AUTOMOBILE ENGINEERING

VTU SOLUTION AUGUST 2022

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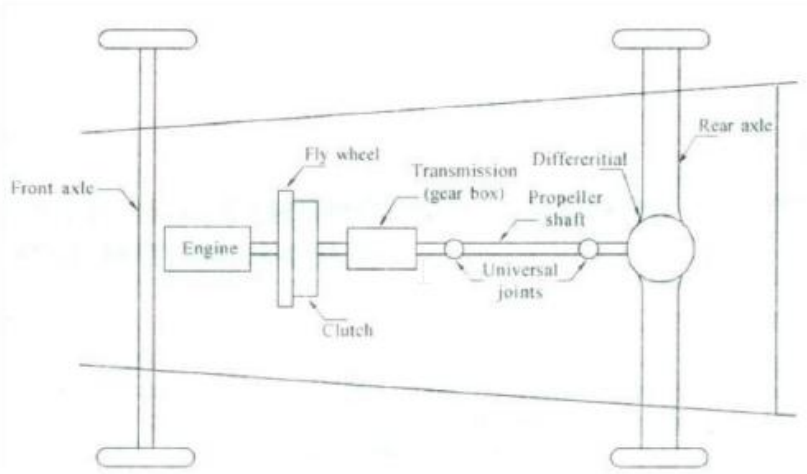

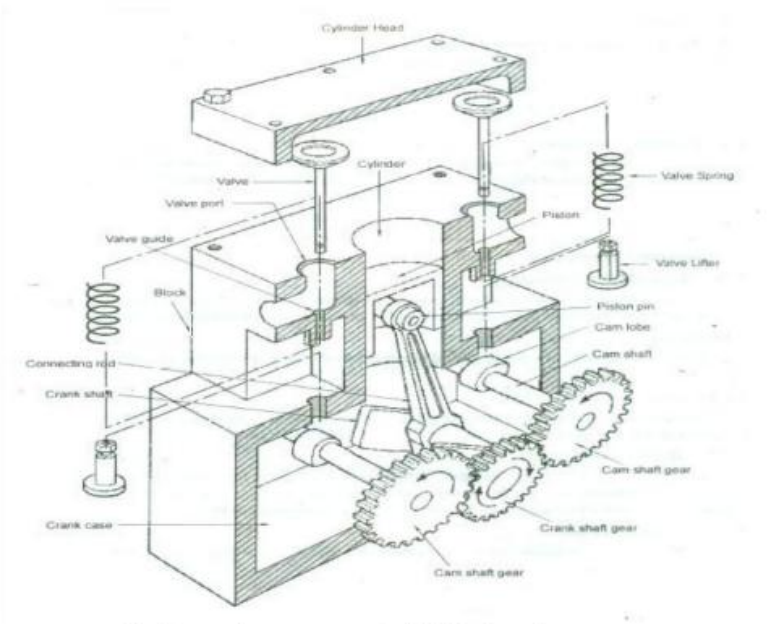

Fig. The various components of the basic engine

The cylinder is the main body of an engine in which piston reciprocates to develop power. It has to with stand very high pressure and temperature (around 2800°C). A cylinder block is one which houses the engine cylinders. If cylinder block and crank case are made integral, then the construction is called 'Mono block'. The cylinder material should be such that it should retain strength at higher temperatures, should be good conductor of heat and should resist rapid wear and tear due to reciprocating action of the piston. Generally cast iron is used. For heavy duty engines alloy steels are used.

For cooling water circulation, passages are provided around the cylinders. Cylinder block also carries lubrication oil to various components through drilled passages.

1.12 PISTON PIN

Piston pin is also known as wrist pin or gudgeon pin, used to connect Piston and connecting rod. It transfers combustion chamber pressure and piston forces to the connecting rod. It is in tubular shape to provide adequate strength with minimum weight. **It passes through** the piston bosses and small end of the connecting rod. It is made of low carbon case hardened steel (carbon - 15%, silicon - 0.3%, manganese - 0.5%).

Piston pins are installed and secured to provide a bearing action in the following three ways.

1.The pin is fastened to the piston by set screws through the piston boss and has a bearing in the connecting rod small end. This permits the connecting rod to swivel as required by the combined reciprocal and rotary motion of piston and crank shaft.

1b)

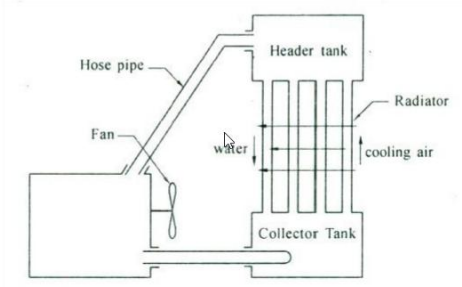

Fig. (a): Thermosyphon Cooling System

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a) Thermosyphon system: In this system the engine is connected to radiator through flexible hoses. The difference in densities of hot and cold regions of cooling water causes water circulation between engine and radiator. The water in circulation absorbs heat from engine cylinder and hence cool it. The heat from the water is then dissipated into atmosphere through the radiator by conduction and convection. This cools the water which is required for further circulation. Sometimes fans are used behind the radiator to increase the air mass flow rate and- hence to increase cooling efficiency.

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2)

1.Dry liners

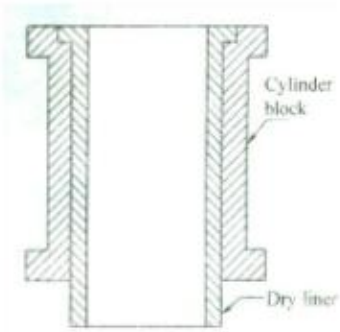

Fig. Dry liners

The dry liners are quite thin and uses block metal to give it full length support. These liners are made in the form of barrel. and a flange is provided at the top which keeps the liner in to position. It is necessary to machine the liner surface accurately both from inside and outside, as the outer surface of the liner makes contact with cylinder block. By shrinking the liner, it is put in to the cylinder bore.

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2. Wet liners

Wet liner is pressed into bore of cylinder block and is supported at top and bottom only. These liners makes direct contact with cooling water on the outside and hence does not require accurate machining on the entire outer surface. A flange is provided at the top which fits into the groove in the cylinder block. Three grooves are provided at the bottom, middle one is empty and top and bottom grooves are inserted with rubber packing's. For water leakage, drainage arrangements are provided from the middle groove. The wet liners are sometimes coated with aluminium on the outside to make the surface corrosion resistant.

When the engine runs, the connecting rod oscillates and the scoop takes the oil from oil trough and splashes on to the cylinder walls each time when it passes through BDC position. This lubricates engine walls, gudgeon pin, main crank shaft bearings, big end bearings etc. The oil dripping from the cylinder walls, collects in the tank where it is cooled by air flow.

