axle is placed on the front side of automobiles. Front wheels are mounted on it. Front axle is generally made of I-section in middle portion and circular or elliptical at the ends. This cross section helps axle to withstand bending due to high loads applied by vehicle weight and torque during braking. The main functions of front axle are:-

- It supports the front part weight of vehicle
- It absorbs upcoming shocks by using shock absorbers
- It facilitates steering mechanism

A) Dead Front Axle

The dead front axles are the axles, which are fixed and do not rotate with the wheels. These axles have high strength and rigidity to support vehicle. The ends of the front axle are designed to accommodate the stud axles.

B) Live Front Axle

The live front axles are the same as dead front axles, there is only one difference that live front axles are used to transmit the power from gearbox to the front wheels in front wheel drive vehicles. It rotates with the front wheels.

2. Stub Axle: (Types of Axles)

Stub axles are generally used in front wheels. Wheels are connected to the stub axle by means of kingpins. It is made of nickel steel and alloy steel which contains chromium and molybdenum. It turns on the pinned pin which is used in light drive. The axle beam eye is locked by taper cotter pin.

Bushes made of phosphor bronze are installed into the fork ends of axle to provide bearing surface for the kingpin. Forces acting on vertical direction are supported by a steel washer or a thrust bearing placed either on the top fork or between lower fork and the underside of the axle beam.

(a) Elliot: – To connect to the front axle, this stub axle uses a yoke, a cotter and a kingpin.
(b) Reverse Elliot: – This type of axle has a layout opposite to the Elliot stub axle.
(c) Lamoine: – This Lamoine stub axle has a L shaped spindle instead of a yoke hinge.
(d) Reverse Lamoine: – It is just the opposite of the standard Lamoine axle.

3. Rear Axles: (Types of Axles)

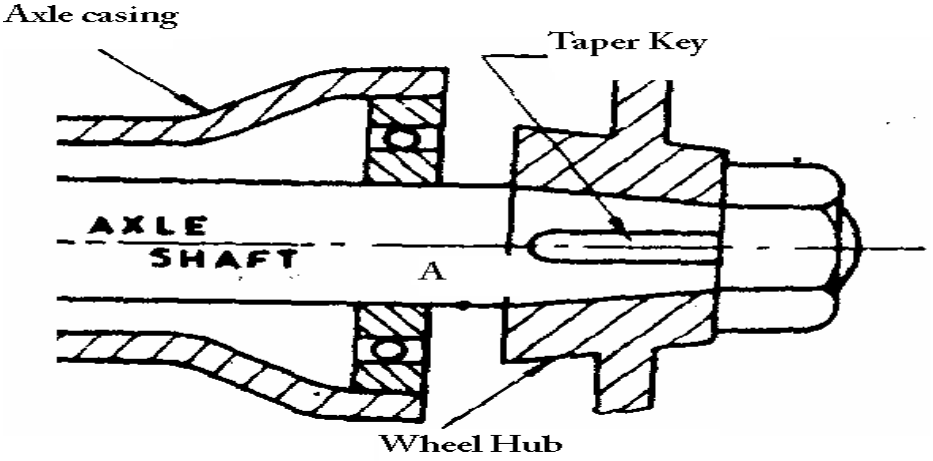
Rear axle is placed in between the differential and the driving wheels to transmit power from the differential to driving wheels. It is employed on the vehicles which are rear wheel drives.
Bearings are provided on rear axle. The vertical load, which comes onto the axle casing, through the springs, is transmitted through these bearings to the shaft and hence the wheels to the ground. The reaction of this load between the wheel and the ground act upwards on the wheel.

Depending upon the method of supporting the rear axles and mounting the rear wheels, therear axles are of three types:

1) Semi floating axle
2) Full floating axle
3) Three quarter floating axle

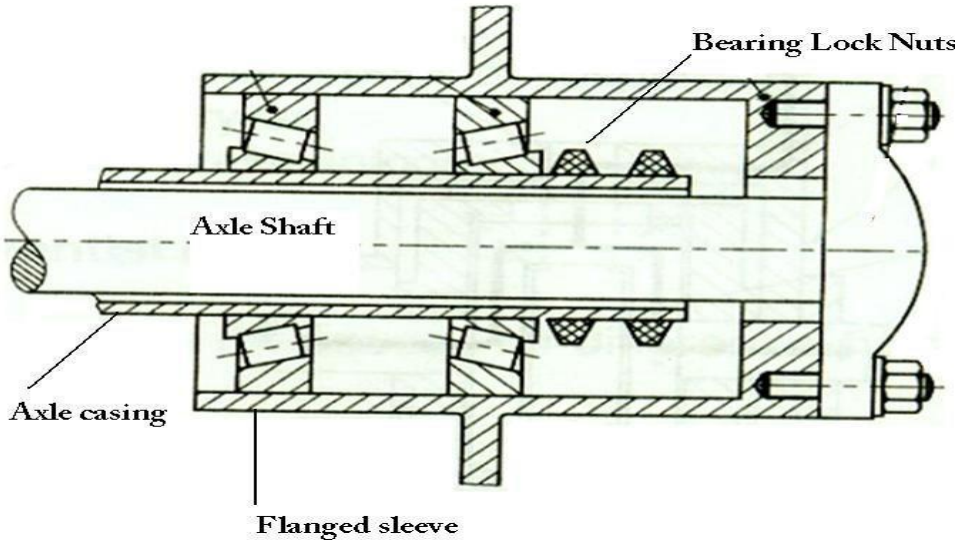
SEMI FLOATING AXLE

The wheel hub is directly connected to the axle shaft or is an extension of the same. The inner end of



axle shaft is splined and is supported by final drive unit, whereas the outer end is supported by single bearing inside the axle casing. All the loads are taken by axle shaft. The vehicle load is transmitted to each of half shafts through the casing and the bearing. This causesa bending load and tendency to shear at point marked 'A'. Semi floating axle is simplest and cheapest of all types therefore it is widely use on cars. However , since the axle shafts have to support all loads , they have to be of large diameter for the same torque transmitted compared to the other type of axle supporting

FULL FLOATING AXLE

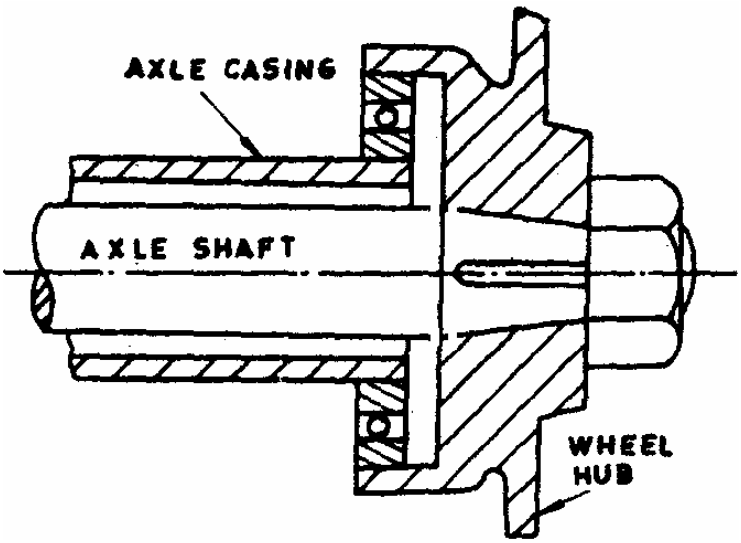


This type is very robust one and is used for heavy vehicles. In this the **axle shaft carry only the driving torque .** A full floating axle has two deep-groove ball or taper roller bearings, located between the axle casing wheel hub. The outer of the axle is made flanged to which the wheel hub is bolted. The axle is not supported by bearings at either end, and its position is maintainedby the way that it is supported at both ends The weight of the vehicle and end thrust are not carried by them , the weight being completely

supported by the wheels and the axle casing . As the axle shaft carry only driving torque , their failure or removal does not affect the wheels. The axle may be removed from the housing without disturbing the wheel by removing the nuts An additional advantage of the design is the ability to withstand the vehicle even if it has a broken axle. This type of axle is more expansive and heavier than the other axles.

THREE QUARTER FLOATING AXLE:

In the three quarter floating axle the single bearing located between the hub and the axle casing. Thus, the weight of the vehicle is transferred to the axle casing, and only the side thrust and driving' torque are taken by the axle. The inner end of this axle has the same construction as that of the semi-floating axle. The axle shaft does not take any shearing or bending loads due to the weight of the vehicle. However it has to take the end loads and driving torque. Although the three quarter floating axle is more reliable but it is not as simple as the semi floating axle.



Steering wheel alignment

It is also called wheel alignment in general. It involves aligning the car's wheels in such a way that they are parallel to each other and perpendicular to the ground.

In the following cases, your car may need wheel alignment:

① **Steering wheel bending:** If the car finds that the steering wheel is off-center during straight-line driving, it may need to be aligned.

② **Handling problems:** Poor wheel alignment will affect the handling of the vehicle, causing it to be unstable or unresponsive.

③ **Uneven tire wear:** If the inner or outer edge of the tire wears unevenly, it may be a sign of misalignment.

④ **The vehicle drifts or pulls to one side:** When driving on a flat road if the vehicle drifts or pulls to one side without steering wheel input, it may be caused by misalignment.

How to fix steering wheel alignment

Fixing steering wheel alignment requires specialized equipment, and recommend finding a professionally trained mechanic or a professional auto service center to get it done. But if you suspect that your vehicle's steering wheel alignment is turned off, here are steps you can take:

① **Check the tires:** Check the tires for uneven wear, especially if there are signs of excessive wear on the inner or outer edges of the tires.

② **Test drive:** Test drive on a straight and flat road, observe and pay attention to whether the steering wheel of the vehicle is eccentric.

③ **Find a reliable tire service center:** Look for an auto service center with a good reputation and experienced technology in wheel alignment.

Regularly maintaining proper wheel alignment can extend the life of your tires, improve fuel efficiency, and provide better handling and safety while driving.

Steering System:

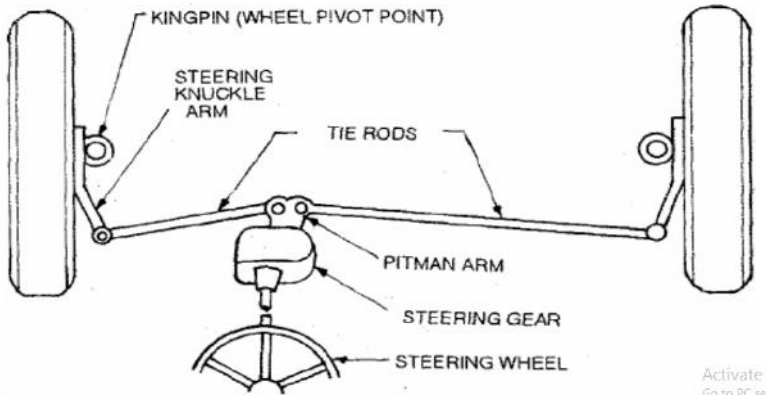
• Steering is the term applied to the collection of components, linkages, etc. which will allow a vehicle to follow the desired course.

• The front wheels are supported on front axle so that they can swing to left or right for steering. This movement is produced by gearing and linkage between the steering wheel in front of the driver and the steering knuckle or wheel.

• The complete arrangement is called “Steering System”.

• The function of steering system is to convert the rotary movement of the steering wheel into angular turn of the front wheels.

• The steering system also absorbs a large part of the road shocks, thus preventing them from being transmitted to the driver.



