AUTOMOBILE ENGINEERING

UNIT –I

INTRODUCTION:

Automobile Engineering is a branch of engineering which deals with designing, manufacturing and operating automobiles. It is a segment of vehicle engineering which deals with motorcycles, buses, trucks, etc. It includes mechanical, electrical, electronic, software and safety elements.

An Automobile is a ***self propelled vehicle*** which is used to transportation of passengers and cargo over the ground, or through the water, or through the air.

So, The Engineering applied to Automobiles for their Design, Manufacture, Maintenance, Operation, is Automobile Engineering.

1. COMPONENTS OF FOUR WHEELER AUTOMOBILE

The automobile can be considered to consist of five basic components:

(a) The Engine or Power Plant: It is source of power.

(b) The Frame and Chassis: It supports the engine, wheels, body, braking system, steering, etc.

(c) The transmission which transmits power from the engine to the car wheels. It consists of clutch, transmission, shaft, axles and differential.

(d) The body.

(e) Accessories including light, air conditioner/hearer, stereo, wiper, etc.

1.1 Engine or power plant

The engine is the power plant of the vehicle. In general, internal combustion engine with petrol or diesel fuel is used to run a vehicle. An engine may be either a two-stroke engine or a four-stroke engine.

An engine consists of a cylinder, piston, valves, valve operating mechanism, carburetor (or MPFI in modern cars), fan, fuel feed pump and oil pump, etc. Besides this, an engine requires ignition system for burning fuel in the engine cylinder.

1.2 Chassis and frame

The chassis is formed by the frame with the frame side members and cross members. The frame is usually made of box, tubular and channel members that are welded or riveted together. In addition to this, it comprises of the springs with the axles and wheels, the steering system and the brakes, the fuel tank, the exhaust system, the radiator, the battery and other accessories. Along with this the frame supports the body

1.3 Transmission System (Clutch and Gear Box)

The power developed by the engine is transferred to the wheels by transmission system. Transmission system must do three jobs:

(a) It must provide varying gear ratios. Number of gear ratios is equal to number of gears in a vehicle.

(b) It must provide a reverse gear for moving vehicle in reverse direction.

(c) It must provide a neutral or disconnecting arrangement so that the

engine can be uncoupled from the wheels of the vehicle. In a conventional transmission system, there is a clutch, a manually operated transmission (gear box), a propeller shaft and a differential or final drive.

1.4 Clutch

The purpose of the clutch is to allow the driver to couple or decouple the engine and transmission. When clutch is in engaged position, the engine power flows to the transmission through it (clutch). When gears are to be changed while vehicle is running, the clutch permits temporary decoupling of engine and wheels so that gears can be shifted. In a scooter, the clutch is operated by hand where as in a car the clutch is operated by foot. It is necessary to interrupt the flow of power before gears are changed. Without a clutch, it will by very difficult

1.5 Final Drive

Final drive is the last stage in transferring power from engine to wheels. It reduces the speed of the propeller shaft (drive shaft) to that of wheels. It also turns the drive of the propeller shaft by an angle of 90^{o} to drive the wheels.

The propeller shaft has a small bevel pinion which meshes with crown wheel. The crown wheel gives rotary motion to rear axles. The size of crown wheel in bigger than that of bevel pinion, therefore, the speed of rear axles (or crown wheel) in lower than the speed of pinion. Final drive is of two types, i.e. chain type and gear type.

1.6 Braking System

Brakes are used to slow down or stop the vehicle. Hydraulic brakes are generally used in automobiles, where brakes are applied by pressure on a fluid. Mechanical brakes are also used in some vehicles. These brakes are operated by means of leavers, linkages, pedals, cams, etc. Hand brake or parking brake is usually a mechanical brake. These are used for parking the vehicles on sloppy surfaces and also in case of emergency.

1.7 Gear Box

Gear box contain gearing arrangement to get different speeds. Gears are used to get more than one speed ratios. When both mating gears have same number of teeth, both will rotate at same number speed. But when one gear has less teeth than other, the gear with less number of teeth will rotate faster than larger gear. In a typical car, there may be six gears including one reverse gear. First gear gives low speed but high torque. Higher gears give progressively increasing speeds. Gears are engaged and disengaged by a shift lever.