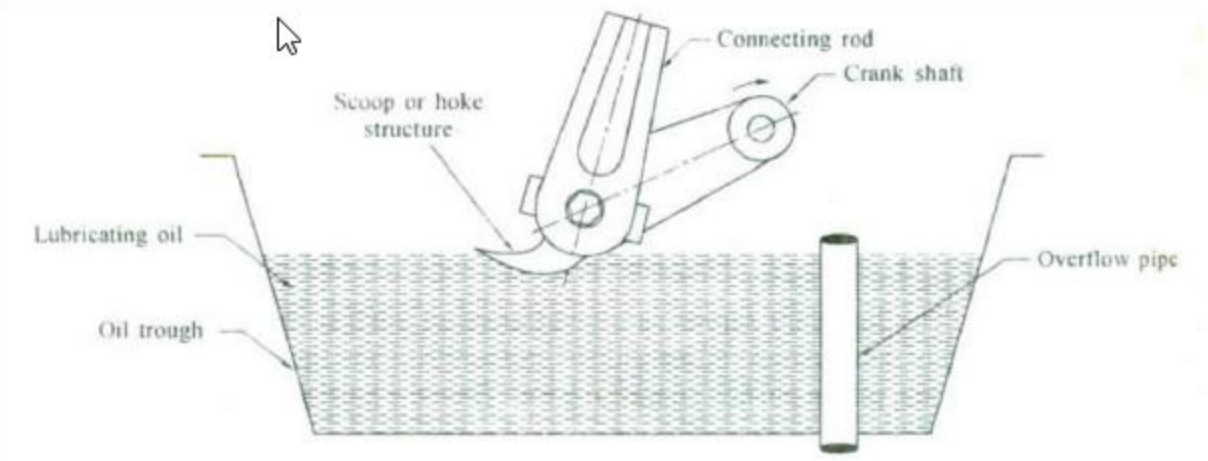

Fig. Splash lubrication system

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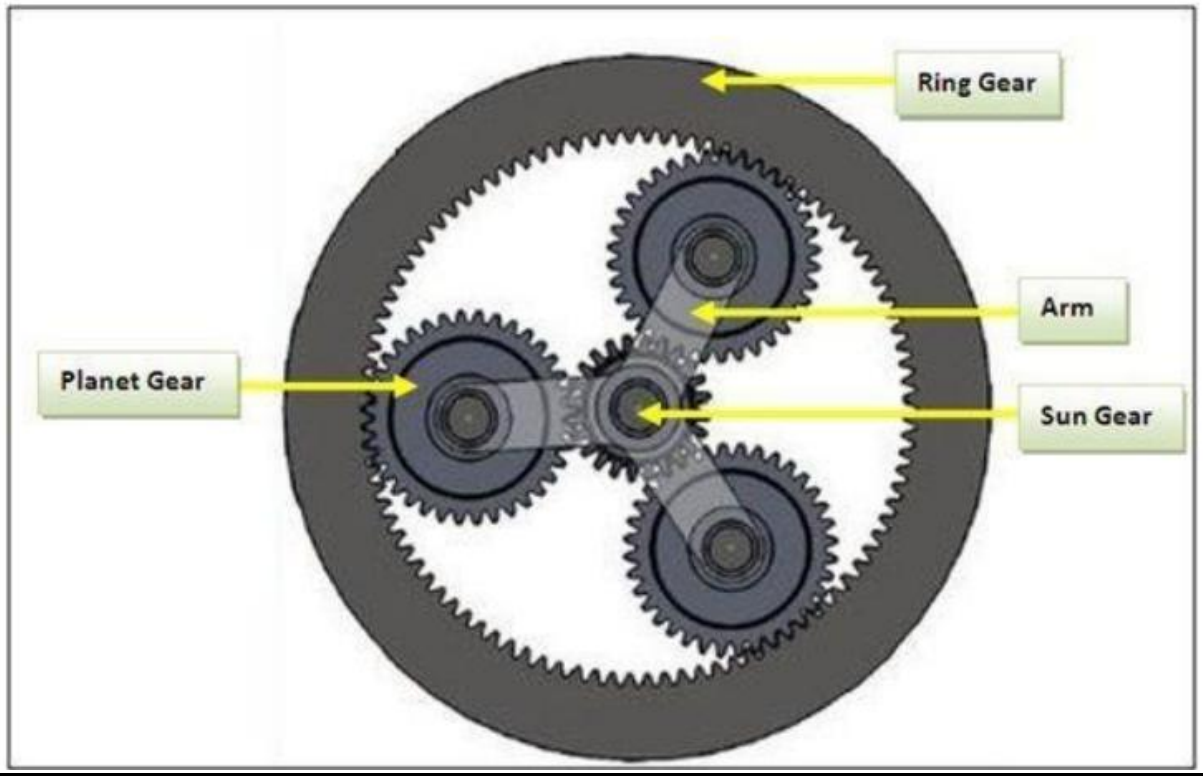
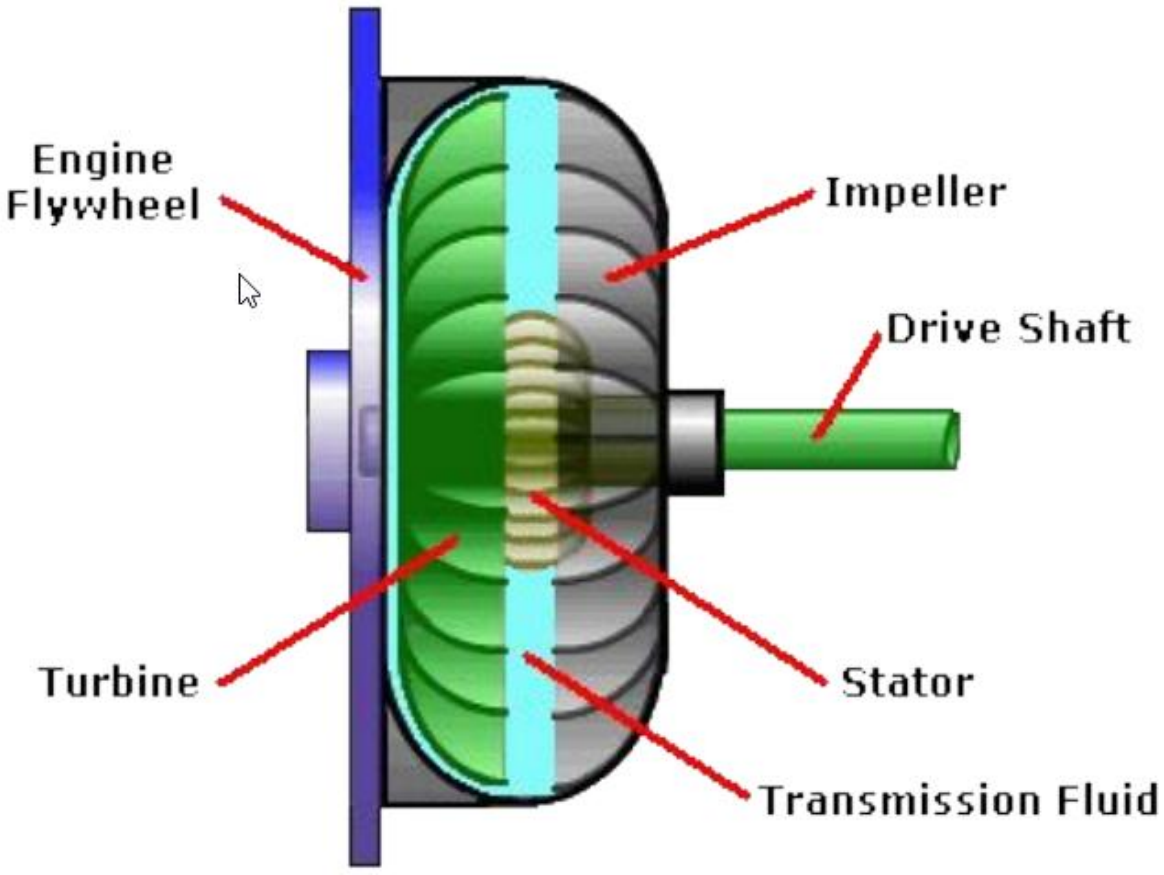
3)



- A fluid coupling is a hydrodynamic device used to transmit rotating mechanical power. It has been used in automobile transmission as an alternative to a mechanical clutch
- Fluid coupling consists of three components, plus the hydraulic fluid.
- The housing, also known as the shell (which must have an oil tight seal around the drive shafts), contains the fluid and turbines.
- Two turbines: One connected to the input shaft; known as the pump or impellor, primary wheel, input turbine, driving member.
- The other connected to the output shaft, known as the turbine, output turbine, secondary wheel or runner or driven member
- The driving turbine, known as the 'pump', (or driving torus) is rotated by the prime mover, which is typically an internal combustion engine or electric motor. The impellor's motion imparts both outwards linear and rotational motion to the fluid.
- The hydraulic fluid is directed by the 'pump' whose shape forces the flow in the direction of the 'output turbine'. Here, any difference in the angular velocities of 'input stage' and 'output stage' result in a net force on the 'output turbine' causing a torque; thus causing it to rotate in the same direction as the pump.
- The motion of the fluid is effectively toroidal - travelling in one direction on paths that can be visualized as being on the surface.If there is a difference between input and output angular velocities the motion has a component which is circular (i.e. round the rings formed by sections of the torus)

Torque Converter

- The impeller's speed is regulated by the engine side of this hydrodynamic circuit (i.e. speed of the pump blades). When the vehicle is stationary, or the driver applies the brakes, the impeller will slow considerably, while the pump continues to spin. This allows the torque converter to act like the clutch in a manual transmission – it allows the engine to continue running while the vehicle is at a complete stop.
- Once the transmission fluid has been hurled onto the impeller blades, it has to return to the pump in order to keep the cycle going. Since the fluid is now flowing in a different direction than the pump, it has to be reversed to avoid slowing down (and stalling) the engine.