Front wheel steering Geometry:

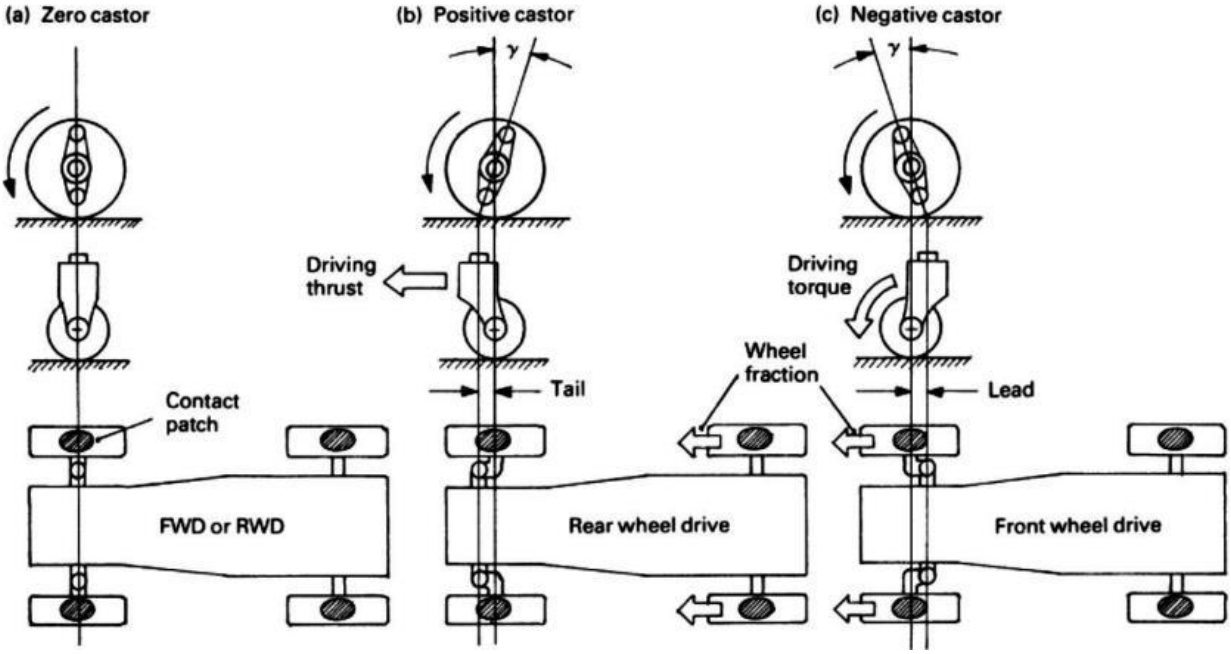
The term "steering geometry" (also known as "front-end geometry") refers to the angular Relationship

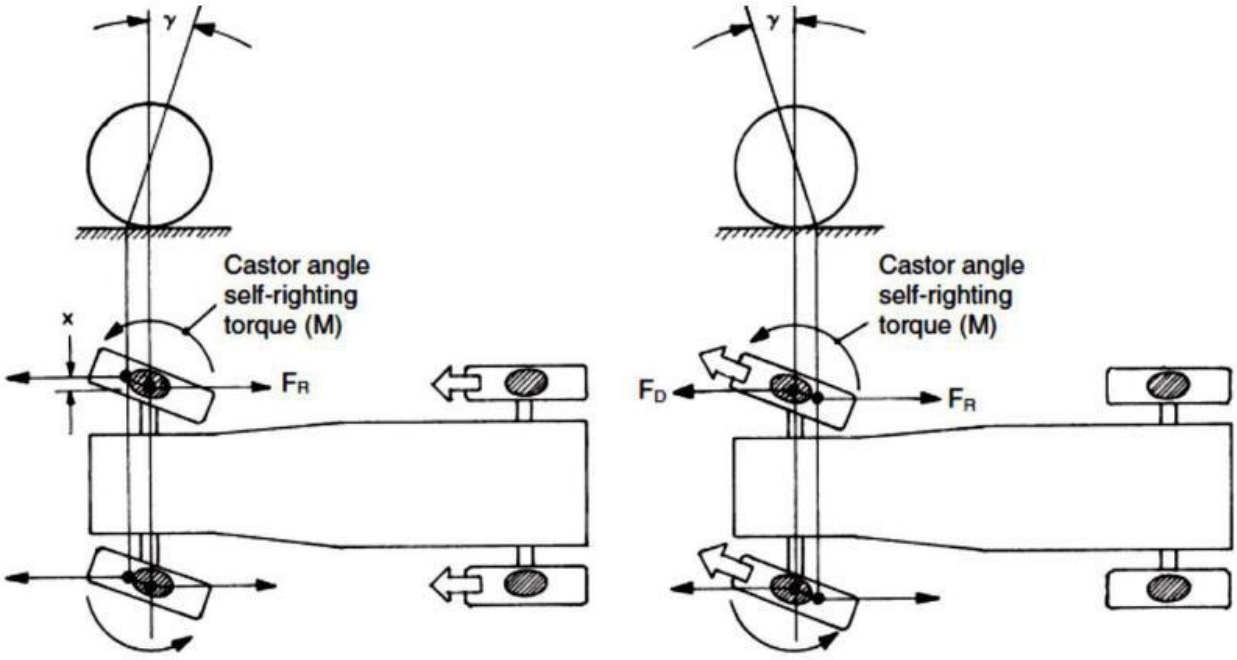
between suspension and steering parts, front wheels, and the road surface. Because alignment deals with angles and affects steering, the method of describing alignment measurements is called steering geometry.

1. Castor
2. Camber
3. King Pin Inclination (Steering axis Inclination)
4. Toe-in or Toe- Out

Castor Angle:-

• The inclination of king pin axis in front or rear direction so that the tire contact center is either behind or in front of the imaginary pivot center produced to the ground is known as Castor Angle.
• The angle between the king pin axis and the vertical, in the plane of the wheel is called as castor angle.
• 2 to 8 Degrees.





(a) Rear wheel drive castor angle self-righting torque effect

(b) Front wheel drive castor angle self-righting torque effect

Camber Angle:

• The angle between center line of tire and the vertical line when viewed from front of the vehicle is known as Camber Angle.

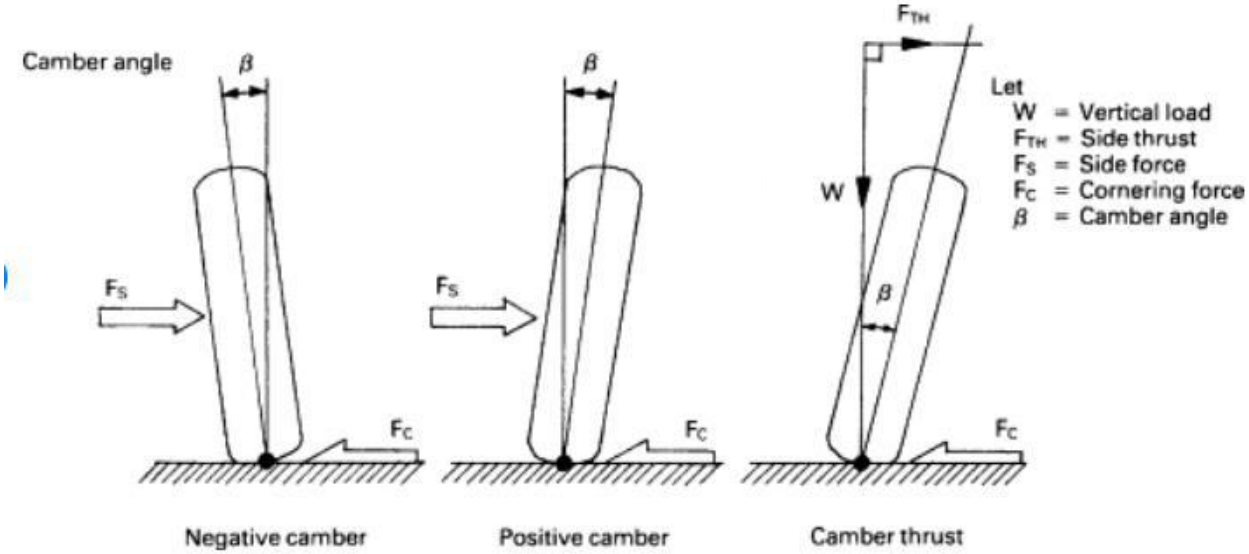
• If the top of the wheel (when viewed from front) is leans outward than bottom it is positive camber conversely if bottom of the wheel is outward than the top it is negative camber.

• Generally, it should not exceed 2 Degrees.

• Positive camber is used on most of vehicles.

• Positive camber increases steering effort.

• Negative camber is used on racing cars to provide directional stability and reduce steering effort.



Negative camber

Positive camber

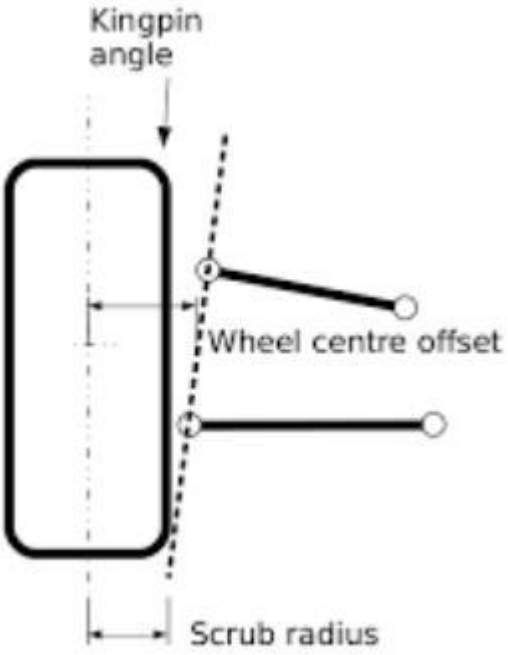
Camber thrust

King Pin Inclination or Steering Axle Inclination:

• The angle between the vertical line and the center of the king pin or steering axle when viewed from front of the vehicle is known as KPI or SAI.

• The KPI in combination with Castor angle is used to provide the directional stability in modern cars by tending to return the wheels to straight ahead position after any turn.

• This inclination varies from 4 to 8 degree in modern cars.

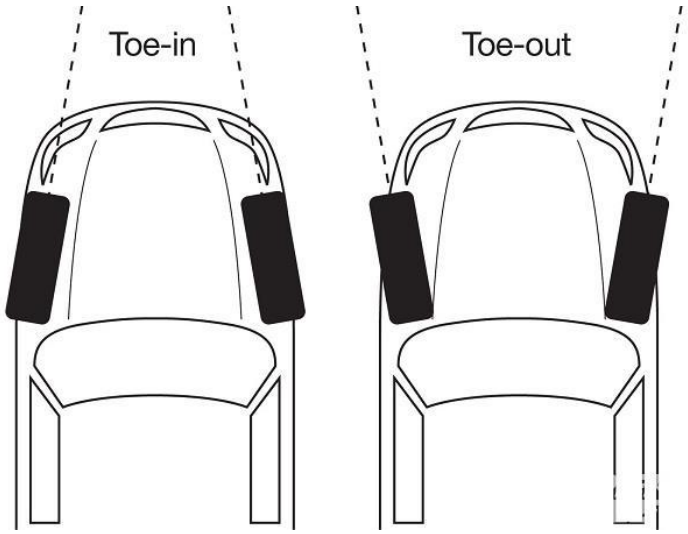


Toe- In & Toe- Out:

• In automotive engineering, toe also known as tracking.

• Positive toe, or toe in, is the front of the wheel pointing in towards the centerline of the vehicle

• Negative toe, or toe out, is the front of the wheel pointing away from the centerline of the vehicle.



Steering linkages

The steering linkage is a component of the steering system that helps transfer motion from the steering wheel to the wheels on the vehicle and helps to turn them in the right direction at the correct speed. It is also integrated with the front suspension, steer axle, and wheel/tire components.

Purpose of Steering Linkages

Steering linkage is a term used to describe a system of different pivots and connecting parts located between the steering arms and steering gear that moves the tires of a vehicle.

Steering linkages take the motion from the steering gear output and transfer it to the steering arms, which in turn send it to the wheels and allow them to turn in different directions. The system functions when a driver turns the steering wheel.

Steering Linkage Parts

Steering linkages feature a range of parts depending on which system is used, including the steering knuckles, steering control arm, tie rod ends, draglink, Pitman arm, and ball joints.

- **Steering control arm:** Control arms are components that connect the draglink and steering knuckle on the driver's side of a vehicle. When the draglink is moved in a straight line, the steering control arm moves the steering knuckle, which changes the angle of the steering knuckle.
- **Steering knuckles:** Mounted to the front axle beam by steel pins also known as "kingpins," steering knuckles allow the pivoting action required to steer the vehicle. The knuckles also contain a spindle where bearings and wheel hubs are mounted.
- **Ball joints:** These components help form a connection between the steering control arms and steering knuckles. They allow the steering knuckles to have mobility. They play a key role in helping front wheels move back and forth, as well as up and down, and do not affect steering.
- **Tie rod ends:** Tie rod ends are ball sockets that connect the control arms on each steering knuckle. They help transfer and synchronize the steering action of both steer wheels. Tie rods feature grease that works to cushion and protect the balls and sockets of the linkages as they move against each other.