1.8 Steering System

In front wheels can be turned to left and right by steering system so that the vehicle can be steered. The steering wheel is placed in front of driver. It is mechanically linked to the wheels to provide the steering control. The primary function of the steering system is to provide angular motion to front wheels so that

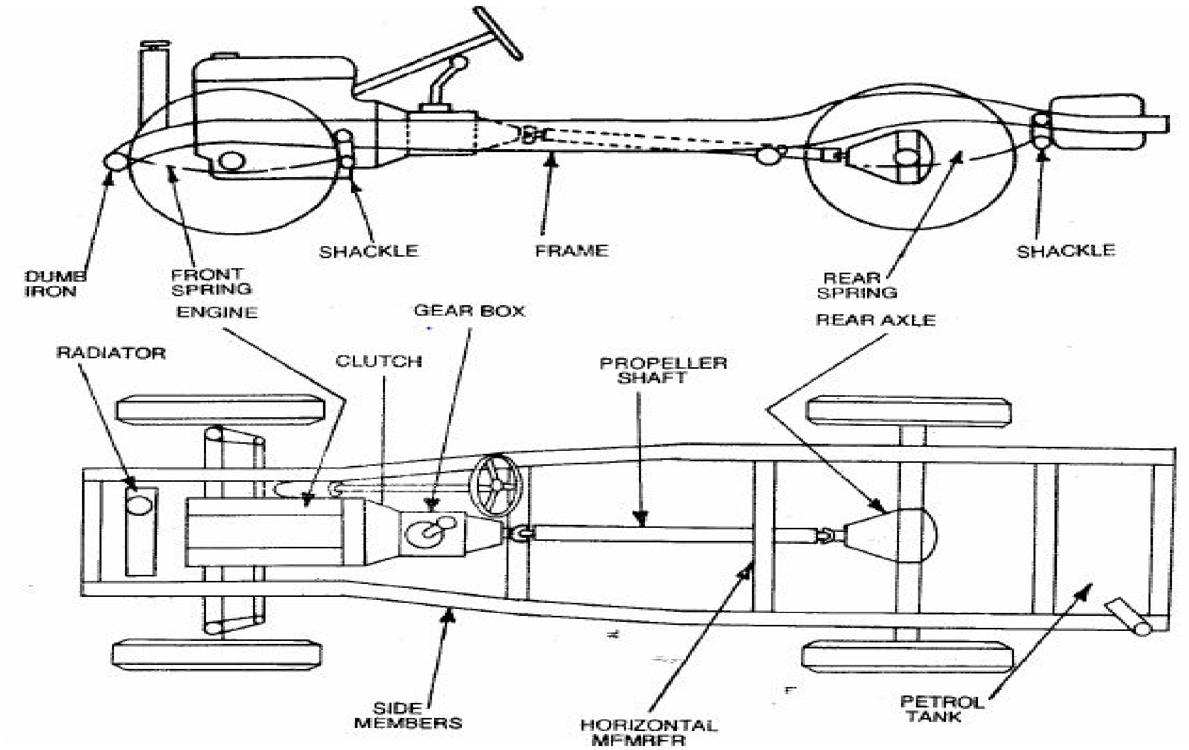
vehicle can negotiate a turn. It also provides directional stability to vehicle when the vehicle moves ahead in straight line.

2. CHASSIS FRAME AND BODY

Chassis is a French term and was initially used to denote the frame parts or Basic Structure of the vehicle. It is the back bone of the vehicle. A vehicle with out body is called Chassis. The components of the vehicle like Power plant, Transmission System, Axles, Wheels and Tyres,

Suspension, Controlling Systems like Braking, Steering etc., and also electrical system parts are mounted on the Chassis frame. It is the main mounting for all the components including the body. So it is also called as Carrying Unit.

Layout of Chassis and its main Components:



The following main components of the Chassis are

1. Frame: it is made up of long two members called side members riveted together with the help of number of cross members.

2. Engine or Power plant: It provides the source of power

3. Clutch: It connects and disconnects the power from the engine fly wheel to the transmission system.

4. Gear Box

5. U Joint

6. Propeller Shaft

7. Differential

2.1 FUNCTIONS OF THE CHASSIS FRAME:

1. To carry load of the passengers or goods carried in the body.

2. To support the load of the body, engine, gear box etc.,

3. To withstand the forces caused due to the sudden braking or acceleration

4. To withstand the stresses caused due to the bad road condition.

5. To withstand centrifugal force while cornering

2.2 TYPES OF CHASSIS FRAMES:

There are three types of frames

1. Conventional frame

2. Integral frame

3. Semi-integral frame

1. Conventional frame: It has two long side members and 5 to 6 cross members joined together with the help of rivets and bolts. The frame sections are used generally.

a. Channel Section - Good resistance to bending

b. Tabular Section - Good resistance to Torsion

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

2. Integral Frame: This frame is used now a days in most of the cars. There is no frame and all the assembly units are attached to the body. All the functions of the frame carried out by the body itself. Due to elimination of long frame it is cheaper and due to less weight most economical also. Only disadvantage is repairing is difficult.

3. Semi - Integral Frame: In some vehicles half frame is fixed in the front end on which engine gear box and front suspension is mounted. It has the advantage when the vehicle is met with accident the front frame can be taken easily to replace the damaged chassis frame. This type of frame is used in FIAT cars and some of the European and American cars.

