UNIT-I VEHICLE STRUCTURE AND ENGINES

1.1 INTRODUCTION

The Petrol or Diesel engine is the source of power for Automobiles. Such engines are Internal Combustion or Heat Engines, the function of which is to convert heat energy available in the fuel into mechanical work.

An automobile is a self propelled vehicle. In other words, an automobile is one which can move by itself. As the name implies, it is a mobile or a moving power unit on road. Self-propelled means a unit which contains its own power source, necessary for moving ,within itself. As a vehicle, it is used for transportation of passengers and goods.

Thus, an automobile is a self propelled vehicle which contains the power source for its propulsion and it is used for carrying passengers and goods on the ground. Bus, Car, Truck, Motorcycle, Scooter, etc., are good examples for self propelled vehicles.

1.2. VEHICLE CLASSIFICATION

1.2.1 The automobiles can be classified according to the following

1. Number of wheels and number of axles.
2. Type of power plants (prime movers) used.

3. Load carrying capacity and their weights.
4. Purpose served.
5. Fuel used.
6. Drive system used.
7. Capacity of the engine.

(1) On the basis of the number of wheels

1. Two-wheelers such as Mopeds, Scooties, Scooters, and Motorcycles.
2. Three-wheelers such as tempos, road rollers, tractors.
3. Four-wheelers such as Cars, jeeps, minibuses, trucks, tractors, buses and ra cars.
4. Five-wheelers such as road rollers.
5. Six-wheelers such as truck-tankers, good carriage vehicles.
6. Eight or more-wheelers such as a Car transporting vehicles, rocket transpo

(2) On the basis of the prime mover used

1. Steam engine driven auto vehicles.
2. I. C engine driven auto vehicles.
   a) Petrol vehicles b) Diesel vehicles c) Gas vehicles
3. Gas turbine driven auto vehicles.
4. Wankel engine driven auto vehicles.
5. Electric power driven auto vehicles.
6. Battery (Chemical power) driven auto vehicles.
7. Solar energy driven auto vehicles.
8. Hybrid powered auto vehicles.

(3) On the basis of the weight of the vehicle and its payload ca|

1. Light weight or light duty vehicles.
2. Medium weight or medium duty vehicles.
3. Heavy weight or heavy duty vehicles.
4. Extra heavy duty vehicles.
5. Special purpose (load) vehicles.

(4) On the basis of the purpose served

1. On-the-road vehicles - Scooters, Cars, trucks, etc.,
2. Off-the-road vehicles - Tractors, Construction equipment, e
3. On and Off-the-road vehicles- Military tanks, Gun carriage:

(5) On the basis of the fuel used

1. Petrol vehicles such as Maruti Omni, Matiz, Felicia, Santro,
2. Diesel vehicles such as Mercedes-Benz E250D, Ambassador Diesel.
3. Dual Fuel (Petrol and Diesel) vehicles such as Fargo, Dodg
4. Gas vehicles such as CNG (Compressed Natural Gas) Volv
5. Hydrogen vehicles such as Musashi III Car.

(6) On the basis of type of the wheel drive system

1. Single Wheel drive (1 Wd)
2. Two Wheel drive (2 Wd)
3. Four Wheel drive (4 Wd)
4. All Wheel drive (6 Wd or more)

Left hand drive and Right hand drive vehicles

Whether a vehicle is front wheel drive or rear wheel drive; has 2 wd or 4 wd; it is controlled by the driver through a steering wheel. The steering wheel may be located either on the left or on the right side of a vehicle. Depending upon its position, the autovehicle is known as left hand drive vehicle or right hand drive vehicle.