Types of Steering Linkages

When it comes to heavy-duty steering linkage gear systems, there are three general types. They are the worm-and-sector, rack-and-pinion and recirculating-ball steering gear systems.

Worm and sector

The worm gearing used in these steering systems is slightly modified. The threads of the driving worm gear are meshed with the threads of a sector gear (via an input shaft). Rotating the input shaft transfers the rotary motion (via an output shaft) to the Pitman arm. The Pitman arm movement is transmitted through the draglink, to the steering control arm, then the steering knuckle, and finally to the wheels.

Rack and pinion

The rack-and-pinion steering linkage is the more common option seen on most cars, smaller trucks and SUVs. A semi-truck's rack-and-pinion utilizes a vertical pinion gear, horizontal rack and power-assist system that helps translate the motion of the steering wheel into linear motion, which actuates the tie rods, turning the wheels on the vehicle. Freightliner introduced rack-and-pinion steering on its Cascadia chassis in 2007.

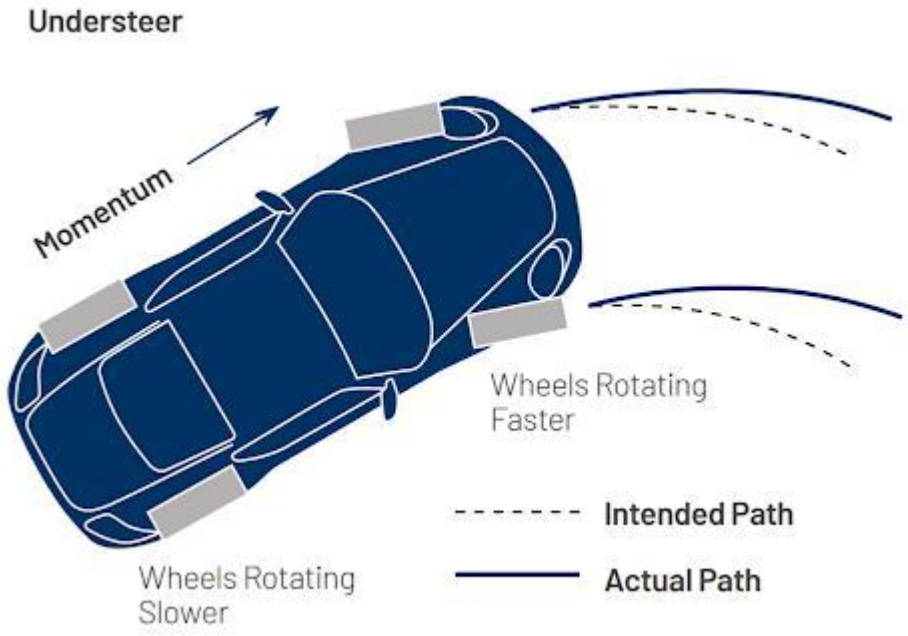
Recirculating ball

The input shaft of this type is also connected to the worm gear. However, the worm gear that's used is straight. A ball nut mounted on the worm gear mates with it and has exterior teeth on one side that mesh with a sector gear. There are ball bearings located in the grooves between the ball nut and worm gear that transmit force when the steering wheel is turned.

As the ball turning the nut moves up and down, it causes the sector gear to rotate, which in turn causes the Pitman arm to transfer motion through the draglink, to the steering control arm, and the steering knuckle to turn the wheels.

Under steering

Under steer is when a vehicle turns less than the angle requested through steering input, i.e. the front tyres struggle for traction, causing the vehicle to under-rotate and push wide through a turn.



What causes under steer?

Under steer happens as a direct result of driver input. Turning the steering wheel harshly, abruptly or just too much for the vehicle's speed versus the available grip will exceed the front tyres' traction, forcing the nose of the car to slide wide across the road surface in under steer. Cold or wet conditions make this all the more likely of course, whilst a lack of weight over the front tyres when smoothly accelerating too much too early mid-corner also triggers the problem.

Symptoms of under steer include:

- Tyre screeching from the front wheels
- Drifting towards the outside of a bend
- Steering that feels light
- Vibration through the steering wheel

How to correct under steer

We know that under steer is a result of the front tyres losing adhesion to the road surface. We know this is caused by excessive acceleration, steering, or speed for the steering angle required and available grip. To regain control, it is necessary to first remove (or at least reduce) the cause.

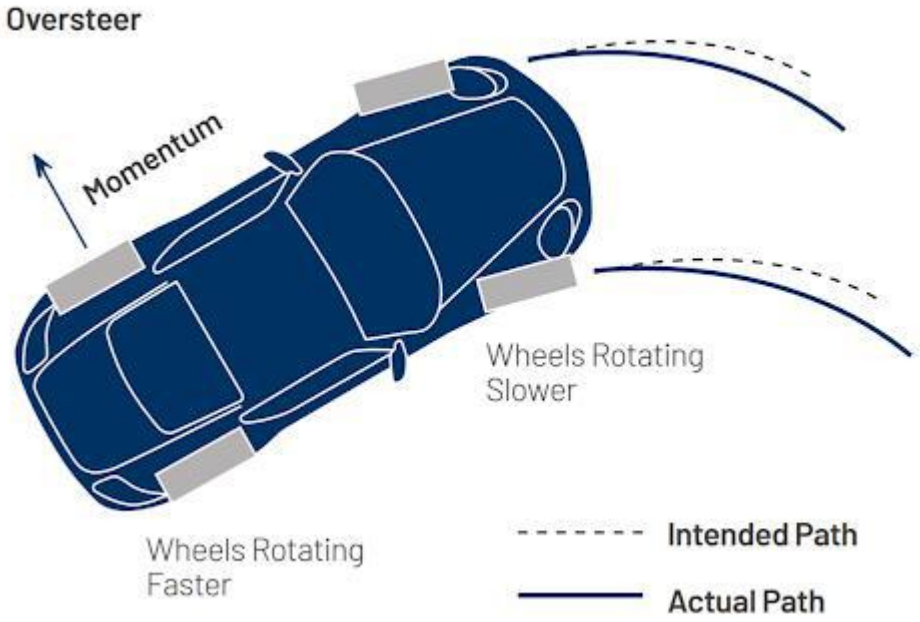
Easing off the throttle (and braking if necessary), when under steer occurs is instinctive and helps restore grip thanks to the reduction in speed and forward weight transfer pressing the front tyres on to the road. Unfortunately, it is also an instinctive reaction to wind on more and more steering lock to try and force the car to turn. This merely exaggerates the problem as increasing the steering input when front end grip is lost merely increases the slip angle, taking the tyres further from the point where they will regain traction. Therefore, though counter-intuitive, briefly release a little of the steering input at the same time as easing off the throttle. Doing so enables the tyres to regain grip sooner and therefore regain control of the car. This is one of those occasions when less means more.

There are also some simple adjustments that can be made to the car to reduce the likelihood of under steering. These include:

- Reducing tyre pressure or using softer tyres at the front of the car.
- Softening the anti-roll bar or front springs.
- If aerodynamics are fitted, increasing the front down force.

Over steering

Oversteer is when a vehicle rotates more than the angle requested by the driver through steering input, most commonly understood as the rear tyres sliding sideways in a bid to overtake the front tyres.



What causes over steer?

Over steer is a result of one of three driver actions:

- Applying excessive, sudden throttle in a powerful gear whilst steering (in a rear wheel drive car).
- Lifting off the throttle suddenly whilst steering
- Excessive 'trail braking'

In the first instance, the harsh application of too much power can overcome the rear tyres' traction and create wheel spin, with the lateral inertia from the steering input causing the spinning tyres to slide sideways.

In the last two instances, excessive forward weight transfer leaves the now light rear tyres with little grip, resulting in an over steer slide when the heavily laden front tyres turn into a bend. This is known as 'lift-off' over steer and can affect all cars, whether with rear, front or all-wheel drive.

Symptoms of over steer include:

- The car begins to spin so that the driver faces the inside of the corner
- The back of the car becomes "light" and unsteady due to lack of grip

How to correct over steer

Firstly, we need to understand what that cause is:

1. Is there too much power going through the rear tyres overwhelming their grip level?

2. Is there excessive forward weight transfer entering a bend, the transition leaving the rear tyres with insufficient grip on the road (lift-off over steer)

As the causes are different, so too are the techniques to recover the situation.

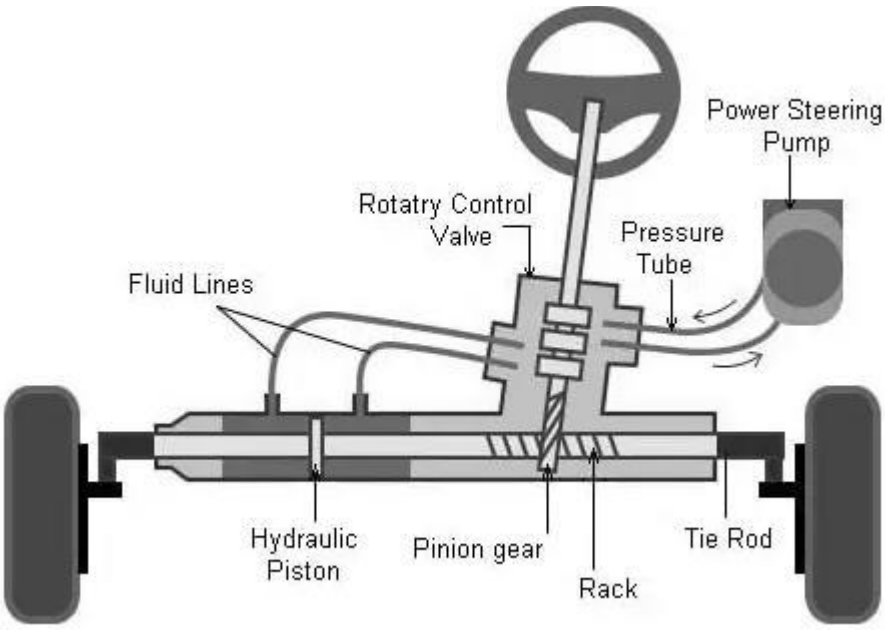
There is at least a common theme with the steering. As was the case in correcting an under steer, turning towards the slide assists recovery. In the heat of the moment, however, it is not uncommon for drivers to forget which way to turn, either steering in the wrong direction or simply freezing and not reacting at all; whilst some initially turn in the correct direction to begin with, only to change their mind when the car doesn't react instantly.

Power Steering

Power steering is a system that reduces the driver's effort required for steering to turn the steering wheel. With the help of power steering, it easier for the vehicle to turn or maneuver.

Working of Power Steering

The **power steering** unit is located at the lower end of the steering column in place of the usual conventional steering gear. It is connected by two oil lines to the hydraulic pump mounted on the generator. The pump with a relief valve avoids excessive oil pressures.



The power steering unit has:

- A valve body with four valves.

- Two power cylinders have pistons one on each side.

The Valves will deliver the oil to help in making a turn. This works on the endwise movement of the steering column shaft. The steering wheel rotates the worm. Thus it imposes end-wise thrust (either up or down) on the worm as per the direction of rotation. This creates the movement of the steering column shaft through a small fraction of an inch.

As the valve is integral with the shaft, moves in the valve body. This action admits oil under pressure in one or the other end of the power cylinder. This makes the piston move in one or another direction. This motion is carried to the pitman shaft through the rack and pinion arrangement.

Types of Power Steering System

There are generally five types of power steering systems:

1. Integral power steering
2. Linkage power steering
3. Hydraulic Power Steering
4. Electric Power Steering
5. Electro-hydraulic Power Steering

Unit-V

Suspension & Brakes

Automobile Suspension Spring

Spring absorb shock forces while it maintaining correct ride height. Automotive springs are generally classified by the spring rate (deflection / load).

Suspension springs are the link between wheels and car body. Their primary task is to compensate uneven road surfaces and thus provide an assurance of high levels of ride comfort. Secondly, they must ensure that the wheels always have safe contact with the road regardless of its condition. Reliable transmission of drive, braking and transverse forces relies on these requirements being met. As such, suspension springs are one of the most safety-critical components of modern vehicles. They affect handling, road-holding and braking performance.