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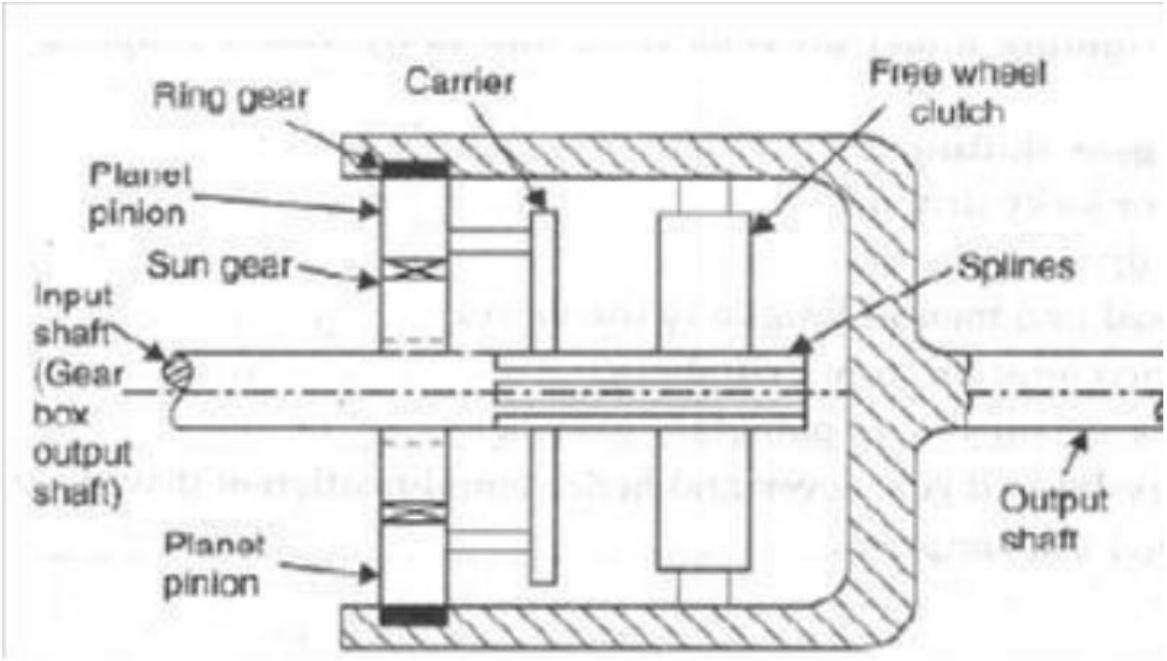
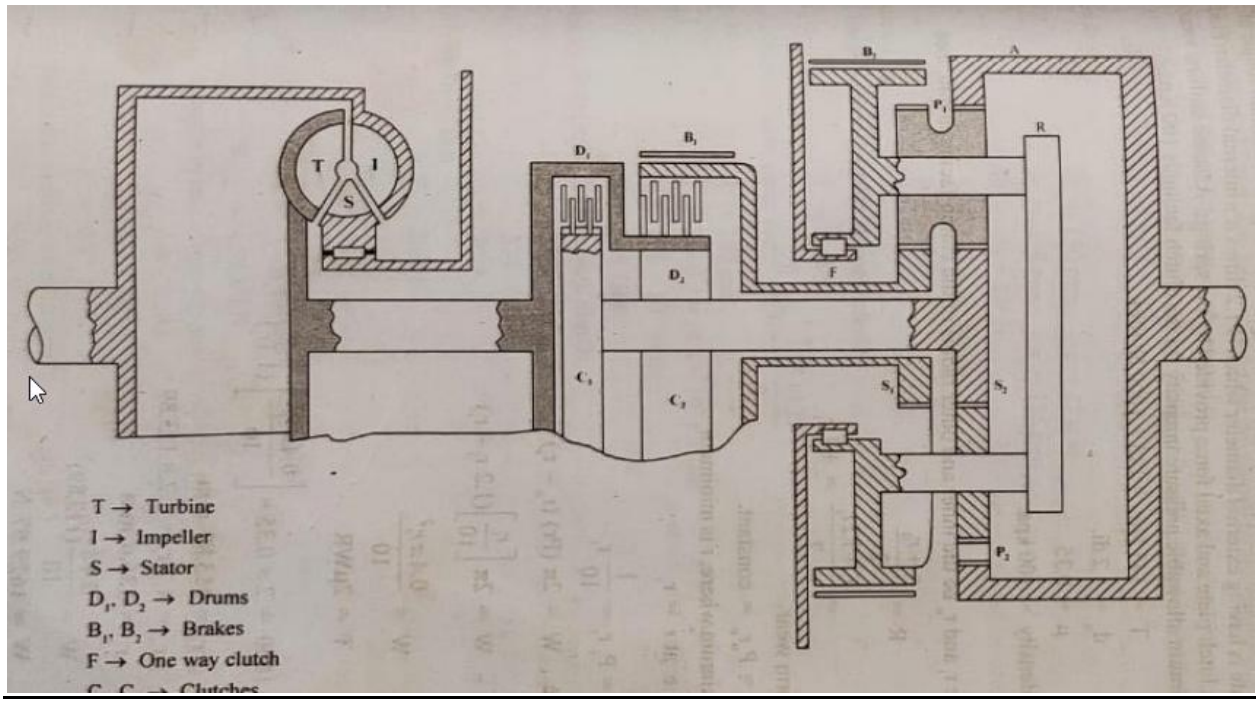


It consists of an epicyclic gear train in which the sun gear is free to rotate on the input shaft, while the carrier can move on splines, on the input shaft. A freewheel clutch is also fitted on the input shaft splines. The output shaft is connected to the ring. When the sun gear is locked with the casing i.e., it becomes stationary, of the output shaft is increased i.e., overdrive is engaged.

When the sun gear is locked to the carrier or to the ring, solid drive through n is obtained. Thus depending on the locking of the sun gear with ring gear or with carrier the overdrive or the normal direct drive is obtained. There is another possible control of the mechanism i.e., when the sun wheel is kept free to rotate on the input shaft. In this case there is direct drive through the freewheel clutch when


T
I
S
D_1
B_1
B_2
A
P_1
R
D_2
F
C_1
C_2
S_1
S_2
P_2
T → Turbine
I → Impeller
S → Stator
D_1, D_2 → Drums
B_1, B_2 → Brakes
F → One way clutch
C, C → Clutches

5)

6.11 (a) Camber

Camber angle is the inclination between the centre line of the tyre and the vertical . If the wheels are inclined or tilted outward at the top, it is called "positive camber", and if the wheels are inclined inward at the top, it is called "negative camber". t is also called as 'wheel rake angle:.

Front wheels are not mounted parallel to each other, instead they are tilted slightly outward at the top. This is done to prevent the top of the wheels from tilting inward too much due to excessive loads or play in the king pins and wheel bearings.