(7) On the basis of the engine capacity

The Capacity of an engine is expressed by its swept volume which is given as

$$V_s = \pi D^2 L/4$$

Table : Engine capacity of some autovehicles

ENGINE CAPACITY (CC)	VEHICLE
47.5 (50)	Escort 'Toro Jazz', ' Roza '
60	Kinetic Safari V2, Bajaj Signets
70	TVS Sport
75	Hero Winner, Pearl Yamaha, LML Zip
93	Kinetic K-4
150	Bajaj, Lambretta
796	Maruti Omni
1200	Premier Padmini
1366	Premier Diesel
1489	HM Trekker
2982	Toyota Land Cruiser

1.3 VEHICLE CONSTRUCTION

The Automobile consists of two main assemblies

1. Chassis
2. Body (Superstructure)

The Chassis is a combination of various components which enable the vehicle t on the road. A body mounted on the chassis is a box or lid to cover the vehicle. general construction, the Chassis comprises of the following main details.

- Basic structure
- Power Unit
- Transmission Unit
- Accessories Unit
- Electrical Systems
- Control and Instruments
- Body (or Superstructure)

1.4 CHASSIS

An Automobile is made up of mainly two units - The body and the Chas

A vehicle arrangement without body is called chassis. The various compo and systems of the chassis are the power unit, power train and the running sy:

The power unit contains only the engine; transmission includes clutch, prop shaft with universal joints, differential and the rear axle shafts; Running sys consist of brakes, wheels, tyres, frame, suspension and the steering system.

The layout of a conventional chassis with various components mounted o shown in figure 1.1.

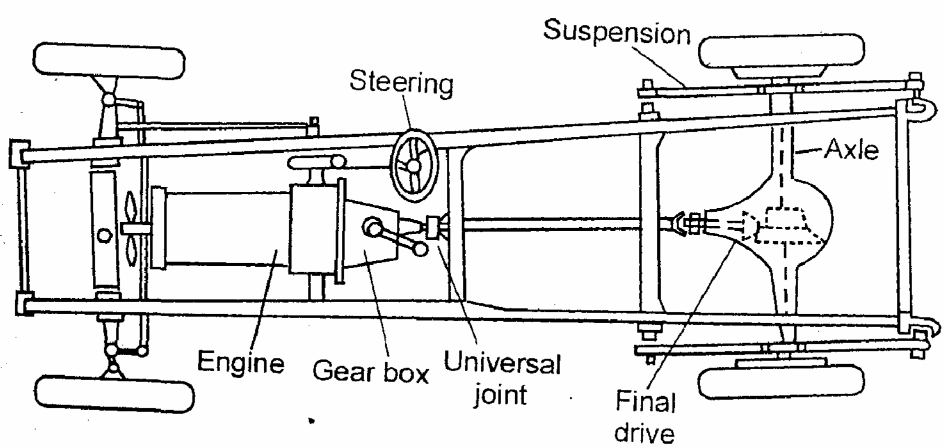


Figure 1.1 Chassis layout

Cross bracings are provided in the chassis to withstand the shock, blows, twists and vibrations. As per the layout, the engine is mounted on the front part of the frame. Rubber cushioned mounts or pads are used to support the engine on the frame. The clutch is placed, next to the engine, connected to the flywheel; Transmission or the gear box is positioned or attached to the clutch shaft. Then a propeller shaft is laid to connect the gear box on one end and the final drive on the other end. These are enclosed in a housing, bolted to the rear axle spring, which is connected to the frame through springs. The entire arrangement mounted and bolted on the chassis frame is supported by the front and rear suspension systems. This is positioned over front and rear wheel and tyre assemblies, to avoid or minimise the transmission of shock to the frame.

The Chassis includes the following components

1. Frame
2. Front suspension
3. Steering mechanism
4. Radiator
5. Engine, Clutch, Gear box
6. Propeller Shaft
7. Rear springs
8. Road wheels
9. Differential, half shaft, Universal joints
10. Brakes and Braking system,
11. Storage battery
12. Silencer
13. Shock absorbers, fuel tank, Petrol and hydraulic pipe cables and some means of mounting these components.

1.5 FRAME

The word frame is used to denote the main skeleton of the vehicle. In automobile construction, chassis frame forms the basic requirement. It serves as the main foundation and base for alignment for the chassis. The front end of the frame carries the engine and the rear end carries rear axle housing, the wheels and tyres. The other components on the frame are steering system, fuel tank, battery, brake, shock absorber etc.