2.3 VARIOUS LOADS ACTING ON THE FRAME:

Various loads acting on the frame are

1. Short duration Load - While crossing a broken patch.

2. Momentary duration Load - While taking a curve.
3. Impact Loads - Due to the collision of the vehicle.
4. Inertia Load - While applying brake.
5. Static Loads - Loads due to chassis parts.
6. Over Loads - Beyond Design capacity.

2.4 STATE THE DIFFERENT BODIES USED IN AUTOMOBILES:

The Automobile bodies are divided in two groups 1.Passenger Body 2.Commercial body

According to Chassis design the body can divided into

1. Conventional Type

2. Integral Type

3. Semi- Integral Type

According to other usage:

1. Light vehicle Bodies - cars, jeeps

2. Heavy vehicle Bodies – Busses, Lorries

3. Medium vehicle Bodies - Vans, Metadoors

2.5 REQUIREMENTS OF BODIES FOR VARIOUS TYPES OF VECHILE:

The body of the most vehicle should fulfill the following requirements:

1. The body should be light.

2. It should have minimum number of components.

3. It should provide sufficient space for passengers and luggage.

4. It should withstand vibrations while in motion.

5. It should offer minimum resistance to air.

6. It should be cheap and easy in manufacturing.

7. It should be attractive in shape and colour.

8. It should have uniformly distributed load.

9. It should have long fatigue life

10.It should provide good vision and ventilation.

3. ENGINE

3.1 Types of Automobile engines

There are many different types of internal combustion engines. They can be classified by:

1. Application. Automobile, truck, locomotive, light aircraft, marine, portable power system, power generation

2. Basic engine design. Reciprocating engines (in turn subdivided by arrangement of cylinders: e.g., in-line, V, radial, opposed), rotary engines (Wankel and other geometries)

3. Working cycle. Four-stroke cycle: naturally aspirated (admitting atmospheric air), supercharged (admitting precompressed fresh mixture), and turbo- charged (admitting fresh mixture compressed in a compressor driven by an exhaust turbine), two-stroke cycle: crankcase scavenged, supercharged, and turbocharged

4. Valve or port design and location. Overhead (or I-head) valves, underhead (or L-head) valves, rotary valves, cross-scavenged porting (inlet and exhaust ports on opposite sides of cylinder at one end), loop-scavenged porting (inlet and exhaust ports on same side of cylinder at one end), through- or uniflow- scavenged (inlet and exhaust ports or valves at different ends of cylinder)

5. Fuel. Gasoline (or petrol), fuel oil (or diesel fuel), natural gas, liquid pet- roleum gas, alcohols (methanol, ethanol), hydrogen, dual fuel

6. Method of mixture preparation. Carburetion, fuel injection into the intake ports or intake manifold, fuel injection into the engine cylinder

7. Method of ignition. Spark ignition (in conventional engines where the mixture is uniform and in stratified-charge engines where the mixture is non-uniform), compression ignition (in conventional diesels, as well as ignition in gas engines by pilot injection of fuel oil)

8. Combustion chamber design. Open chamber (many designs: e.g., disc, wedge, hemisphere, bowl-in-piston), divided chamber (small and large auxiliary chambers; many designs: e.g., swirl chambers, prechambers)

9. Method of load control. Throttling of fuel and air flow together so mixture composition is essentially unchanged, control of fuel flow alone, a combination of these

10. Method of cooling. Water cooled, air cooled, uncooled (other than by natural convection and radiation)

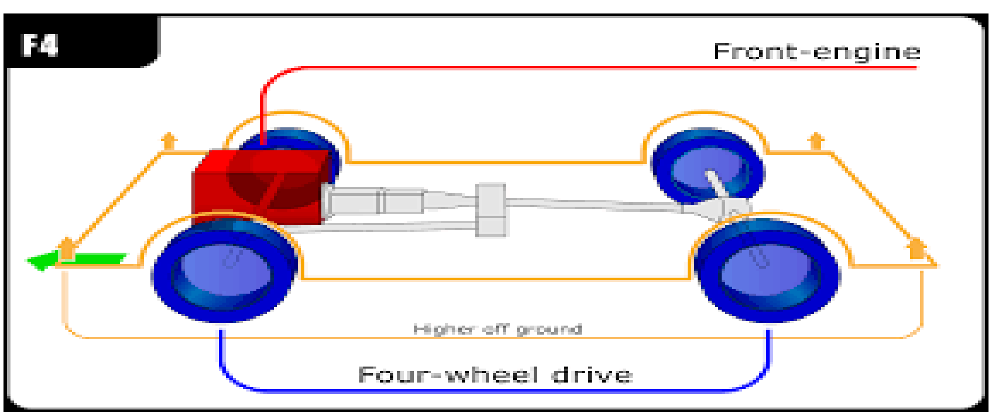
4. POWER TRANSMISSION

4.1FRONT-WHEEL DRIVE

Front-wheel-drive vehicles are the more common arrangement for most cars and mini-vans these days. These vehicles do not have conventional transmissions, drive axles or driveshafts. Instead, power is transmitted from the engine to a transaxle, or combination of transmission and drive axle, in one unit. Refer to the Automatic or Manual Transmission/Transaxle Section for more information on the transaxle.