Effect: It is noted that, to make the tyre wear more uniform, tyre should roll vertically on the ground. Tyre will wear more on one side than the other side, when it is tilted inward or outward. The positive camber causes the tyre to roll like a truncated cone. The positive camber makes the wheel to toe out and tyre will wear more on the outer side. Similarly the negative camber makes the wheels to and tyre will wear more on the inner side. Initially

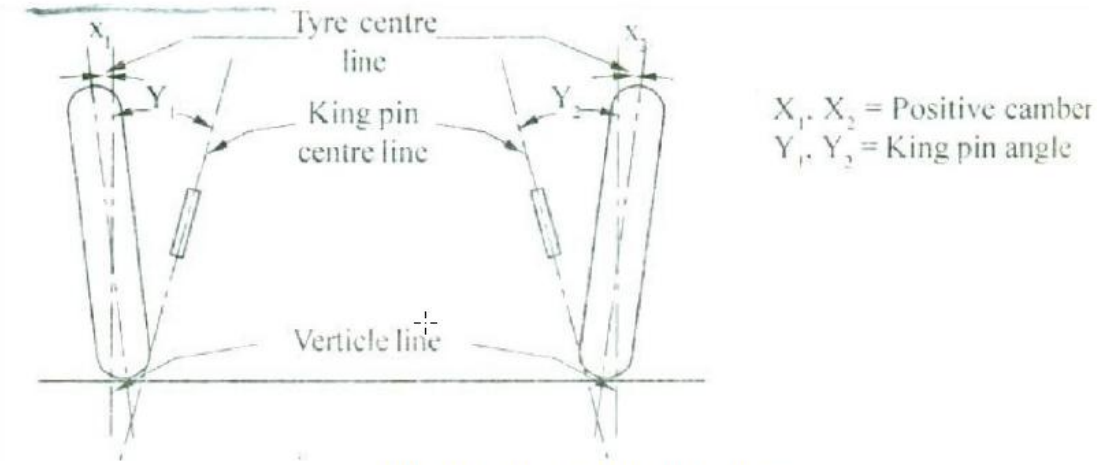


Fig. (a) Camber and king pin inclination

6.11 (b) King pin angle or Steering axis inclination

The king pin or Ball joints are mounted in such a way that they slant inward. The king pin inclination is the inward tilt of the king pin or ball joint centre line from the vertic Ie. [i.e. the angle between verticle and king pin or ball joint centre line]. In case of king pin, this is called king pin angle and if ball joints are used, then it is called steering axis inclination.

Effect: King pin inclination in combination with caster provides directional stability. When the vehicle turns, the vehicle body is lifted up slightly due to king pin inclination. After completing the turn, driver leaves the steering wheel and vehicle weight causes the wheels to recover straight ahead position. The king pin angle is kept about 7 to 8 de rees and exact amount depends upon wheel rake angle. This king pin angle also ;;uses suspension shocks to be transmitted to and absorbed by the heavy inner spindle and knuckle assembly.

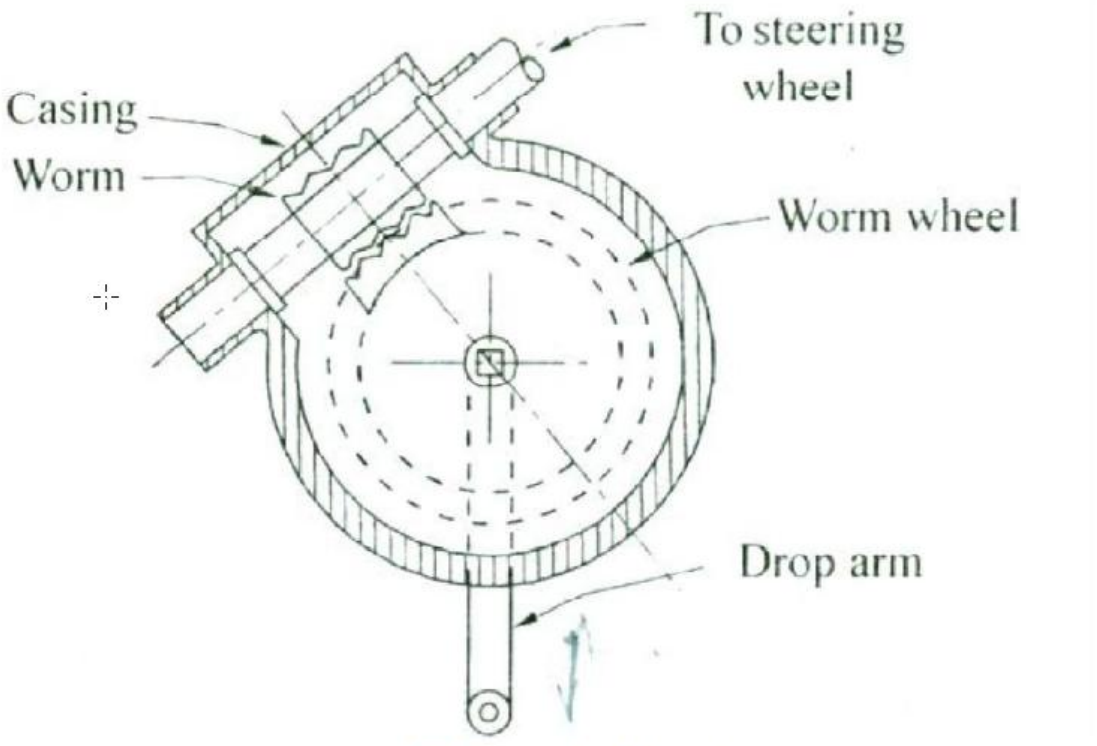


Fig. Worm and wheel steering gear.

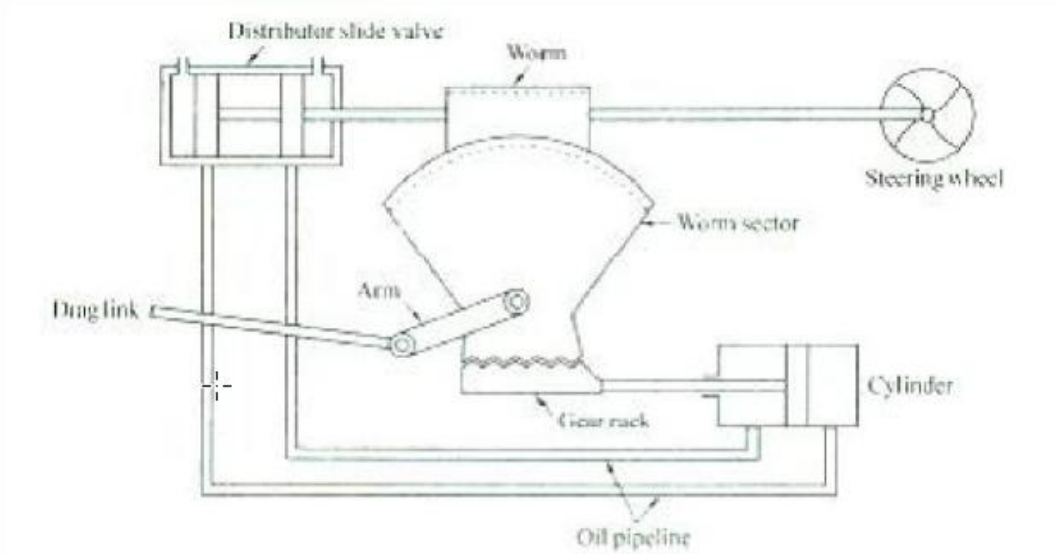


Fig. Oil assisted power steering

The main objectives of the suspension system are:

1. To prevent the road shocks from being transmitted to the vehicle parts, thereby providing suitable riding and cushioning effect to the occupants.
2. Reduces wear on the tyre.
3. To keep the vehicle stable while in motion by providing good road holding during driving, cornering and braking.
4. Provides safe vehicle control and free of irritating vibrations.

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6)

NORMAL COMBUSTION:

Under ideal conditions the common internal combustion engine burns the fuel/air mixture in the cylinder in an orderly and controlled fashion. The combustion is started by the spark plug some 10 to 40 crankshaft degrees prior to top dead center (TDC), depending on many factors including engine speed and load. This ignition advance allows time for the combustion process to develop peak pressure at the ideal time for maximum recovery of work from the expanding gases.