The frame is provided with cross rods to increase the rigidity, withstand shocks and vibration.

by a frame, which is supported on the wheel axis by the leaf springs. Normally used cross sections are channel section, Tubular or Box section. Channel section is good for bending; Tubular section resists torsion and Box section serves as good resistance to bending and torsion. The construction of chassis must maintain the working assemblies in their correct positions and also provide easy mounting of the body.

The frame is closer at the front to provide adequate steering lock and unswept at the rear to provide clear space for the movement of the axle. Due to springing action it also makes the chassis height low.

2. Integral or frameless type

The body structure is fabricated to carry out the functions of the body and frame. The units that are attached to the body are also riveted directly to the frame. Frame-less construction has the advantage of reduced weight, less manufacturing cost, absorbing shock during accident.

Back bone frame

(a) (b)

Figure 1.2 Back bone frame

A central longitudinal steel tube is called back bone. The Cross Section of the frame is shown in the figure 1.2. The section shown in (a) uses single arm parallel type of suspension. The engine gear box unit is accommodated at the forked front end of the frame and the driving shaft is made to pass through the inside of the central tubular portion of the frame. The dotted line indicates some brackets used to support the body. The frame shown in (b) is slightly different. In that, the cross section is built up of two channel sections, which are pressed and welded together. This type of frame has been used in independent suspension.

Frame members

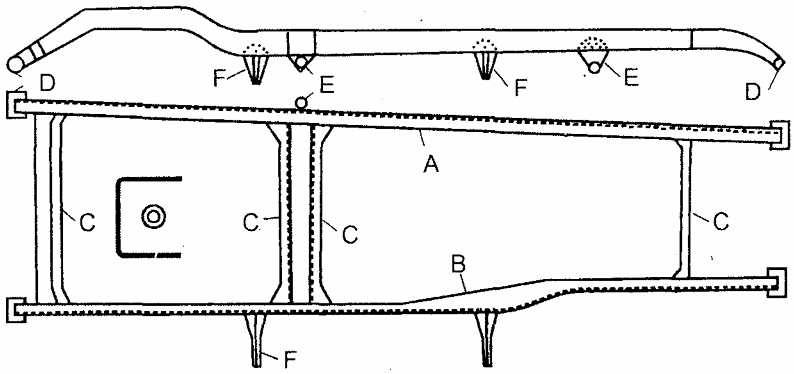


Figure 1.3 Chassis frame - conventional

The construction of the frame is shown in figure 1.3. This consists c longitudinal or side members A and B, generally made in the form of pressin channel section. These are generally arranged to be closer at the front. Th members are brazed by a number of cross members - C.

Dump irons - D are provided at the front and rear ends. Brackets 'E' are as shown, to which springs are connected and brackets are provided to support the ru boards. Some more brackets F supporting the engine, gear box, brakes, shafts etc provided at the required places. The frames are stiffened with cross pressing for indepe suspension and are stiffer at the front end.

X - type frame

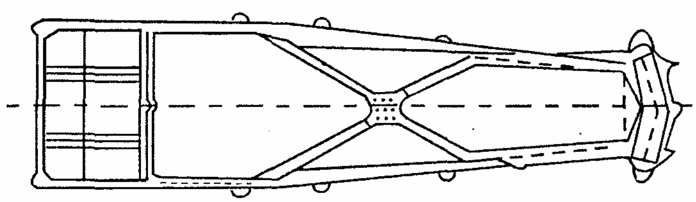


Figure 1.4 X-type frame

Some of the chassis frames are cross members which crosses in the fo X - fork as shown in figure 1.4. The side members and cross members are rigidly att to each other by riveting or welding. Heavy side members are eliminated and cross me are connected with the floor of the body. 'X' member may be of channel or box se This imparts torsional rigidity to the frame.

Integral or frameless or chassis less type

This is sometimes known as unitary monocoque or integral construction. This arrangement provides stiff and light construction and heavy side members eliminated. The floor is strengthened by cross members. In this type of arrangement there is no separate frame, all the components are attached to the body. In this arrangement, assembly procedure is quick and easier. Moreover, the body is light and strong.