Types of suspension springs

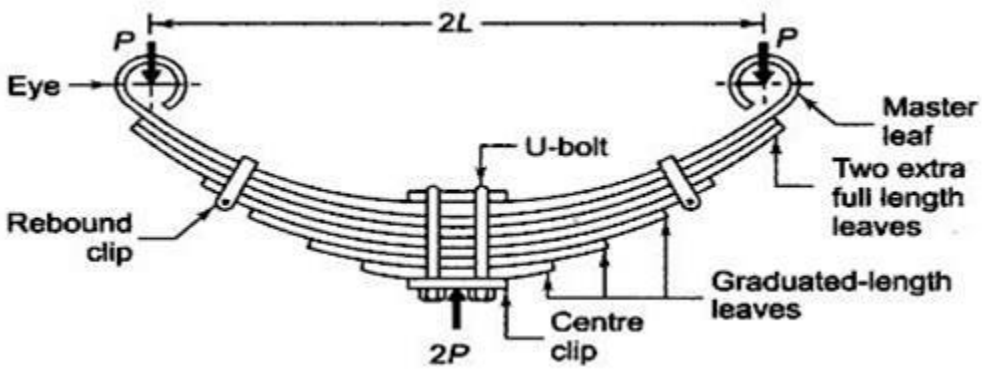
1. Leaf spring
    a. Full – elliptic type
    b. Semi – elliptic type
    c. Three Quarter – elliptic type
    d. Transverse Spring type
    e. Helper Spring type
2. Coil spring / Helical springs
3. Torsion bar / Torque rod

Automakers are aware of the inherent limitations of steel springs, which they tend to produce undesirable oscillations, and have developed other types of suspension materials and mechanisms in attempts to improve performance:

4. Rubber springs:
    a. Compression Springs
    b. Progressive Springs
5. Plastic springs
6. Air springs:
    a. Bellow Type
    b. Pestoon Type
7. Hydraulic springs

1. Leaf Spring:

Leaf springs are multi-layered steel plates clamped together. Leaf springs are formed by bending. They are made of long strips of steel. Each strip is named as Leaf. The long leaf is called master leaf / main leaf, and it consists of eyes at its both ends.

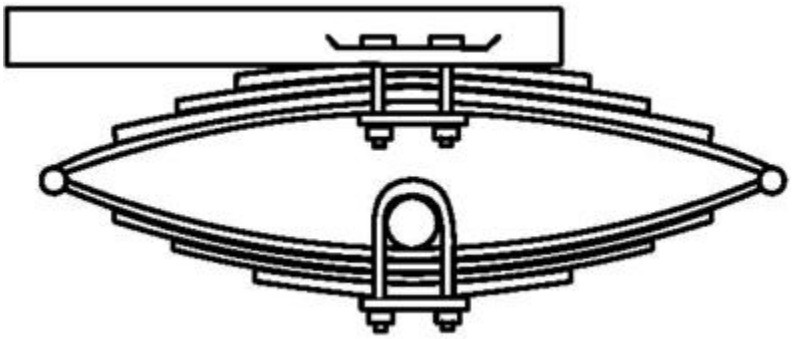


One end is fixed to the chassis frame, the other end is fixed to the shackle spring. The spring will get elongated during expansion and shortened during compression.

This change in length of spring is compensated by the shackle. The U-bolt and clamps are located at the intermediate position of the spring. The bronze or rubber bushes are provided on both eyes on the master leaf.

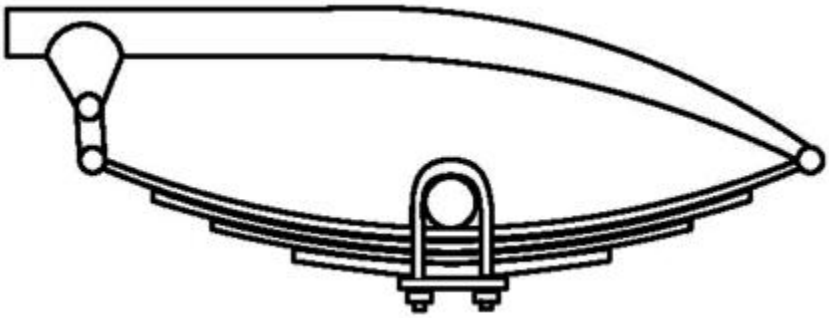
a. Full elliptic:

The advantage of this type is the elimination of shackle and spring. The lubrication and wear frequently, which are one of the main drawback of that type of springs.



b. Semi – elliptic:

This type is more popular for rear suspensions are used in 75% of older cars.



c. Three – Quarter – elliptic type:

This type is rarely used in now-a-days. It gives resistance, but occupies more space than other types.

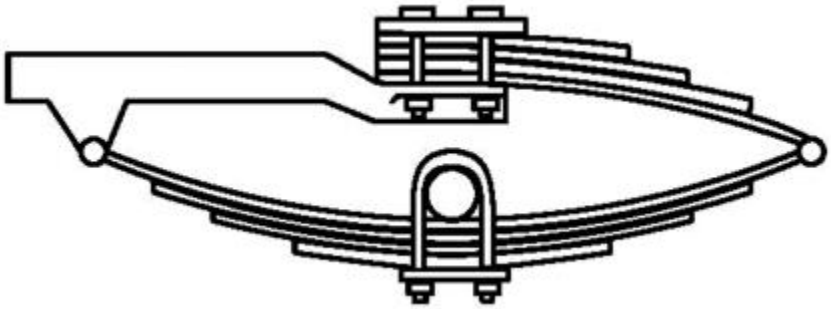


Fig: Three-quarter-elliptic spring

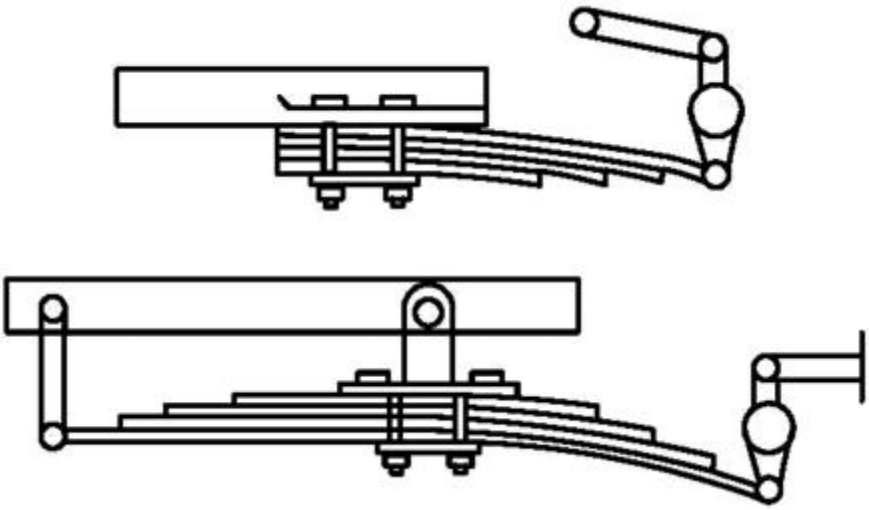


Fig: Quarter-elliptic spring

d. Transverse Type:

This type of spring is arranged transversely across the car instead of longitudinal direction. The transverse spring for front axle as shown in figure, this is bolted rigidly to the frame at the centre and attached to the axle by means of shackle at both ends.

Fig: Transverse spring

e. Helper Leaf Springs:

The helper springs are used in heavy vehicles for rear suspension. When vehicle fully loaded the main spring as well as helper spring to come in action and absorb the road shocks. When the load of the vehicle is less the helper spring will not act and the main spring only absorb the road shocks.

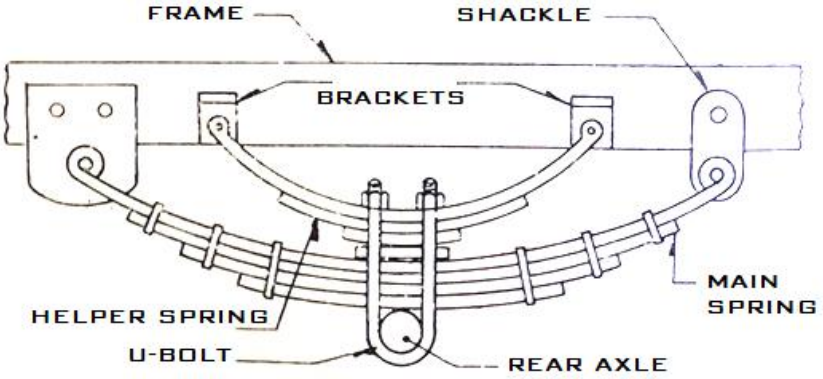


Fig: Helper spring

2. Coil springs:

Coil spring is made of thick steel wires a length of special spring steel, usually round in section which is wound in the shape of coil. The ends of coil spring are kept flat so that could seat properly. They can store twice energy per unit volume in comparison to leaf spring. To seat the coil springs pan shaped brackets or spring seats are attached to the axles. This suspension is also used in combination with torque tube or torque rod.

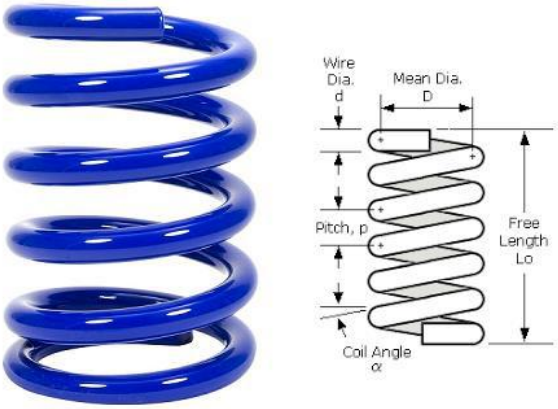


Fig: Coil spring

3. Torsion bar / Torque rod:

Torsion bars are long steel rods of either circular or square cross section. The springing action is generated by the torsional forces when the torsion bar is twisted.

A torsion bar suspension, also known as a torsion spring suspension, is any vehicle suspension that uses a torsion bar as its main weight-bearing spring.

The effective spring rate of the bar is determined by its length, cross section, shape, material, and manufacturing process.

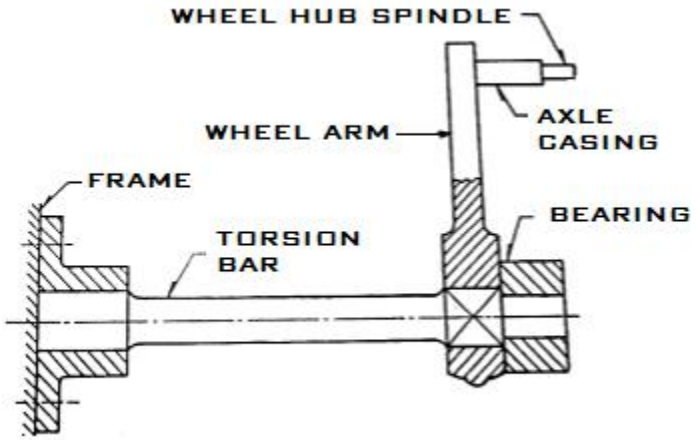


Fig : Torsion bar

4. Rubber spring:

As rubber can store more energy per unit mass than any other type of spring material, considerable weight can be saved with rubber suspension. Rubber springs, if works on compres-sion or shear, can be used as the main suspension spring, otherwise can be fitted along with metal springs to improve the suspension characteristics. Large rubber 'bump' stops used in many suspension layouts stiffens the suspension spring against maximum deflection.

Fig: Rubber spring

Figure represents a rubber suspension system in a simplified form, that is similar to the one used on a popular small car. The spring is installed between the frame and the top link of the suspension system. When the spring is connected to a point near the link pivot, deflection of the spring reduces to a

minimum, without affecting the total wheel movement. This arrangement of spring provides a rising-rate characteristic, which is 'soft' for small wheel movements but becomes harder as the spring deflects.

The energy released from the rubber spring after deflection is considerably less than that imparted to it. This internal loss of energy is called hysteresis, which is an advantage, because lower-duty dampers may be used. Some rubber suspension systems have a tendency to 'settle down' or 'creep' during the initial stages of service, therefore allowance for this must be provided.