A single transaxle accomplishes the same functions as a transmission and drive axle in a front-engine/rear-drive axle design. The difference is in the location of components.

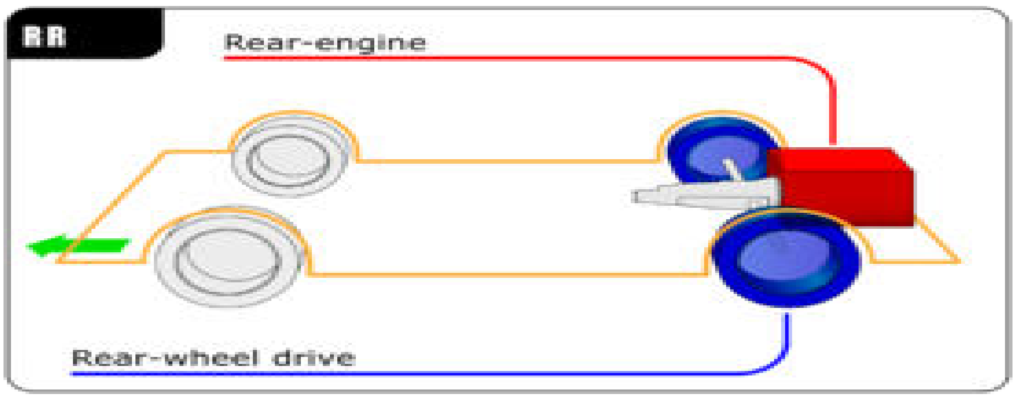
In place of a conventional driveshaft, a front wheel drive design uses two driveshafts, usually called halfshafts, which couple the drive axle portion of the transaxle to the wheels. Universal or constant velocity joints are used just as they would be in a rear wheel drive design.



4.2 REAR-WHEEL DRIVE

Rear-wheel-drive vehicles are mostly trucks, very large sedans and many sports car and coupe models. The typical rear wheel drive vehicle uses a front mounted engine and transmission assemblies with a driveshaft coupling the transmission to the rear drive axle. The rear axle assembly is usually a solid (or live) axle, although some import and/or performance models have used a rigidly mounted center differential with halfshafts coupling the wheels to the differential.

Some vehicles do not follow this typical example. Such as the older Porsche or Volkswagen vehicles which were rear engine, rear drive. These vehicles use a rear mounted transaxle with halfshafts connected to the drive wheels. Also, some vehicles were produced with a front engine, rear transaxle setup with a driveshaft connecting the engine to the transaxle, and halfshafts linking the transaxle to the drive wheels.



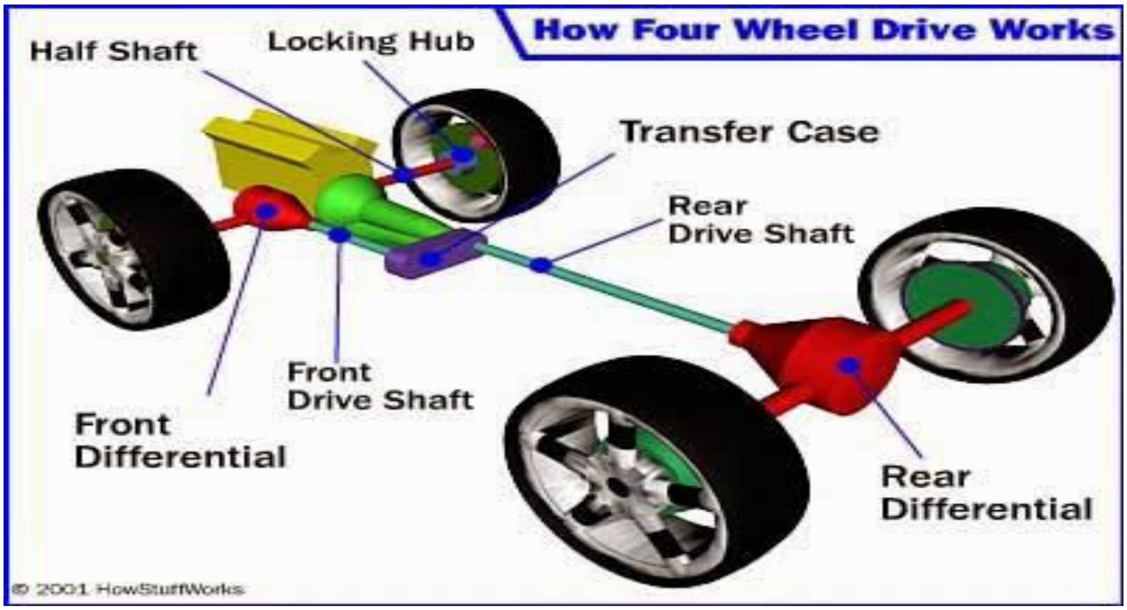
4.3 FOUR-WHEEL DRIVE

When the vehicle is driven by both the front and rear wheels, two complete axle assemblies are used and power from the engine is directed to both drive axles at the same time. A transfer case may be attached to, or mounted near, the rear of the transmission/transaxle and directs the power flow to the rear and/or front axles through two driveshafts. Since the angles between the front and rear driveshafts change constantly, slip joints are used on the shafts to accommodate the changes in distance between axles and transfer case.