The structure contains an under frame with side members and cross members which are welded together as a single assembly. The pressed steel body is attached to the under frame by welding and riveting. A sub-frame can be attached to the body frame in the front of the body shell, to carry the engine on the front suspension. Grooves are pressed in the steel floor and side pannels to provide increased stiffness to the floor. This construction is shown in the figure1.5. Throughout the structure, the stresses are evenly distributed. Good torsional rigidity and resistance to bending are provided by this welded structure and reinforcement with thicker material is provided at some points where certain components are to be attached. In certain cases, rubber insulations are used in the sub frame to mount the engine and suspension members.

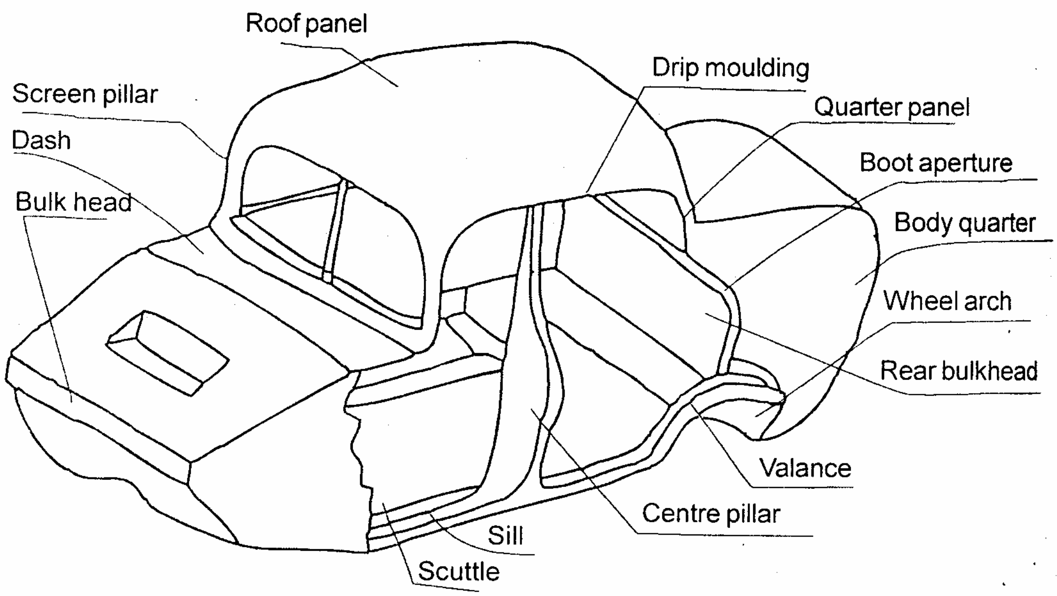


Figure 1.5 Car body

Sub-Frame

Mostly different components of the motor vehicle are bolted directly either on the main frame or on the cross members of the frame. But the engine and the gear box are sometimes supported on additional frames called Sub-frames. These are simple in construction, and mounted on rubber blocks. The Sub-frame supports the main frame at three points. This is to isolate the components from twisting and flexing effects, and thereby to protect the body from engine vibrations. Sub-frames are used in vehicles, employing independent rear suspension.

Some of the advantages of sub-frames are

1. Helps to dampen vibrations.

2. Simplifies production while assembling and facilitates repair, service and overhaul.

1.6 BODY

Body is the superstructure of the vehicle. This is bolted to the chassis. A complete vehicle is referred to the combination of Chassis and Body. Body is merely a cover to the Chassis. The body may be shaped according to the needs and convenience. The body of the motor vehicle must fulfill the following requirements.

1. Sufficient space to accommodate passengers and luggage.
2. Suitable shape to reduce air resistance
3. It should be light and strong enough to resist bending, torsion and impact stresses.
4. It should have continuous access to the engine and suspension system.
5. The load should be distributed evenly.
6. The mounting of the body should have minimum vibrations.
7. It should be cheap and simple in manufacture.
8. The design of the panels should be suitable for mass production and changes in style and design.
9. It should be made of sheet metal of sufficient thickness for adequate safety during collision.
10. It should provide clear vision and be of aesthetic in shape.