Fig: Rubber suspension spring

5. Plastic springs:

Plastic spring for motor cars is about to roll out fiber glass-reinforced epoxy road springs which match the function of steel coils in coping with severe loading, but are around 40% lighter.

The engineers work determinedly to avoid every scrap of unnecessary weight – not only in the body but also in every other component and assembly.

Ultra-lightweight design is a particular priority for the car's chassis and suspension, since any reduction in unsprung mass improves ride comfort and handling.

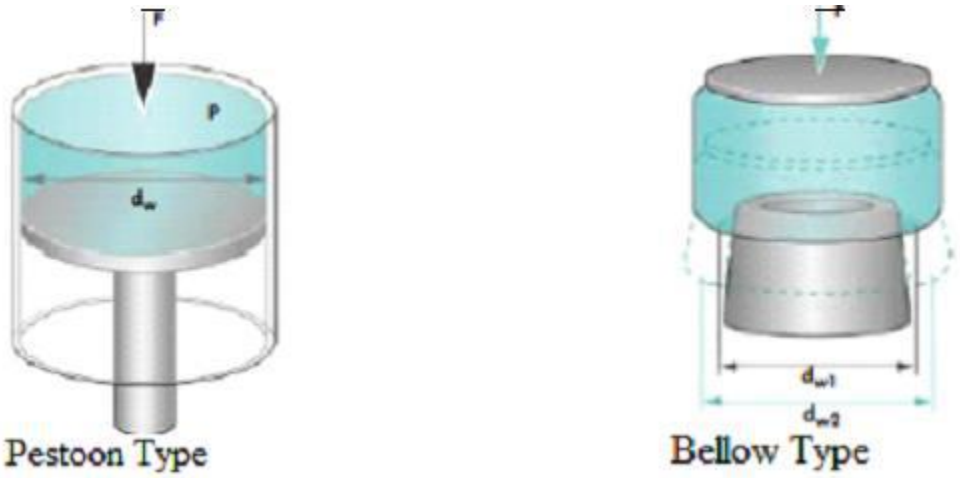
Plastic spring is capable of absorbing torsional loads extremely well if it is designed with this specific purpose.

6. Air springs:

Air springs offer several advantages over metal springs, one of the most important being the possibility of controlling the spring rate.

Inherently, the force required to deflect the air unit increases with greater deflection, because the air is compressed into a smaller space and greater pressure is built up, thus progressively resisting further deflection.

Air spring generally made of rubber material with two major types are, Bellow Type and another is Piston Type.



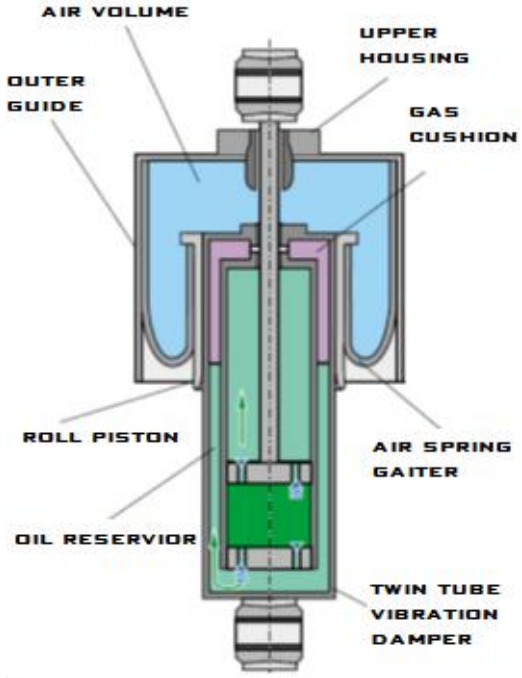


Fig: Air spring

Air spring can be tuned for the required application by adjusting the following parameters:

a) Size of effective area Aw.
b) Size of air spring volume (air volume) and
c) Outer contour of roll piston.

The air spring basically comprises;

a) An upper housing with an outer guide.
b) The air spring gaiter.
c) The roll piston (lower housing).
d) An auxiliary accumulator.
e) The integrated vibration damper.

7. Hydraulic springs:

Hydraulic springs are comparatively small, thick-walled cylinders in which the spring effect is produced by applying a load to the fluid in the cylinder through a small piston entering at the centre of one end of the cylinder.

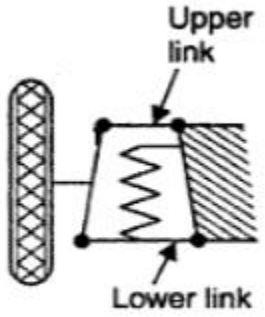
The piston movement, or deflection, is produced by the compression of the fluid and the deformation (bulging) of the cylinder walls. These springs are particularly useful in applications requiring high load capacities and stiffness's.

Front axle independent suspension systems

In this system, the wheels connect to the frame in such a way that the movement of one wheel is not dependent on the other. Hence, each wheel acts as a separate suspension unit. The rise and fall of either wheel has no direct effect on the other. As a result, each wheel is able to maintain its level position regardless of the action of the other front wheel.

Today, most passenger cars use independent front suspension. It provides softer springing action, improved steering geometry and better bonding of wheels with the road. Additionally, this suspension improves the ride and handling qualities of the vehicle. Thus, it offers better ride comfort for the passengers.

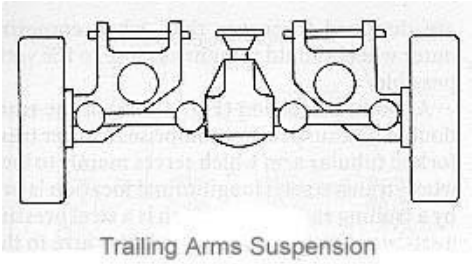
Wishbone Suspension System:

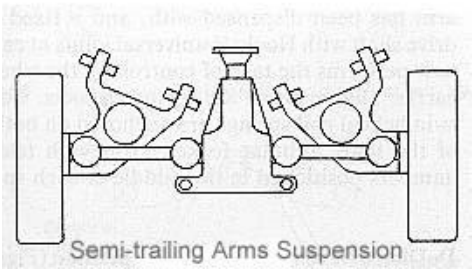


Wishbone Suspension

- The wishbone type is the most popular independent suspension system.
- It consists of two (occasionally parallel) wishbone-shaped arms to locate the wheel. Each wishbone or arm has two mounting points to the chassis and one joint at the knuckle.
- The shock absorber and coil spring mount to the wishbones to control vertical movement.
- The vehicle weight is transmitted from the body and the cross member to the coil spring through which it goes to the lower wishbone member.
- The wishbones not only position the wheels and transmit the vehicle load but also rest acceleration, braking and cornering forces.
- The upper arms are shorter in length then the lower ones. This helps to keep the wheel track constant thereby avoiding the tyre scrub thus minimizing wear.

Trailing arm suspension System



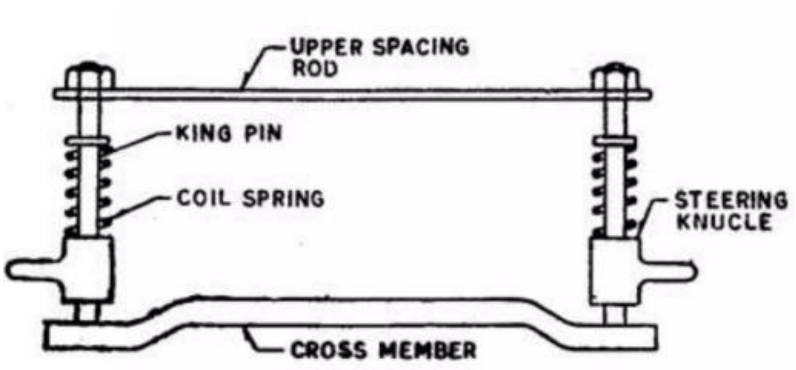


The above figures employ two trailing arms which are pivoted to the car body at the arm's front edge. The arm is relatively large compare with other suspensions' control arms because it is in single piece and the upper surface supports the coil spring. It is rigidly fixed to the wheel at the other end.

Note that it only allows the wheel to move up and down to deal with bump. Any lateral movement and camber change (with respect to the car body) is not allowed. Nevertheless, when the car rolls into a corner, the trailing arm rolls for the same degree as the car body, thus changes camber angle (with respect to the road surface). Now, you can see both wheels lean towards the outside of the corner, thus lead to under steer. Because of this reason, pure trailing arm was forgotten by car makers long long ago. Instead of it, they adopted semi-trailing arm.

Vertical link suspension System

- In this suspension the king pin is directly attached to the cross member of the frame.
- It can slide up and down as shown corresponding to the motion of the wheel and there by compressing or elongating the springs.
- In this type, the wheel track, wheel base and wheel altitude remain unchanged.
- But the system is having the disadvantage of less stability.



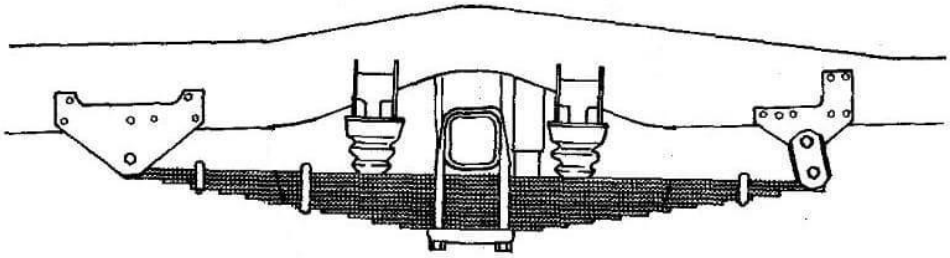
Rear axle suspension systems

Following are three types of rear-axle suspensions generally found in vehicles.

1. Longitudinal leaf spring rear end suspension
2. Transverse leaf spring rear end suspension
3. Coil spring rear end suspension

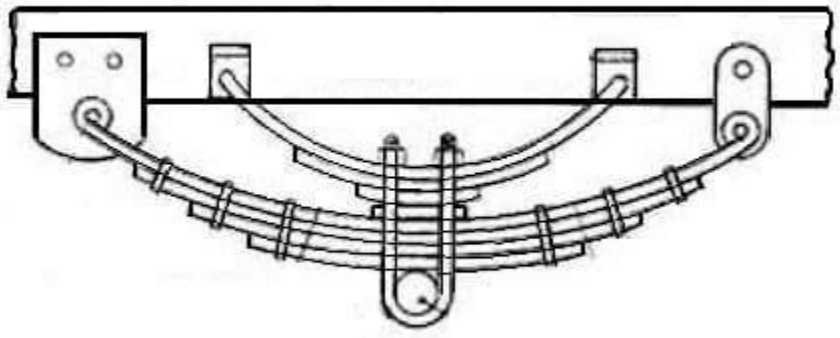
Longitudinal and Transverse Leaf Spring Rear End Suspension

Longitudinal leaf spring and coil spring rear end suspensions are widely used in modern vehicles. Transverse leaf spring rear end suspension is used in conjunction with the Hotchkiss drive; the leaf springs must be made strong and resilient enough to transmit the driving thrust and torque to resist sideways, in addition, to hold the spring weight of the body.



The spring weight is kept as less as possible, in order to improve the side of the vehicle. Because the springs do not generally support the wheels, rims, tyres, brakes and rear axles, the weight of these parts is called the spring weight.

The spring is clamped the rear-axle housing by U-bolts, its every end is pivoted to the frame, by means of eyes formed in the ends of the longest leaf.