The spark across the spark plug's electrodes forms a small kernel of flame approximately the size of the spark plug gap. As it grows in size, its heat output increases, which allows it to grow at an accelerating rate, expanding rapidly through the combustion chamber. This growth is due to the travel of the flame front through the combustible fuel air mix itself, and due to turbulence which rapidly stretches the burning zone into a complex of fingers of burning gas

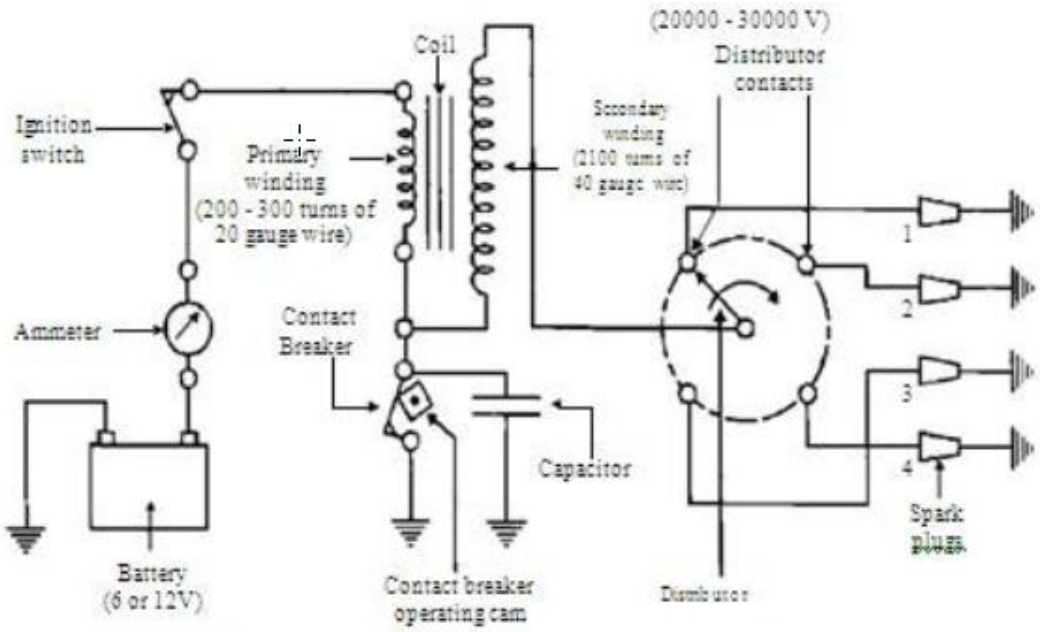

Figure 4.2 : Schematic Diagram of Coil/Battery Ignition System

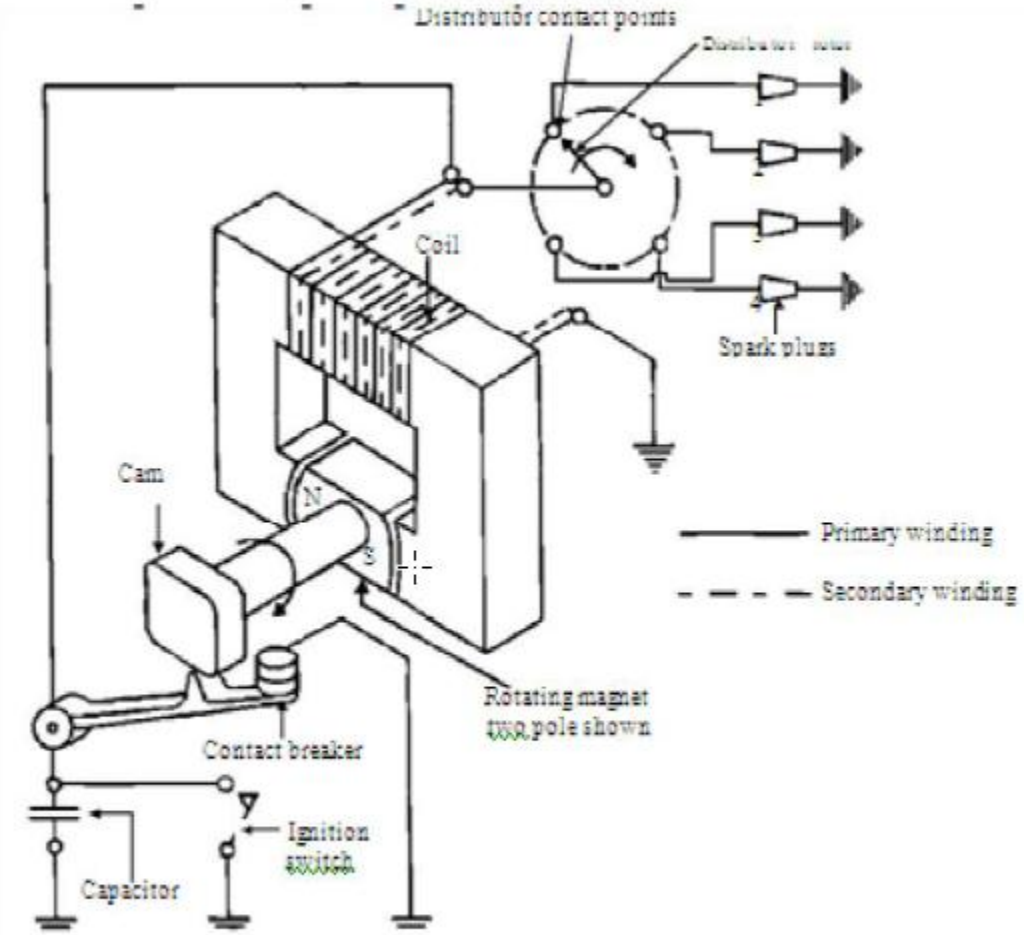

Figure 4.3 : Schematic Diagram of Magneto Ignition System

7.9 AIR SUSPENSION SYSTEM

Air or pneumatic suspension is incorporated in some tourist buses to improve the riding comfort of the passengers. The air suspension system posses the following advantages over conventional metal springs.

1. The spring rate varies much less between laden and un laden conditions This decreases dynamic loading
2. Changes in head lamp alignment due to change in load are avoided.
3. It improves riding comfort to the passengers.
4 .Longer service life of the vehicle due to improved smoothness of run

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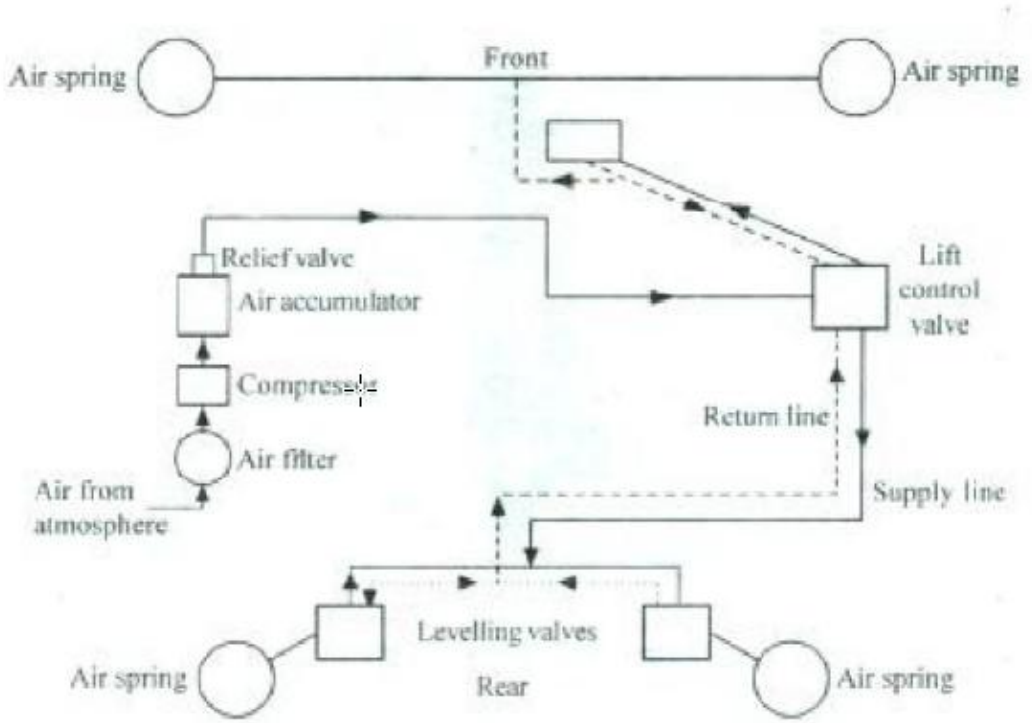

Layout of air suspension system

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7)

3.32 OBJECTIVES OF SUPER CHARGING

Mainly super charging is done to induct more amount of air into cylinder per unit time and hence to burn more amount of fuel to increase power output. Following are the objectives of supercharging