:NGINE TYPES

Internal combustion engines can be classified on any one of the followin
:

a) Type of fuel used:

1. Petrol or Gasoline engine
2. Diesel engine
3. Gas engine

b) Cycle of Operation:

1. Otto cycle engine
2. Diesel cycle engine
3. Dual combustion cycle or semi-diesel engine

c) Type of Ignition used:

1. Spark ignition engine
2. Hot-spot ignition engine
3. Compression ignition engine

d) Method of fuel admission:

1. Carburettor engine (Petrol)
2. Air injection engine (Diesel)
3. Airless or solid injection engine (Diesel)

e) Number of strokes per cycle:

1. Four stroke engine
2. Two stroke engine

f) Arrangement of cylinders:

1. Vertical engine
2. Horizontal engine
3. Radial engine
4. V-engine
5. Opposed cylinder engine

g) Valve location:

1. Overhead valve engine
2. Side valve engine

h) Type of cooling engine:

1. Air cooled engine
2. Water cooled engine.

i) Lubrication Systems:

1. Wet sump
2. Dry sump
3. Pressurised

j) Speed:

1. Slow speed engine
2. High speed engine
3. Medium speed engine

k) Method of Governing:

1. Hit and miss governed engine
2. Qualitatively governed engine
3. Quantitatively governed engine

l) Application:

1. Stationary engine
2. Automotive engine
3. Marine engine
4. Locomotive engine

One of the classifications of Internal combustion engines is by cylinder arrangement, Normally there are four methods by which engine cylinders may be arranged. 1. Inline 2. Vee Type 3. Opposed Cylinders 4. Radial.

1. Inline

As shown in figure 1.7 the cylinders are arranged side by side in one row. Th cylinder nearest to the radiator is called cylinder number 1.

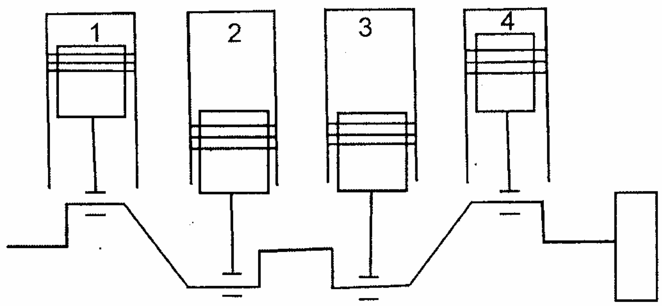


Figure 1.7 In-line

2. Vee type

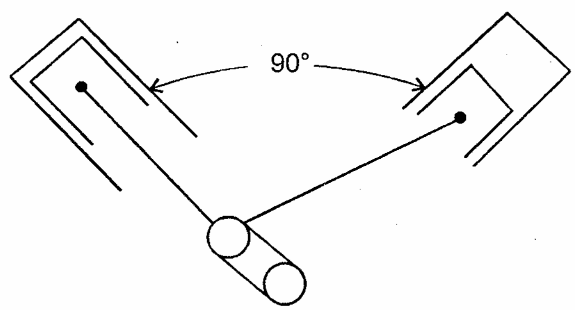
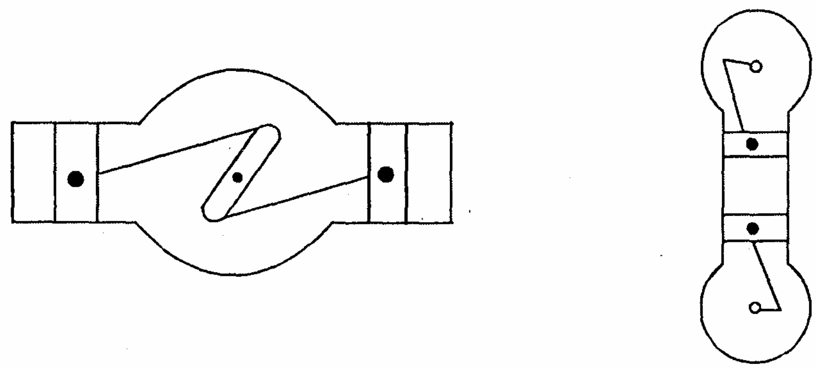