Another form of four or All Wheel Drive (AWD) design may use a front mounted engine and modified front wheel drive transaxle assembly with an additional power output. Two halfshafts connect the front wheels to the transaxle. Some models may have a transfer case connected to the transaxle's additional power output. A driveshaft couples the front transaxle or transfer case to the rear differential with two halfshafts driving the rear wheels.

Shifting devices attached to transfer cases disengage the front drive axle when four wheel drive capability is not needed. However, some newer transfer cases are in constant mesh and cannot be totally disengaged. These are known as "full-time" four wheel drive and are just what the name says, four wheel drive operating all the time. This is made possible by either a differential in the transfer case or through the use of a hydraulic viscous coupling.

Jeep& vehicles use a full-time system called Quadra-Trac, which is full-time four wheel drive with a limited slip differential in the transfer case. All you have to do is drive.



5. SUPERCHARGER

A **supercharger** is an air compressor that increases the pressure or density of air supplied to an internal combustion engine. This gives each intake cycle of the engine more oxygen, letting it burn more fuel and do more work, thus increasing power.

Power for the supercharger can be provided mechanically by means of a belt, gear, shaft, or chain connected to the engine's crankshaft.

When power is provided by a turbine powered by exhaust gas, a supercharger is known as a *turbo supercharger* typically referred to simply as a *turbocharger* or just *turbo*. Common usage restricts the term *supercharger* to mechanically driven units.

5.1 Types of supercharger

There are two main types of superchargers defined according to the method of gas transfer: positive displacement and dynamic compressors. Positive displacement blowers and compressors deliver an almost constant level of pressure increase at all engine speeds (RPM). Dynamic compressors do not deliver pressure at low speeds; above a threshold speed, pressure increases with engine speed.

Positive displacement

Positive-displacement pumps deliver a nearly fixed volume of air per revolution at all speeds (minus leakage, which is almost constant at all speeds for a given pressure, thus its importance decreases at higher speeds).

Major types of positive-displacement pumps include: Roots, Lysholm twin-screw, Sliding vane Scroll-type supercharger, also known as the G-Lader

Positive-displacement pumps are further divided into internal and external compression types.

Roots superchargers are external compression only (although high-helix roots blowers attempt to emulate the internal compression of the Lysholm screw).

- External compression refers to pumps that transfer air at ambient pressure into the engine. If the engine is running under boost conditions, the pressure in the intake manifold is higher than that coming from the supercharger. That causes a backflow from the engine into the supercharger until the two reach equilibrium. It is the backflow that actually compresses the incoming gas. This is an inefficient process and the main factor in the lack of efficiency of Roots superchargers when used at high boost levels. The lower the boost level the smaller is this loss, and Roots blowers are very efficient at moving air at low pressure differentials, which is what they were invented for (hence the original term "blower").All the other types have some degree of internal compression.

- Internal compression refers to the compression of air within the supercharger itself, which, already at or close to boost level, can be delivered smoothly to the engine with little or no back flow. This is more effective than back flow compression and allows higher efficiency to be achieved. Internal compression devices usually use a fixed internal compression ratio. When the boost pressure is equal to the compression pressure of the supercharger, the back flow is zero. If the boost pressure exceeds that compression pressure, back flow can still occur as in a roots blower. Internal compression blowers must be matched to the expected boost pressure in order to achieve the higher efficiency they are capable of, otherwise they will suffer the same problems and low efficiency of the roots blowers.

Dynamic

Dynamic compressors rely on accelerating the air to high speed and then exchanging that velocity for pressure by diffusing or slowing it down.

Major types of dynamic compressor are: Centrifugal, Multi-stage axial-flow, Pressure wave supercharger

6. TURBOCHARGER

A **turbocharger**, or **turbo** (colloquialism), from Greek a turbine-driven forced induction device that increases an internal combustion engine's efficiency and power output by forcing extra air into the combustion chamber. This improvement over a naturally aspirated engine's power output is because the compressor can force more air—and proportionately more fuel—into the combustion chamber than atmospheric pressure alone.

Turbochargers were originally known as **turbo superchargers** when all forced induction devices were classified as superchargers. Nowadays the term "supercharger" is usually applied only to mechanically driven forced induction devices. The key difference between a turbocharger and a conventional supercharger is that a supercharger is mechanically driven by the engine, often through a belt connected to the crankshaft, whereas a turbocharger is powered by a turbine driven by the engine's exhaust gas. Compared to a mechanically driven supercharger, turbochargers tend to be more efficient, but less responsive. Twin charger refers to an engine with both a supercharger and a turbocharger.