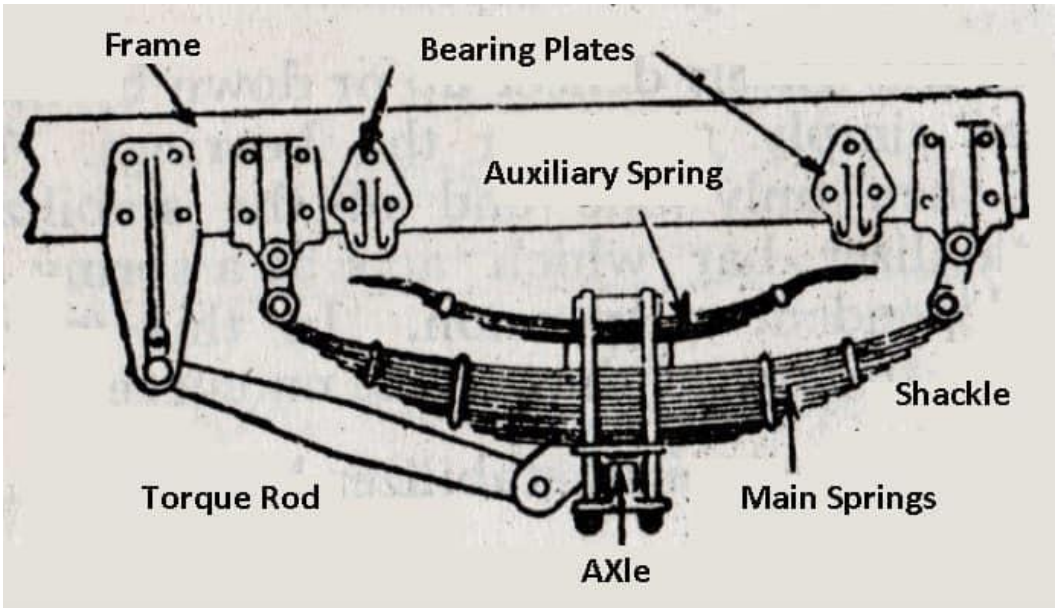


One end of the long leaf is secured to the front hanger by a bolt and the other end to the rear hanger by spring shackles. Both the hangers are bolted to the frame.

The spring elongates in compression and shortens in expansion. This change in length of the spring is compensated by a shackle.

At the middle position of the spring length, the rebound clips are placed. They are loose enough to permit the leaves to slide on the other, and yet tight enough to permit the leaves together when the spring rebounds.

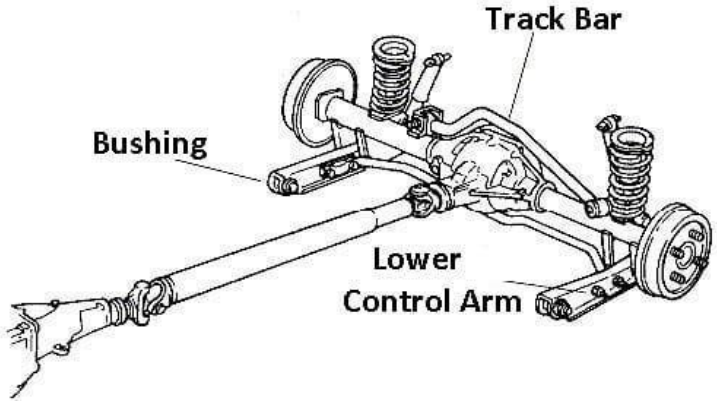
The spring eyes are usually provided with bushings or some anti-friction material, such as bronze or rubber.



The figure shows a heavy-duty truck rear end suspension with leaf type auxiliary springs and torque rods. This type of suspension is used in truck intended for more severe operations and with rear axle loading exceeding 10000 kg. The figure shows rear-end suspension of a car with Hotchkiss drive.

Coil Spring Rear End Suspension

The figure shows coil spring rear end suspension. This type of suspension is always used in conjunction with torque tube, torque reaction link, or torque rod drive. Therefore the coil springs are not subjected to driving thrust or twist.

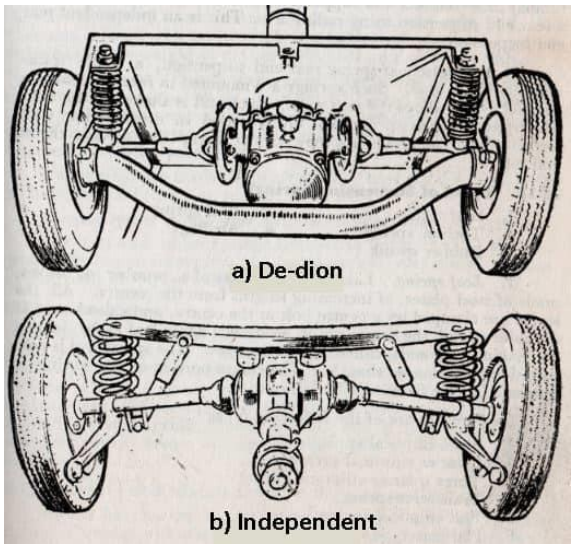


Stabilizers and radius rods are also used which relieve the coil springs of all stresses except those acting in a vertical direction. The stabilizer prevents excessive roll or sideways when the car is concerning.

The radius rod keeps the rear axle and frame in lateral alignment. The coil springs are seated in pan-shaped brackets spring seats attached to the rear axle.

De-Dion and Independent Type Coil Spring Rear End Suspensions

The figure shows De-Dion and independent type coil spring rear end suspensions. At (A), the rigid De-Dion tube is located longitudinally by two parallel links and laterally by a watt linkage. The tube maintains the track at a constant width.



It is to be noted that De-Dion suspension is not an independent suspension because a tubular axle connects and supports both the wheels. At (B) is shown a rear-end suspension using the radius arm.

This is an independent rear end suspension.
In traverse leaf spring rear end suspension, a single transverse spring is used. Such springs are mounted in an inverted position parallel to and above the rear axle. Each end is shaken to the axle.

The transverse rear springs are always used in combination with torque-tube drive, and hence they do not carry the driving thrust and torque.

Shock absorbers

A shock absorber is a mechanical or hydraulic device designed to absorb and damp shock impulses. This is achieved by converting the kinetic energy of the shock into another form of energy (typically heat) which is then dissipated.

Applications of shock absorber

Shock absorbers can be seen in many different applications in our everyday life as they support various activities humans can encounter. They are used for highways, bridges, cars, bikes, bicycles, and buildings to absorb the impact of bumps, earthquakes, and high winds. However, different applications require different types of shock absorbers, which can be made of different materials. i.e. a rubber shock

absorber cannot be used on a vehicle and a cylindrical shock absorber cannot be used on a highway. The various types of absorbers require a specific shape and design to fit their intended tasks.

Functions of shock absorbers

Below are the functions of shock absorbers in their various applications:

- The primary function of a shock absorber is to absorb or dampen the compression and rebound of the springs and suspension.
- It helps to control unwanted and excess spring motion
- It keeps tires in contact with the road at all times
- The shock absorber ensures the safest control and quicker braking response of your car.

Components of a shock absorber

Since shock absorbers are used in various applications, they're different in design and operation. The truth is their parts remain similar. Below are the major components of a shock absorber in vehicles:

Mount:

This shock absorber part is help to secure shocks to the vehicle body and suspension. It consists of an upper and lower mount of the same design, containing a surface hollow part that allows bushing and bolt to be inserted.

Bushing:

The bush is located on the mountings, usually made of rubber or urethane. This bushing absorbs vibrations and has separate metal parts to prevent noise and wear. Bushings are among the shock absorber components that can be replaced.

Coil spring:

Not all shock absorber features a coil spring in their parts. It's commonly known as a coil-over-shock absorber or spring coil shock absorber. Absorber with coil spring looks like a suspension strut; one can easily mistake them for each other.

Piston and piston rod:

Shock absorbers piston contains openings or valves that allow its part to revolve around the movement of oil through passageways. The piston rod guides the piston inside the shock absorber cylinder.

Cylinder:

This is a cylindrical tube that acts as the body of a shock absorber. It consists of compression oil and a piston that moves inside it.

Bolts:

Bolts are fasteners used to hold a shock absorber to a vehicle's body on one end and suspension at the other end. These bolts must be torqued to the right torque value so that the absorber won't lose during operation.

Some other small parts of car shock absorbers include:

Oil seal – the oil seal help to prevent the oil inside the shock absorber tube from leaking out while working. It also prevents contamination from entering the tube.
Oil guide – this is an oil passage to ensure the smooth working of the absorber.
Rod guide – the rod guide gives the piston rod smooth movement.
Nitrogen gas and gas chamber – this is contained in a chamber within the compression chamber or cylinder. It prevents the oil from forming bubbles.
Washer and plates – these are a spacer that forms an important part of the shock absorber parts.

Types of shock absorbers:

The application of shock absorbers is very many, various types of vehicles and suspension designs require a specific type. However, no matter the application, all types of shock absorbers fall under these three types:

Conventional telescopic shock absorbers:

The conventional telescopic types of shock absorbers are the most common type that can be found both on front and rear suspension systems. it's relatively inexpensive and It's often replaced rather than repaired.

Strut-type shock absorbers:

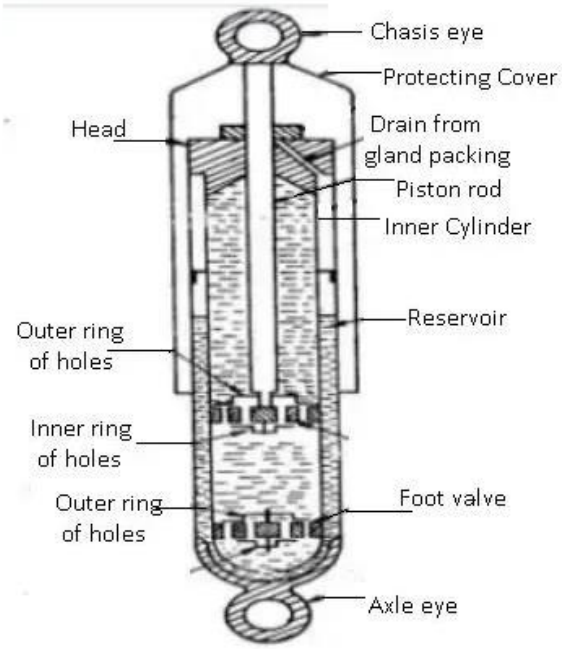
These types of shock absorbers are typically built strong to cope with greater loads and forces. They do the same job as the normal shock absorbers, but it replaces part of the suspension system. Strut types of shock absorbers are commonly seen on the front and rear of small and medium cars, but now trending on larger cars.

These types of shock absorbers are further divided into two; sealed and repairable units. Just as they are named, sealed units are designed to be fully replaced, whereas the repairable struts are fitted with replacement strut cartridges.

Spring seat shock absorbers:

These types of shock absorbers combine the characteristics of both telescopic and Strut types of absorbers. Like struts, a spring seat is a suspension unit and damping device in a single unit, but it's not designed to be subject to high side loads like the struts. This system uses the same components as the conventional type and the spring seat type is sealed requiring full replacement.

Working principle of shock absorbers



The shock absorber works as follows when the vehicle comes across a bump the lower eye moves up. Therefore, the fluid passes from the lower side of valve A to its upper side. But since the volume of the space above valve A is less than the volume of rod G, the fluid exerts pressure on valve B.

This pressure of the fluid through the valve openings gives the damping force. Thus, when the lower eye E moves down, the fluid passes from the upper side of valve A to the lower side, and also from the lower side of valve B to its upper side.

The shock absorber must be filled with shock absorber fluid at regular intervals as recommended by the manufacturer or when required by its condition. The modern telescopic shock absorbers are no longer serviced. If they leak or do not offer proper resistance to push and pull they should be replaced.

Advantages of a shock absorber

- It's available in various shapes and different strengths and hardness, with outstanding elasticity.
- The deformation of a shock absorber is relatively large no matter in tension, compression, shearing, and changing force.
- The natural frequency of the vibration isolation system is lower but has a higher damping effect.

- Easy to maintain without sliding
- The modulus of elasticity in a shock absorber is much smaller than that of metal, and large elastic deformation can occur.
- The shock absorption effect is good.
- Convenient installation and disassembly.

Disadvantages of a shock absorber

Despite the great advantages of a shock absorber some limitations still occur. below are the disadvantages of a shock absorber in a car:

- It has a low ability to resist environmental pollution and temperature change.
- Its life is short
- A shock absorber finds it difficult to achieve a natural frequency below 5Hz
- Some types cannot be repaired but have to be replaced.

Air Suspension System

Air springs are used in air suspension systems. The installation and configuration of air suspension systems varies for different makes and models but the underlying principle remains the same. The metal spring (coil or leaf) is removed, and an airbag also referred to as an air spring, is inserted or fabricated to fit in the place of the factory spring. When air pressure is supplied to the airbag, the suspension can be adjusted either up or down (lifted or lowered).