1.For a given weight and bulk of the engine, super-charging increases power output. This is important in air craft, marine and automotive engines where weight and space are considered

2.To obtain better performance from the existing engine

3.To compensate for loss of power due to high altitudes for air craft engines

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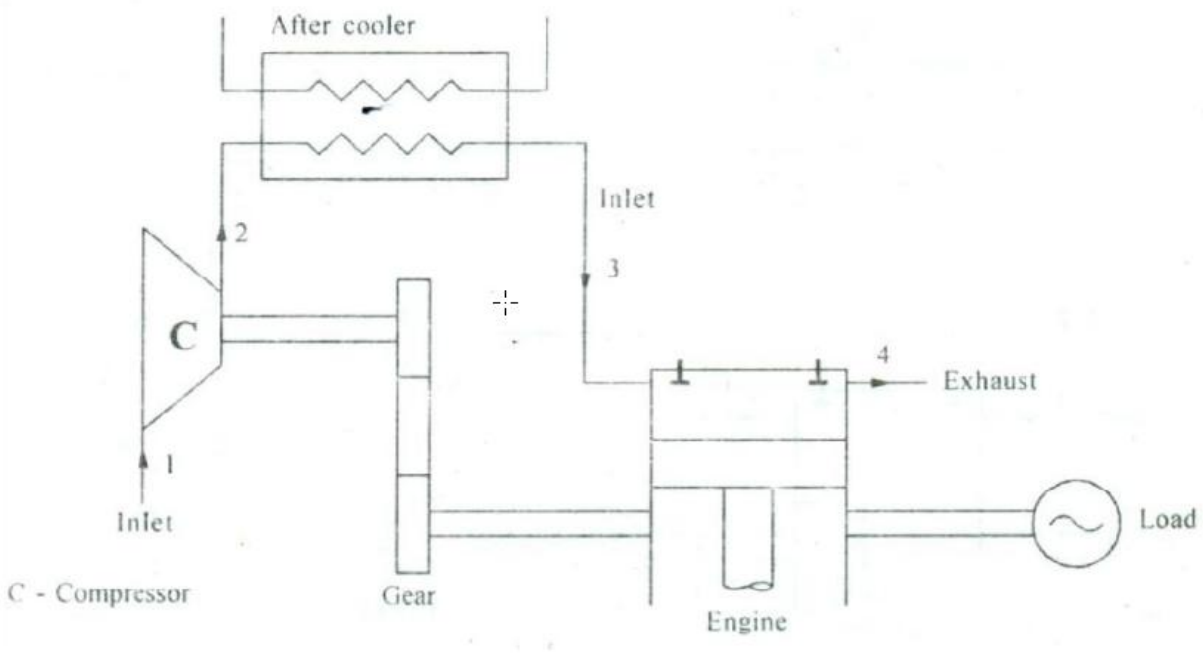

Fig. Supercharging of engine by compressor

engine.

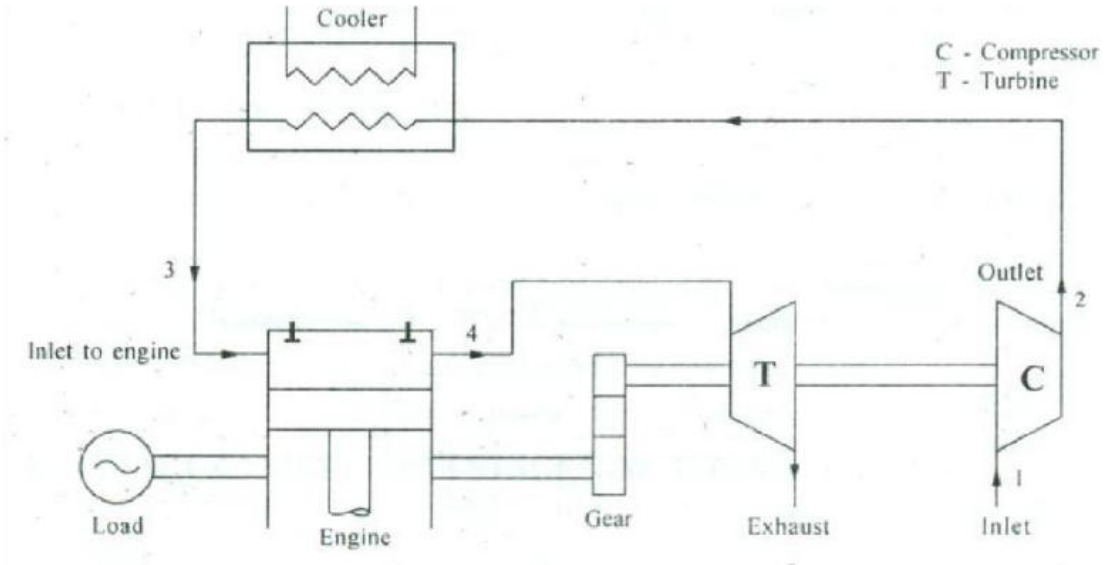

Fig. Super charging arrangement in which engine, turbine and compressor are coupled

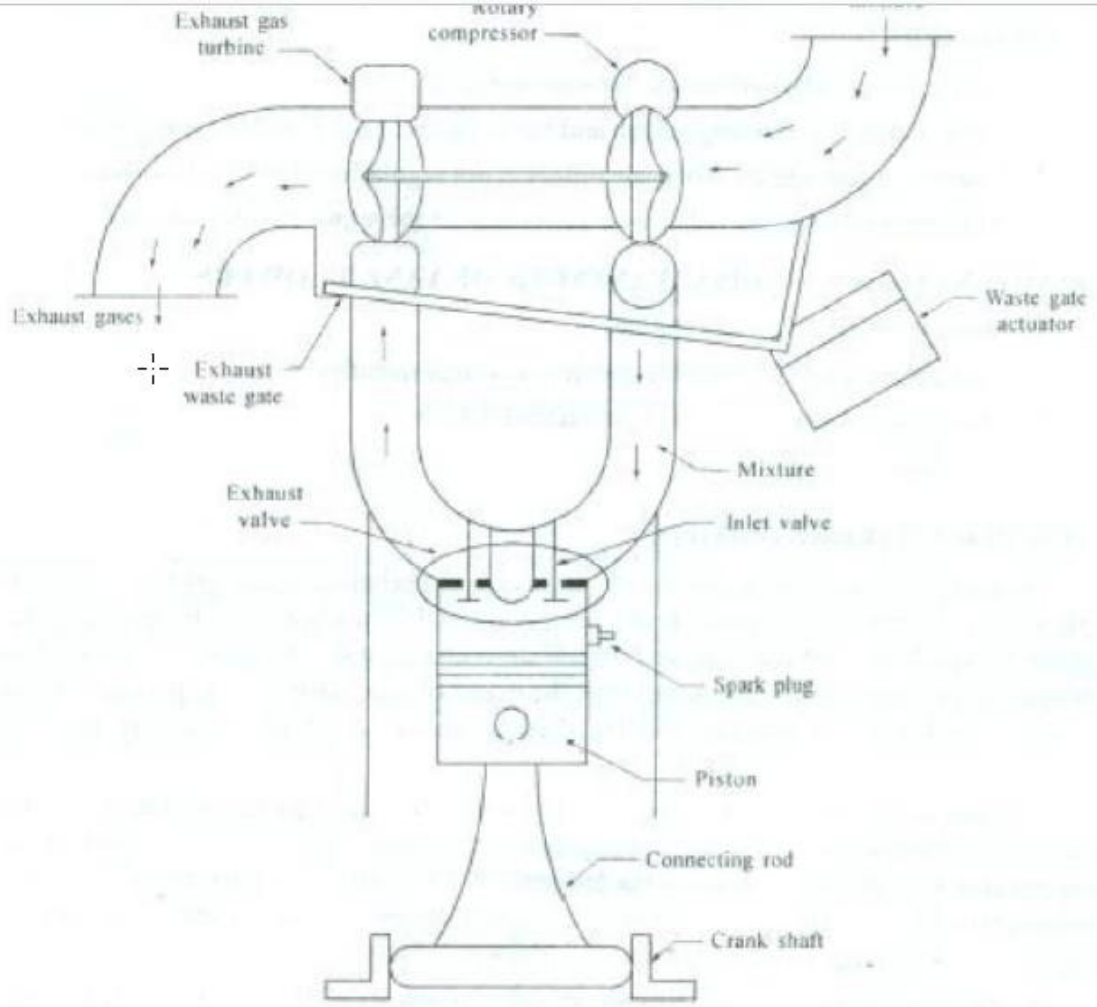

Fig. Exhaust turbo charging of a single cylinder engine

The exhaust gas enters the turbine inlet side of the turbocharger through a pressurized chamber and a series of filters. The nozzle blade rings concentrates the exhaust gas on to the turbine wheel. The movement of the turbine wheel rotates the shaft which in turn rotates the impellor of the compressor. A part of this air goes to the labyrinths seal from the outlet side of the turbine.