Turbochargers are commonly used on truck, car, train, aircraft, and construction equipment engines. They are most often used with Otto cycle and Diesel cycle internal combustion engines. They have also been found useful in automotive fuel cells

Supercharging versus turbo charging

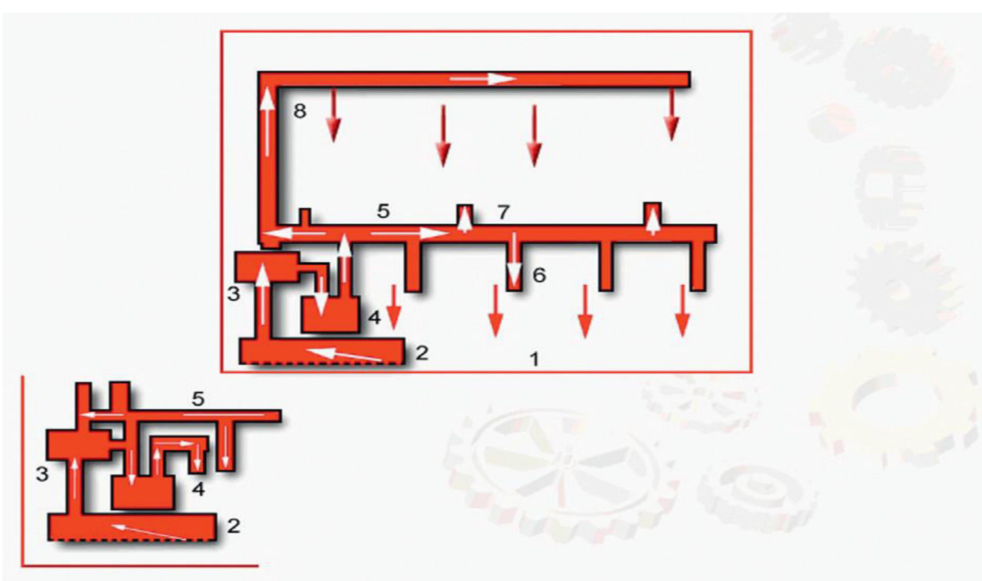
In contrast to turbochargers, superchargers are mechanically driven by the engine.[12] Belts, chains, shafts, and gears are common methods of powering a supercharger, placing a mechanical load on the engine. For example, on the single-stage single-speed supercharged Rolls-Royce Merlin engine, the supercharger uses about 150 horsepower (110 kilowatts). Yet the benefits outweigh the costs; for the 150 hp (110 kW) to drive the supercharger the engine generates an additional 400-horsepower, a net gain of 250 hp (190 kW). This is where the principal disadvantage of a supercharger becomes apparent; the engine must withstand the net power output of the engine plus the power to drive the supercharger.

Another disadvantage of some superchargers is lower adiabatic efficiency as compared to turbochargers (especially Roots-type superchargers). Adiabatic efficiency is a measure of a compressor's ability to compress air without adding excess heat to that air. Even under ideal conditions, the compression process always results in elevated output temperature; however, more efficient compressors produce less excess heat. Roots superchargers impart significantly more heat to the air than turbochargers. Thus, for a given volume and pressure of air, the turbocharged air is cooler, and as a result denser, containing more oxygen molecules, and therefore more potential power than the supercharged air. In practical application the disparity between the two can be dramatic, with turbochargers often producing 15% to 30% more power based solely on the differences in adiabatic efficiency (however, due to heat transfer from the hot exhaust, considerable heating does occur).

By comparison, a turbocharger does not place a direct mechanical load on the engine, although turbochargers place exhaust back pressure on engines, increasing pumping losses.[12] This is more efficient, because while the increased back pressure taxes the piston exhaust stroke, much of the energy driving the turbine is provided by the still-expanding exhaust gas that would otherwise be wasted as heat through the tailpipe. In contrast to supercharging, the primary disadvantage of turbo charging is what is referred to as "lag" or "spool time". This is the time between the demand for an increase in power (the throttle being opened) and the turbocharger(s) providing increased intake pressure, and hence increased power

7. OIL FILTERS

Even new engines can contain very small particles of metal left over from the manufacturing process or grains of sand that have not been removed from the crankcase after casting. Old engines continually deposit tiny bits of metal worn from highly loaded components such as the piston rings. To prevent any of these lodging in bearings or blocking oil ways, the oil is filtered



The primary fi lter is a wire mesh strainer that stops particles of dirt or swarf from entering the oil pump. This is normally on the end of the oil pick-up pipe. An extra filter is also used that stops very fi ne particles. The most common type has a folded, resin-impregnated paper element. Pumping oil through it removes all but smallest solids from the oil.