Air spring is nothing but flexible bellows, usually made from textile-reinforced rubber, containing compressed air which is used to carry the load on vehicles. The air pressure inflates the bellows and raises the chassis from the axle. Air springs have elasticity or “springiness” when it is compressed. It is used on many heavy-duty trucks, trailers, and buses on the road today.

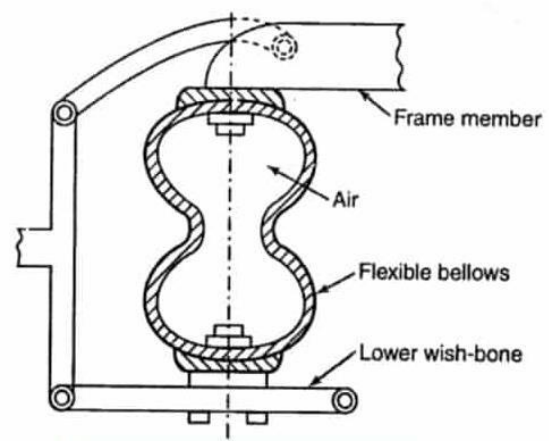
Types of air suspension:

The following are different types of air suspension systems based on the design of air spring used.

1. Bellow type air suspension
2. Piston type air suspension
3. Elongated bellows air suspension

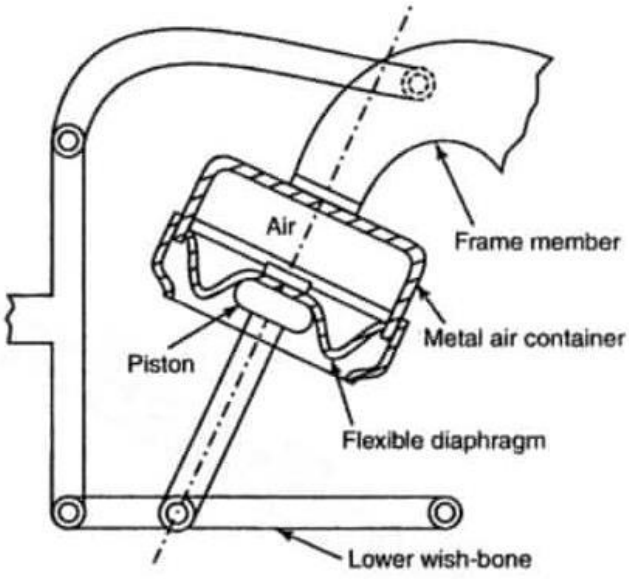
(i) Bellow type air suspension (spring):

This type of spring consists of rubber bellows. The bellows are made into circular sections having two convolutions for proper functioning as shown in Figure. So, a bellow type air suspension replaces the coil spring.



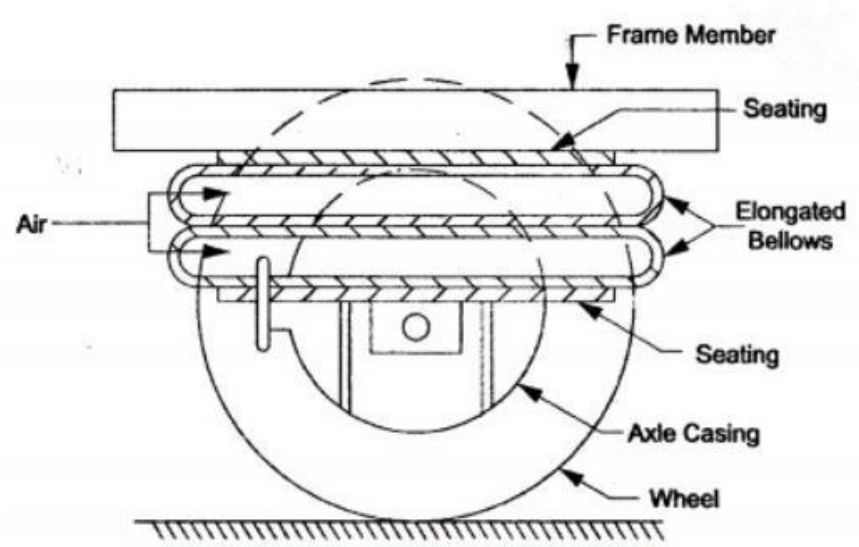
(ii) Piston type air suspension (Spring):

This spring has a metal-air container in the form of an inverted drum. The drum is connected to the frame. A sliding piston is connected to the lower wishbone. A flexible diaphragm provides a seal. The diaphragm is tightly connected at its outer circumference to the lip of the drum and at the center to the piston as shown in Figure



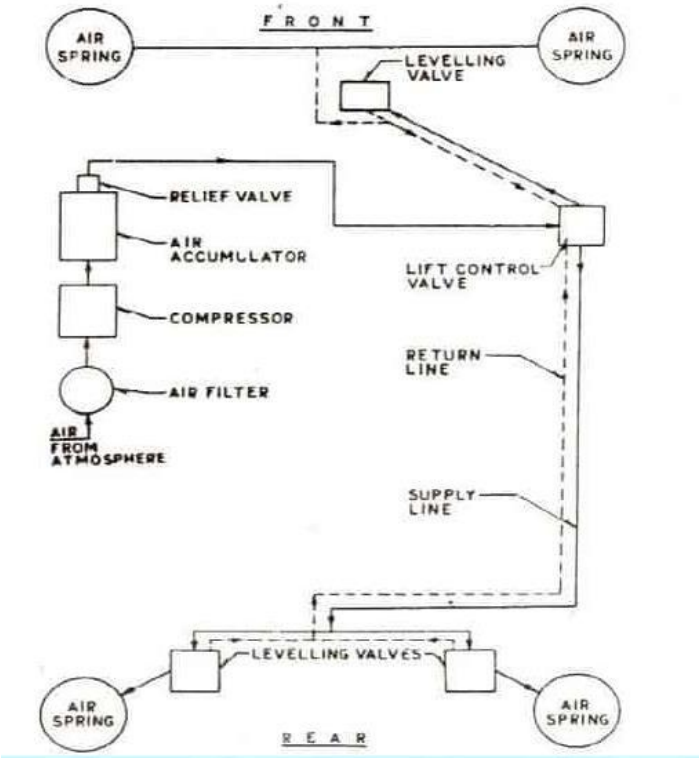
(iii) Elotlgated bellows air spring:

When this system of suspension is employed to the rear axle of the vehicle, then elongated bellows are used. These bellows are of approximately rectangular in shape but they are with semi-circular ends having generally two convolutions. These elbows are arranged between the rear axle and the frame of the vehicle. To resist the torques and thrusts, the radius rods are used at the rear axle.



Air Suspension System:

Diagram of Air Suspension System:



Components of Air Suspension System:

The components of the air suspension system are:

1. Air filter
2. Air Accumulator
3. Relief valve
4. Air spring
5. Lift control valve
6. Return valve
7. Supply line

Construction of Air Suspension:

The layout of an air suspension system has been shown in Fig. The four air springs, which may be either the bellows-type or the piston type, are mounted on the same position where generally the coil springs are mounted. It also consists of an air compressor, air accumulator, relief valve, lift control valve, leveling valve, and pipeline.

Working of Air Suspension:

An air compressor takes the atmospheric air through a filter and compresses it to a pressure of about 240 MPa, at which pressure the air in the accumulator tank is maintained, which is also provided with a safety relief valve. This high-pressure air goes through the lift control valve and the leveling valves, to the air springs as shown. Each air spring is filled with compressed air which supports the weight of the vehicle. The air gets further compressed and absorbs the shock when the wheel encounters a bump on the road.

Advantages of air suspension:

The advantage of air suspension is as follows:

1) A variable space for wheel deflection is put to optimum use by virtue of the automatic control devices

2) Because the vehicle altitude is also constant, changes in head lamp alignment due to varying loads are avoided.

3) The spring rate varies much less between the laden and unladen conditions, as compared with that of conventional steel spring. It reduces the dynamic loading.

4) The improved standard of ride comfort and noise reduction attend with air springs reduces both driver and passenger fatigue.

Disadvantages of Air Suspension System:

Disadvantages of an air suspension system are as follows

- Higher initial cost
- Occupies more space.
- The maintenance cost is more.
- Due to lack of friction damping is necessary due to road shocks.

Application of Air suspension System:

The air suspension system is used in Modern Buses, Volvo, passenger cars, and trucks for comfort ride.

Difference between Air Suspension System and Rigid Suspension System

Air Suspension System	Rigid Suspension System
1. In this system air springs or air bellows are used	1. In this system leaf spring or coil spring or both are used.
2. In air suspension system wheel deflection is controlled by automatic control devices.	2 In this system there is no automatic control device.
3. Increased riding comfort and decreased noise level.	3 Riding comfort is less as compared to the air suspension system.
4. The springing rate varies much less between the laden and unladen conditions, as compared with that of conventional springs.	4. The springing rate is more as compared to the air suspension system.
5. Stiffness of the system increases with an increase in deflection.	5. Stiffness of the system decreases with an increase in deflection.
6. Application: Volvo bus, Luxury cars	6. Application: Heavy and medium-duty vehicles, passenger cars, etc.
7. Reduced fatigue to the driver and passenger.	7. More fatigue to the driver and passenger as compared to the air suspension system.
8. It consists of Compressor, reservoir, leveling valve, air springs or air bellows, etc.	8. It consists of leaf spring, coil spring, shock absorber, shackle joint, bracket, etc.

Brakes

Requirements of good braking system

A good braking system must fulfill the following requirements.

- The fast running vehicle should be stopped in shortest distance and time.
- The brakes should be equally effective on good and bad roads.
- Brakes should work equally well in all weathers.
- Pedal effort applied by the driver for braking should be less.
- It should have less wearing parts and little maintenance.
- Steering geometry should not be disturbed, when brakes are applied.
- There should be minimum sound when brakes are applied and should not pull the vehicle to either side.
- In case of emergency there should be an independent, parking brake system.

Different types of braking systems:

- Mechanical Brake System
- Hydraulic Brake System
- Pneumatic Brake System
- Electromagnetic Brake System

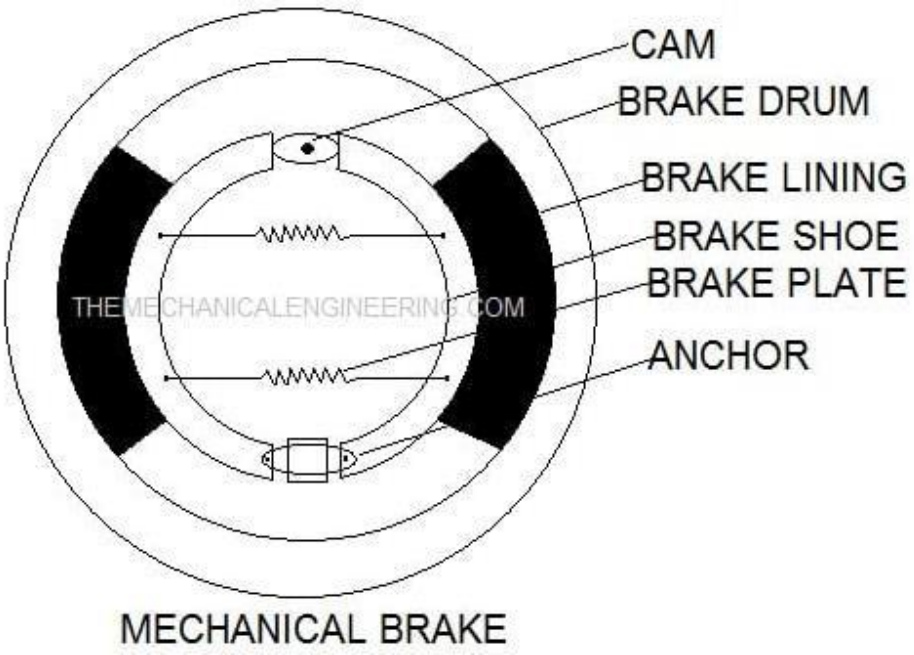
- Servo Brake System
- Electrical brake system
- Disc Brake System
- Drum Brake System
- Emergency Brake
- Anti-lock Braking system
- Service Brakes or Foot oriented Brakes and
- Hand Brake System

1. Mechanical Brake System:

This mechanical braking system is the hand brake or the emergency brake, it generates friction between two surfaces as they rub against each other.