As the impeller rotates, air is sucked in through the center of the impeller and due to the heavy rotational movement, experiences circumferential velocity which pushes it outwards. A radial velocity is gained which pushes the air further outwards on to the inducer. An additional resultant velocity is gained due to the accurately designed inducer inlet angle which gives maximum compressor efficiency.

Excessive pressure leads to spoiling or fouling of the impeller and inducer surfaces. These results in change in angle of incidence and thus drop in efficiency.

Turbo Charging

1. The energy of exhaust gases is used to run super charger
2. It needs a waste gate control
3. It requires special exhaust manifolds
4. In CI engine it reduces smoke
5. Blade erosion takes place due to entry of dust particles
6. Larger pumping elements or nozzles are needed. This over loads cams
7. Pressure ratio is high
8. It is bulky and heavy
9. Easy scavenging
10. Poor response to load change

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8)

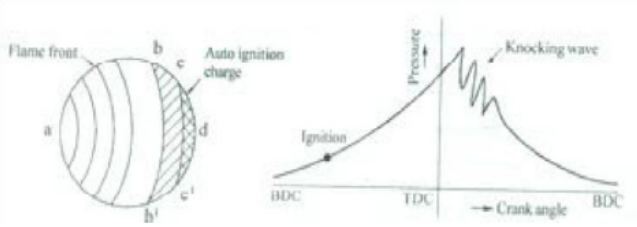

Fig.Combustion with Detonation

Detonation can be prevented by any or all of the following techniques:

- The use of a fuel with high octane rating, which increases the combustion temperature of the fuel and reduces the proclivity to detonate;
- Enriching the air–fuel ratio which alters the chemical reactions during combustion, reduces the combustion temperature and increases the margin above detonation;

2.5 CETANE AND OCTANE NUMBERS

Cetane numbers: In diesel engines cetane number is a measure of ignition lag. Cetane is straight chain paraffin assigned with a rating of 100 cetane numbers (CN) and it has good ignition quality. It is mixed with al ha-methylnaphthalene a hydrocarbon with poor ignition quality i.e., with zero cetane number. A CFR engine running under prescribed conditions test the fuel with this mixture. Thus the cetane number of the fuel is defined as the percent by volume of cetane in a mixture of cetane a I ha-methyl that produces same ignition lag as the fuel being tested, in the same engine and under the same operating conditions.

For a diesel fuel, cetane rating is a measure of its ability to auto ignite readily when it is injected in to the compressed air in the engine. The ignition delay is influenced by several engine design parameters such as compression ratio, injection rate, injection time inlet air temperature etc. The hydrocarbon composition of the fuel and its volatility characteristics also affects the ignition delay. The cetane rating of diesel fuels ranges from 40 to 60. The octane fuels (gasoline) have cetane numbers ranging from 10 to 20 showing their poor suitability as a

2.6 MIXTURE REQUIREMENTS FOR SI ENGINE

In stationary engines the desired air fuel ratio means that gives the maximum economy. Actual air fuel mixture requirements in an operating engine vary under variable speed and load conditions. The A/F ratios must change based on maximum over is required. Also required A/F ratio must be provided for transient conditions like, starting a warm-u and acceleration. In all these conditions, exhaust emission should be minimum.

In steady state operation (It means continuous operation at a given speed and over out with normal engine temperature) of automotive engines, there are three main areas which require' different air-fuel ratios. In each of these, the engine requirements differ. As a result the carburetor has to modify A/F. rati9 to satisfy these demands. These ranges are

1. Idling (mixture must be enriched)
2. Cruising (mixture must be leaned)
3. High Power (mixture must be enriched)

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9)

Catalytic converters have been instrumental in reducing emissions of harmful gases from vehicles since their inception in response to the US Clean Air Act of 1970. Regulated emissions

have been reduced approximately 1/3 while the number of cars on the road have more than doubled. Platinum, palladium and rhodium are essential components in automobile catalytic converters reducing engine-out emissions by well over 90%,and in some cases by ober 99%.

Table 9.6 Emission Standards for 3-Wheel Gasoline Vehicles, g/km

Year	CO	HC	HC+NO x
1991	12 - 30	8 - 12	
1996	6.75	-	5.40
2000	4.00	-	2.00
2005 (BSII)	2.25	-	2.00

Overview of the emission norms in India

I. 1991 - Idle 'CO' Limits for Gasoline Vehicles and Free Acceleration Smoke for Diesel Vehicles, Mass Emission Norms for Gasoline Vehicles.

2. 1992 - Mass Emission Norms for Diesel Vehicles.

8.6 CATALYTIC CONVERTER

The function of catalytic converter is to treat the exhaust gas to convert harmful pollutants into harmless. All exhaust gases must pass through catalytic converter which is located in exhaust system. The catalytic converter consists of a material called catalyst which causes a chemical change without entering into chemical reaction. It makes two chemicals to react with each other and hence reduces amount of HC, CO and NOx in the exhaust gases.

It consists o(two different catalysts, one to treat HC and CO and other to treat NOx' The first catalyst promotes HC to unite with °2 to produce Hp and CO2, The second catalyst promotes CO to react with 02 and hence to release CO2, As this converter oxidises HC and CO, it is known as oxidising converter. The platinum and palladium are listed as oxidising catalysts.

The catalyst used for NO, splits 02 and N2 and hence NOx becomes harmless N2 and 02' The converter is known as reducing converter and metal rhodium is used for this purpose. A large surface area of catalytic converter is coated with catalyst. The coated surface a area or substrate is in the form of a .bed of small beads or pellets or a ceramic honey comb.

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10)

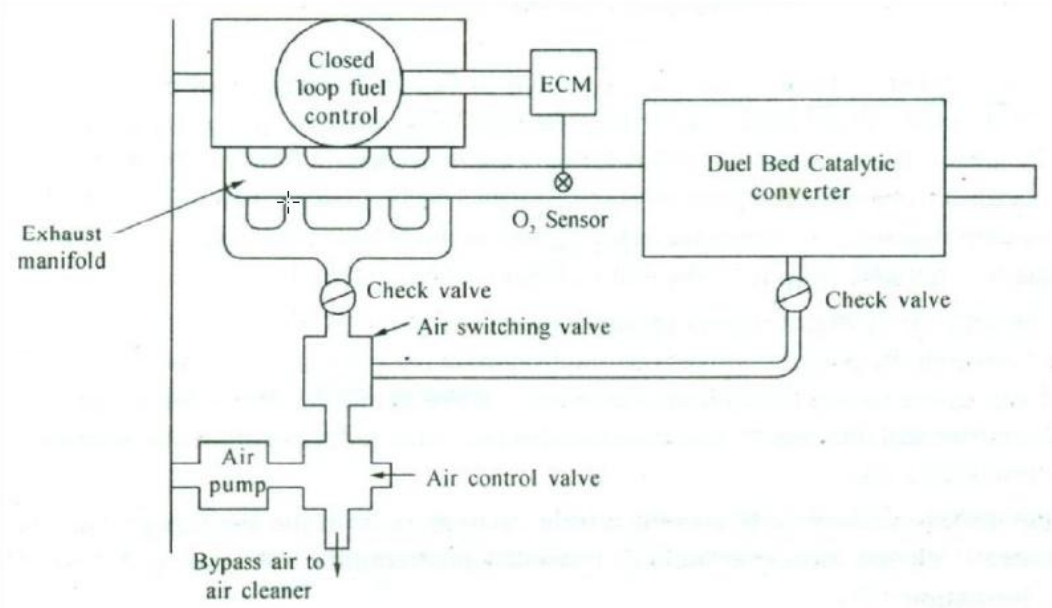

Fig. Air Injection System

The Air injection system consists of air pump, air switching and control valves and the one way check valves. When the engine is cold, the air pump pushes air through nozzles to the exhaust manifold. The nozzles are located opposite to exhaust ports and hence 02 in the air helps to burn any HC and CO in the exhaust gas in the exhaust manifold.