Most engines use a full-flow system to filter all of the oil after it leaves the pump .The most popular method is to pump the oil into a canister containing a cylindrical filter. From the inner walls of the canister, the oil flows through the filter and out from the centre to the main oil gallery. Full-flow filtration works well provided the filter is renewed at regular intervals. If it is left in service too long it may become blocked. When this happens the build-up of pressure inside the filter forces open a spring-loaded relief valve in the housing and the oil bypasses the filter. This valve prevents engine failure, but the engine will be lubricated with dirty oil until the filter is renewed. This is better than no oil! A bypass filtration system was used on some vehicles

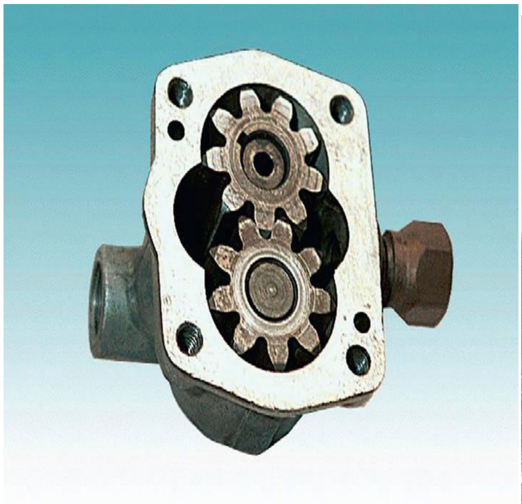
This system only filters a proportion of the oil pump output. The remainder is fed directly to the oil gallery. At first view this seems a strange idea but all of the oil does eventually get filtered. The smaller amount through the filter allows a higher degree of filtration.

For many high-performance applications, a larger oil supply is needed so that engine heat can be removed by the engine oil as well as by the engine-cooling system. A separate reservoir of oil is held in a remote tank and drawn into the main oil pump for distribution throughout the engine in the same way as a wet-sump system. The oil returns to a small sump below the engine. A scavenge pump, with a pick-up pipe in the sump, draws oil out of the sump and delivers it back to the reservoir. An oil cooler is usually fitted in this return circuit.

8. OIL PUMPS

The oil pump is the heart of the system. It pumps oil from the sump into the engine. The main types of oil pump are gear, rotor, gerotor, vane and crescent. The gear type uses two gears in mesh with each other. Drive is made to one gear which, in turn, drives the other. The housing has a figure-of-eight internal shape, with one gear in each end. Ports are machined in the housing and align with the areas where the teeth move into, and out of, mesh. As the teeth separate, the volume in the inlet side of the housing increases and atmospheric pressure in the sump is able to force oil into the pump. The oil is carried around inside the pump in between the teeth and the side of the housing. When the teeth move back into mesh, the volume in the outlet side of the housing is reduced, the pressure rises and this forces the oil out into the engine.

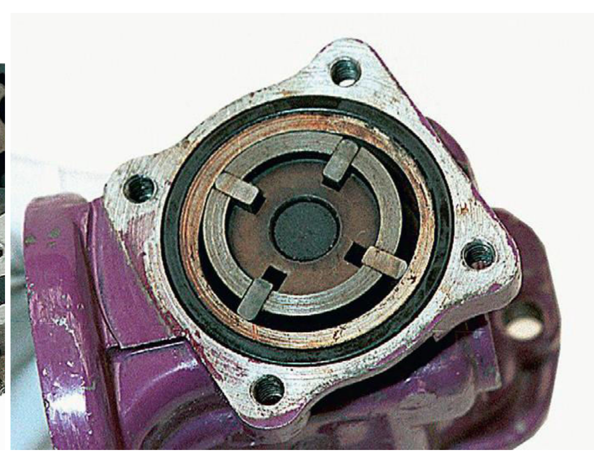
The rotor-type pump uses the same principle of meshing but with an inner rotor with externally formed lobes that mesh with corresponding internal profiles on the inside of an external rotor



Gear Pump

Rotor Pump

The inner rotor is offset from the centre of the pump and the outer rotor is circular and concentric with the pump body. As the rotors rotate, the lobes mesh to give the outlet pressure of the oil supply, or move out of mesh for the intake of oil from the sump. The gerotor (gear rotor pump) is a variation on the smaller rotor pump. The Gerotor pump is usually fitted around, and driven by, the crankshaft. There are inner and outer rotors, with the inner rotor externally lobed and offset from the internally lobed outer rotor. During rotation, the pumping and carrying chambers are formed by the relative positions of the lobes. The crescent pump is named after the solid block in the gear body. This pump is a variation on the gear pump, and also uses gear teeth to create the pumping chambers and to carry oil from the inlet port to the outlet port of the pump. The operation of this pump is based on the meshing of the gear teeth, the positioning of the ports in the housing and alignment at each end of the crescent where the teeth move in and out of mesh. Oil is carried from the inlet port to the outlet port in the spaces between the teeth and the crescent. This type of pump is used for engine lubrication and for automatic transmissions.