In this braking system, a particular force is applied to the pedal and it's carried to the final drum by mechanical components such as a fulcrum, springs, and that are used as linkages to transmit force from one point to another, for slowing down the vehicle.

The slowing down of the speed or capacity of a brake depends on the surface friction as well the actuation force applied to it.



MECHANICAL BRAKE

Advantages of Mechanical Braking System:

- Mechanical brakes are simpler and easy to be maintained.
- It is less expensive than a hydraulic brake system.
- It provides great uses for emergency and parking brakes.

2. Hydraulic Braking System:

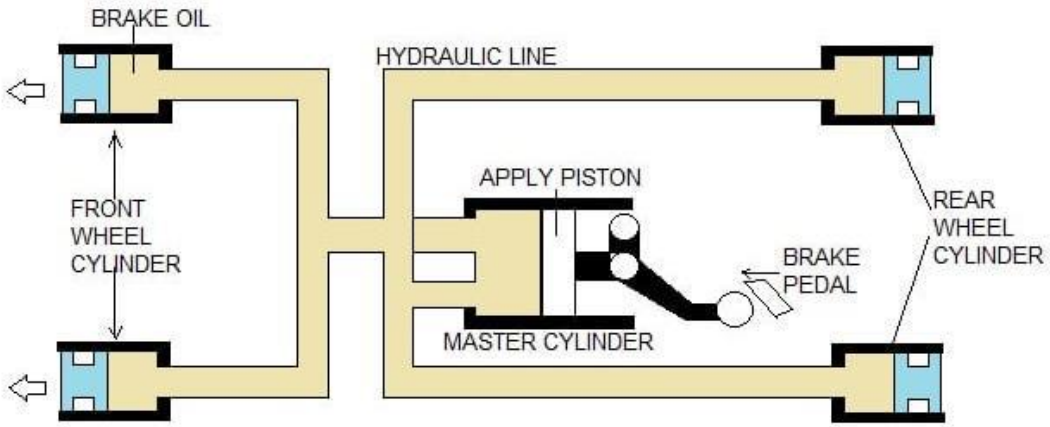
A magnetic flux is passed in a direction perpendicular to the rotating direction of the particular wheel, a rapid current flowing in a direction opposite to the rotation of the wheel creating an opposing force to the wheel rotation thus, gradually slowing down the wheel speed.

It transmits the brake system to the wheels of the brake through the pressure of fluids, converting the pressure into useful work of wheel brakes.

The Brake pedal relays the driver foot effort to the master cylinder piston, which compresses the brake fluid.

The fluid pressure is the same as it's transmitted to the front disc-caliper pistons and the rear disc caliper pistons. As per the process, a different mechanical parking brake must be included with at least two wheels.

This also allows the driver to be in control of the vehicle in the cause of a failure with the Hydraulic Brake system.



HYDRAULIC BRAKE SYSTEM LINE DIAGRAM

Advantages of Hydraulic brake system

The Hydraulics offers the following advantages over the mechanical layout:

- It provides equal braking effort on all wheels.
- Relative brake effort is less to deliver the same output.
- It is full compensated thus each brake receive a full share of pedal effort
- It is more efficient than mechanical.
- Suitable for all types of vehicles having independent suspension.

3. Pneumatic Braking System:

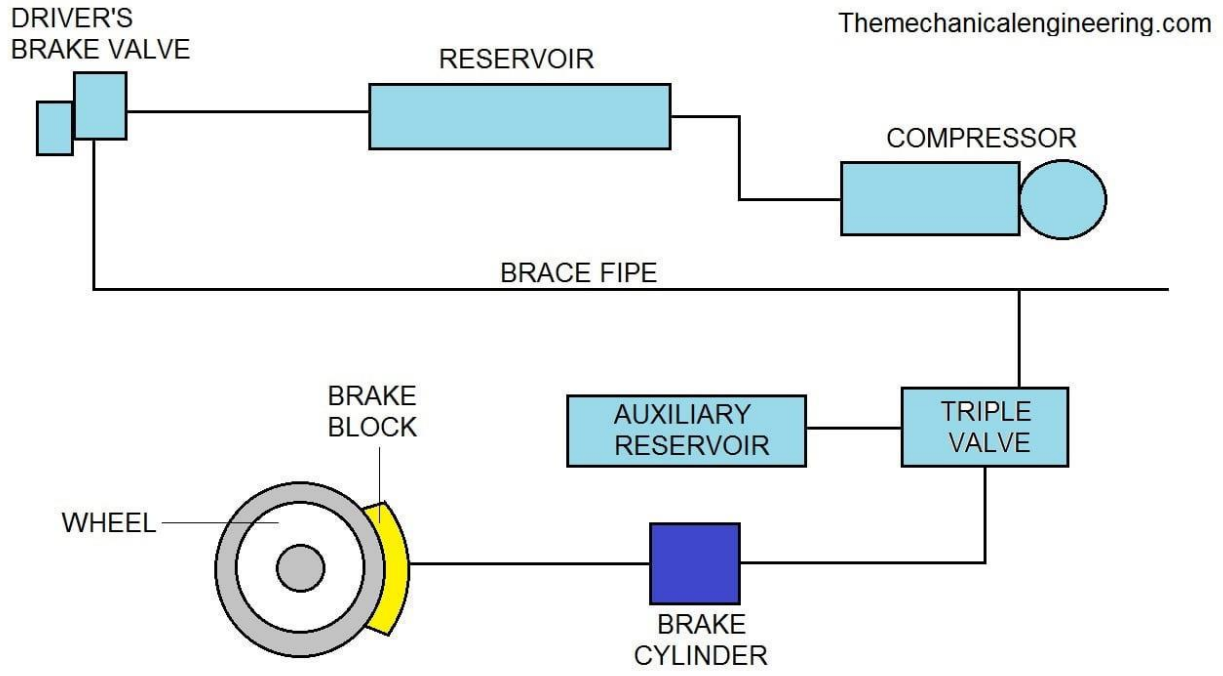
It maintains a higher level of pressure inside it, and the pressure in line starts dropping the moment when the driver applies the brake causing a result in slowing down the vehicle trucks buses and trains use this type of braking system.

It operates on compressed air helps in charging up the entire braking system to maintain optimum pressure.

The charged-up lines make sure for the brakes to be dis-engaged; the very moment the driver applies the force onto the pedal the air pressure drops.

Due to this sudden drop of pressure, the control reservoir, and gets disconnected causing the auxiliary cylinder to be connected to the brake cylinder.

Compressed air from the auxiliary cylinder gets to the brake cylinder causing it to be more engaged. This is how the pneumatic brake works.



Advantages of a pneumatic brake system:

- Pneumatic brake equipment is much more reliable than hydraulic brakes
- If there is a leakage in the pneumatic brake system, there is less wastage as compared to leakage in the hydraulic brake system.
- It is very powerful with a single pedal that can work the entire pneumatic brake equipment which makes everything easy to control and there are fewer chances of mistakes.
- Their systems are clean as the compressed air used in the operation can be directly dumped into the atmosphere.

Emission control system,

In automobiles, emission control system employed to limit the discharge of noxious gases from the internal-combustion engine and other components. There are three main sources of these gases: the engine exhaust, the crankcase, and the fuel tank and carburetor. The exhaust pipe discharges burned and unburned hydrocarbons, carbon monoxide, oxides of nitrogen and sulfur, and traces of various acids, alcohols, and phenols. The crankcase is a secondary source of unburned hydrocarbons and, to a lesser extent, carbon monoxide. In the fuel tank and (in older automobiles) the carburetor, hydrocarbons that are continually evaporating from gasoline constitute a minor but not insignificant contributing factor in pollution. A variety of systems for controlling emissions from all these sources have been developed.

In the crankcase—the portion of the engine block below the cylinders where the crankshaft is located—leaked combustion gases are combined with ventilating air and returned to the intake manifold for reburning in the combustion chamber. The device that performs this function is known as the positive crankcase ventilation valve, or PCV valve.

- To control exhaust emissions, which are responsible for two-thirds of the total engine pollutants, two types of systems are used: the air-injection system and the exhaust gas recirculation (EGR) system. In EGR a certain portion of exhaust gases are directed back to the cylinder head, where they are combined with the fuel-air mixture and enter the combustion chamber. The recirculated exhaust gases serve to lower the temperature of combustion, a condition that favours lower production of nitrogen oxides as combustion products (though at some loss of engine efficiency). In a typical air-injection system, an engine-driven pump injects air into the exhaust manifold, where the air combines with unburned hydrocarbons and carbon monoxide at a high temperature and, in effect, continues the combustion process. In this way a large percentage of the pollutants that were formerly discharged through the exhaust system are burned (though with no additional generation of power).
- Another area for additional combustion is the catalytic converter, consisting of an insulated chamber containing ceramic pellets or a ceramic honeycomb structure coated with a thin layer of metals such as platinum and palladium. As the exhaust gases are passed through the packed beads or the honeycomb, the metals act as catalysts to induce the hydrocarbons, carbon monoxide, and nitrogen oxides in the exhaust to convert to water vapour, carbon dioxide, and nitrogen. These systems are not completely effective: during warm-up the temperatures are so low that emissions cannot be catalyzed. Preheating the catalytic converter is a possible solution to this problem; the high-voltage batteries in hybrid cars, for example, can provide enough power to heat up the converter very quickly.

Environmental effects of engines

- Air Quality
- Ozone Depletion
- Water Quality
- Land Consumption
- GHG Emissions
- Use of Finite Resources
- CFC Emissions
- Noise Pollution

- Lead Emissions
- Waste Motor Oil
- Partitioning of human and animal communities

Emission standards

Emission standards are the rules and regulations that are supposed and necessary to follow by the *Vehicle Designing Industries* (*or manufacturers*) in respective country. Bharat Stage Emission Standards and European Emission Standards are the two important things to learn about. These standards are authored by the respective governments and these standards are all about the limitations of the pollutants released by the vehicles.

As lots of vehicles are entering on to the road results in increasing the count of the vehicles and simultaneously emissions (*air pollution*) are increasing. So, to limit or to control air pollution, emission standards in India is one of the precautionary steps taking by the Indian government and similarly, the European Emission Standards are taken care by the Europe.

These emissions from the vehicles can be decreased by designing the vehicle engine according to the standards for proper combustion itself and of course a good fuel economy too.

What is Bharat Stage Emission Standards?

BS stands for Bharat Stage and Bharat Stage Emission Standards are the standards of automobiles that is followed by the Indian Government. As these standards are given by the Government of India, it is named as Bharat. We started following these standards since the year 2000 and we are achieving great results by these emission standard norms.

The updates (or stages) of these emission rules or emission standards used to change frequently according to the generation and situations. So let us see about these updates.

What is European Emission Standards?

Euro stands for European and these are the standards follow by the European Countries or we can say that it is the European Emission Standards for vehicles. As like as we follow the emission standards in India, Europeans too follow particular rules or standards called European Emission Standards.

Bharat Stage Emission Standards	European Emission Standards	Year of Introducing
BS-I	Euro-I	2000
BS-II	Euro-II	2003
BS- III	Euro-III	2005
BS-IV	Euro-IV	2016
BS-VI	Euro-VI	2020

If we observe the above table closely, in 2000 the standards that we followed is Euro-I. At the starting of this era, we all used to follow the same standards followed by Europe, and this was introduced in the year 2000 and it was named Euro-I in Europe and Bharat Stage-I in India.

So these are the updating versions of Bharat stage emission standards from I to VI in the automobiles till now; it means BS-II is efficient and has less emitting technology compared to BS-I. Same with the BS-V when compared to BS-IV, right now we are in the era of Bharat Stage VI and it is more efficient and less pollutant compared to the BS-V. So Every time number of researchers will work to decrease the emissions from the engines and whenever they found new and feel that it will be the best to introduce, then the new standards are followed with this name Bharat stage.

As like BS-I, BS-II, etc., the European Emission Standards also upgrade their standards; they are like Euro-II, IIII, IV, VI are also the same as BS-I, II, III, IV, VI.

One more point, we observe in the above table that the BS-V in the Bharat stage emission standards is not mentioned because it was introduced in 2016 but it was skipped by the Emission Standards of India due to some reasons.