When the engine warms up, ECM causes the air to pass through catalytic converter, where HC and CO are converted into Hp and CO. The check valve avoids back flow of exhaust gases to the air pump incase of back fire. During deceleration, the bypass valve momentarily diverts air from air pump to the air cleaner, instead of to the exhaust manifold.

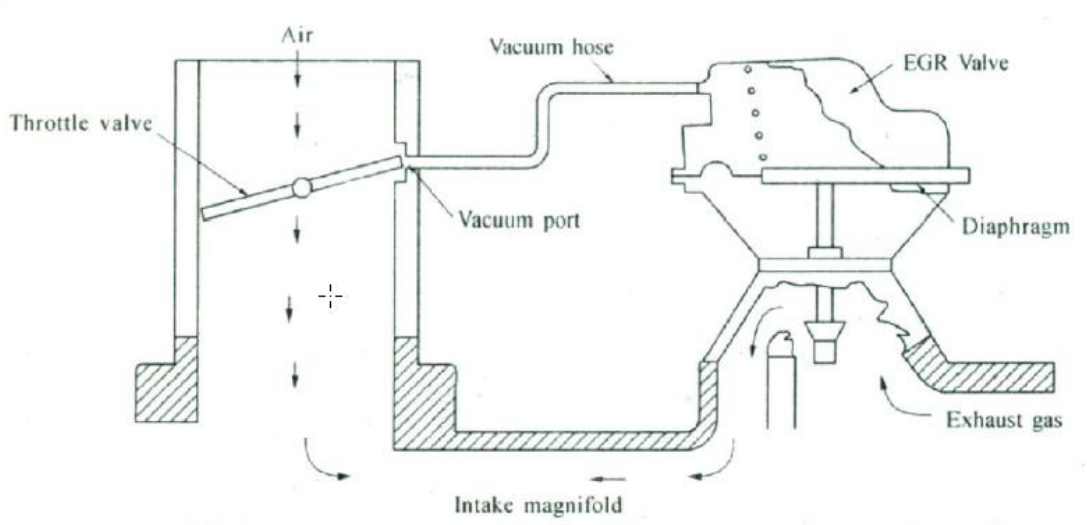

Fig. Schematic diagram of EGR system

8.44 Exhaust gas recirculation

The higher combustion temperature (more than I 927°C) results in the formation of more Nitrogen Oxides. The exhaust gas recirculation of EGR system is used to lower the combustion temperature and hence to reduce NO emissions in the exhaust gas. A small metered quantity (6 to 13%) of inert exhaust gas is sent back in to the intake manifold to reduce combustion temperature and formation of NOx' The exhaust gas is relatively at low

temperature and absorbs heat from the much hotter combustion process. there by reduces combustion temperature and hence formation of O.

The simplest form of EGR system is as shown in figure. It consists of a passage which connects exhaust manifold and intake manifold. The EGR valve opens and closes the passage and it consists of a spring loaded diaphragm that forms a vacuum chamber at the top of the valve. A tube connects vacuum chamber and vacuum port in the throttle body as shown in figure. In absence of vacuum, the diaphragm moves down due to spring action, thus closes the passage. In this situation, no exhaust gas re-circulates, engine is idle and formation of NO x is minimum.

When the throttle opens, it moves past the vacuum port. This allows the intake manifold vacuum to act through the port and moves the diaphragm up to open the valve. As the valve raises up, some exhaust gases passes through the valve in to intake manifold. The exhaust gases mixes with air-fuel mixture and then enters into engine cylinders. This reduces combustion temperature and hence formation of NOx.

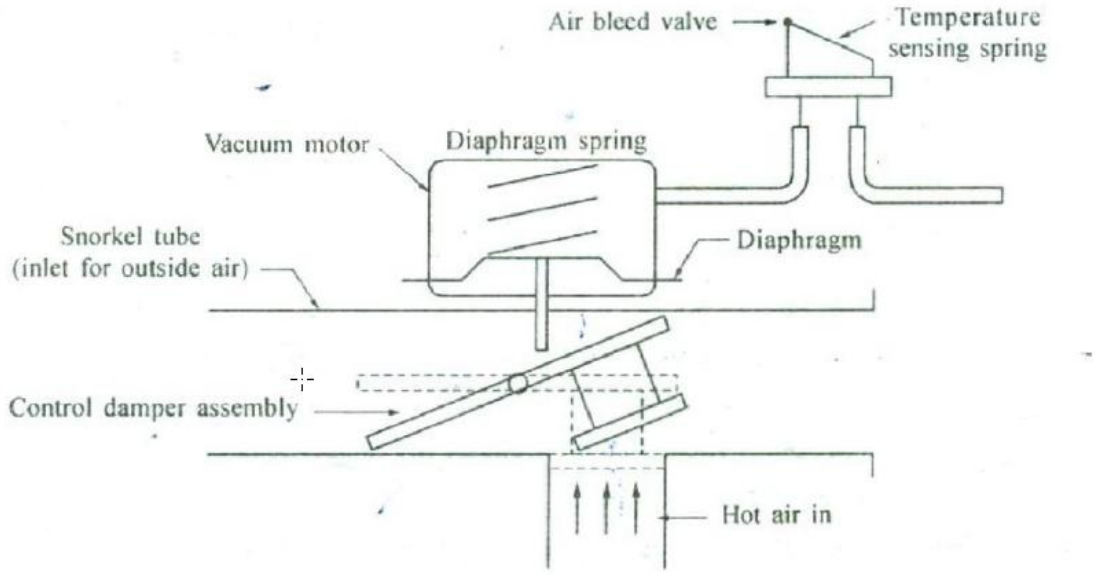

Fig. Thermostatic air cleaner

Faster engine warm up and quicker choke open in reases exhaust emissions during warmu. If the carburettor [fuel supply system] supplies cold air-fuel mixture, only a part of fuel will vaporise. This makes the air-fuel mixture lean and extra rich mixture is required. Therefore, when the engine is cold, a thermostatically controlled air cleaner is used to supply heated air quickly to the carburettor .During cold running, air entering carburettor is heated up by thermostatic air cleaner, which allows engine to run on a leaner air-fuel mixture during warm up.

The thermostatic air cleaner consists of a temperature sensing spring which senses temperature of air entering the air cleaner. The air bleed when air is cold and this applies in take manifold vacuum to the vacuum motor. The diaphragm and hence to control am per assembly moves up due to atmospheric pressure and thus blocks the snorkel tube. This allows all the air to enter through the hot air pipe which is laid near to the exhaust manifold. When the engine starts, the exhaust manifold heats up quickly, and hence allows heated air to enter into the air cleaner. This heated air helps to vaporise the fuel delivered by carburettor or fuel injectors, which in turn improves cold engine performance

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Overview of the emission norms in India

I. 1991 - Idle 'CO' Limits for Gasoline Vehicles and Free Acceleration Smoke for Diesel Vehicles, Mass Emission Norms for Gasoline Vehicles.

2. 1992 - Mass Emission Norms for Diesel Vehicles.

3. 1996 - Revision of Mass Emission Norms for Gasoline and Diesel Vehicles, mandatory fitment of Catalytic Converter for Cars in Metros on Unleaded Gasoline.

4. 1998 - Cold Start Norms Introduced.

5. 2000 - India 2000 (Eq. to Euro I) Norms, Modified IDC (Indian Driving Cycle), Bharat Stage II Norms for Delhi.

6. 200 I - Bharat Stage II (Eq. to Euro II) Norms for all Metros, Emission Norms for CNG & LGP Vehicles.