Gerotor

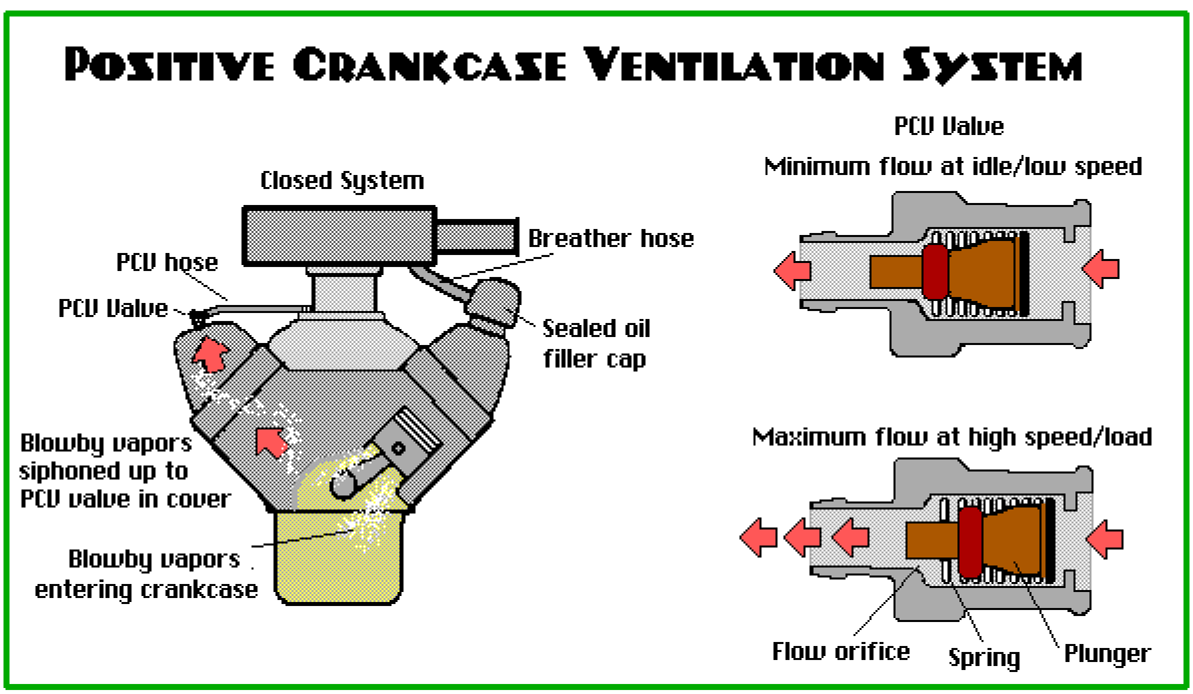
Vane pump

The vane-type pump uses an eccentric rotor with vane plates set at right angles to the axis of the rotor and sitting in slots in the rotor .As the rotor rotates, the vanes sweep around inside the pump housing. The pump chambers increase in volume as the vanes move away from the housing walls, and reduce in volume as the vanes approach the walls. Oil is carried between the vanes and the pump housing from the inlet port to the outlet port.

Most modern engines now use the crankshaft to give a direct drive to the oil pump. These pumps are of the gerotor or crescent design, and are fitted around the front of the crankshaft. This arrangement is used on many overhead camshaft engines because it provides a low position for the pump.

9. CRANK CASE VENTILATION

The Positive Crankcase Ventilation (PCV) system reduces blow by emissions from the engine. About 20% of the total hydrocarbon (HC) emissions produced by a vehicle are blow by emissions from gases that get past the piston rings and enter the crankcase. The higher the mileage on the engine and the greater the wear on the piston rings and cylinders, the greater the blow by into the crankcase.



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HOW PCV WORKS

The major component in the PCV system is the PCV valve, a simple spring-loaded valve with a sliding pintle inside. The pintle is tapered like a bullet so it will increase or decrease airflow depending on its position inside the valve housing. The movement of the pintle up and down changes the orifice opening to regulate the volume of air passing through the PCV valve.

The PCV valve is typically located in a valve cover or the intake valley, and usually fits into a rubber grommet. The location of the valve allows it to pull vapors from inside the engine without sucking oil from the crankcase (baffles inside the valve cover or valley cover deflect and help separate droplets of oil from the blow by vapors).

A hose connects the top of the PCV valve to a vacuum port on the throttle body, carburetor or intake manifold. This allows the vapors to be siphoned directly into the engine without gumming up the throttle body or carburetor.

Because the PCV system pulls air and blow by gases into the intake manifold, it has the same effect on the air/fuel mixture as a vacuum leak. This is compensated for by the calibration of the carburetor or fuel injection system. Consequently, the PCV system has no net effect on fuel economy, emissions or engine performance -- provided everything is working correctly.