Figure 1.8 Vee type

This type is very compact in construction and has a common crankcase. In thi arrangement, the axes of the cylinders are inclined to one another usually at 60°. Whil comparing with the Inline Engine, Vee Type engines are shorter. The short crank Shaft i of good rigidity and operated smoothly with high engine speed. A Vee-Six engine has tw rows of three cylinders arranged with radial angle of 60°.

3. Opposed cylinders

This method is suitable for installation at the rear of the Automobile. As shown i figure 1.9, the cylinders are arranged in opposite direction with the common crank sha and with pins at 180 degrees apart. This arrangement may have cylinders with horizont or vertical axis. In the case of opposed pistons type, a single cylinder houses two pistons with a separate crank shaft. Since the connecting rod movements are identical, it provides a good mechanical balance, but as the crank pins are not in the same line, they produce a rocking couple. This couple produced in either of the directions may tend to swivel the engine horizontally. More over the main disadvantage of this engine is its longer length and has to be placed in transverse direction. The vehicle is normally aircooled.



(a) **(b)**

Figure 1.9 Opposed cylinders

4. Radial engines

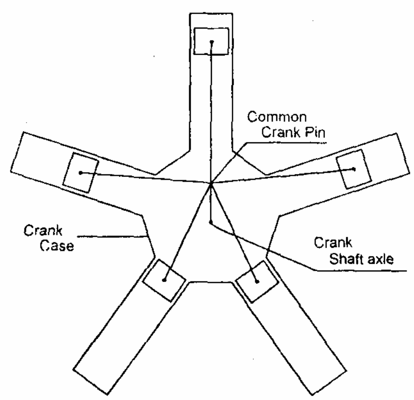


Figure 1.10 Radial engines

This arrangement is shown in figure 1.10 which consists of a single common crank shaft in odd number of cylinders. A single crank pin is employed for all the connecting rods. Because of the Odd number of cylinders, uniform firing is obtained advantageously. Five cylinders are generally used for automobile purposes and seven or nine for Air Craft. They are simple, compact and provide high horse power. These engines are of air cooled type. But they create difficulty in stream line design of the vehicle.

Classification by valve arrangement

Automobile engines are classified mainly into four categories with respect to th arrangement of valves. This arrangement is known as L.I.F and T types. The constructio of the cylinder with respect to valves is shown in figure 1.11.

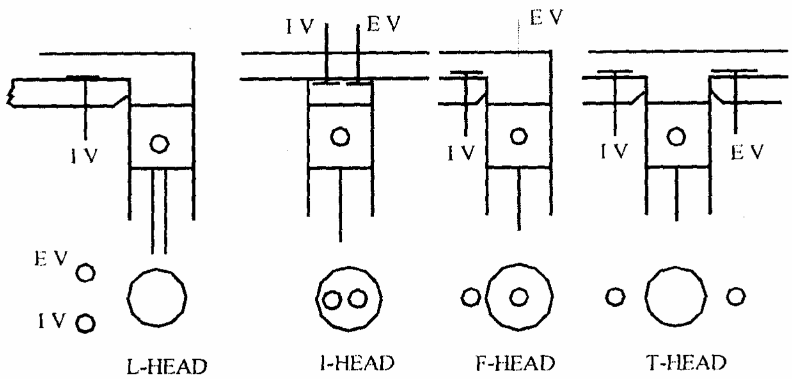


Figure 1.11 Classification - Valve arrangement

'L' Head Engine

In this arrangement, both valves are located by the side and operated by a singl camshaft. The Combustion Chamber and Cylinder form an inverted 'L'.

'I' Head Engine

This arrangement is usually called 'over head valve engine'. In this case the valv are located in the cylinder head. The valves are normally arranged in a single row. A sing camshaft operates both the valves.

'F' Head Engine

This is a combination of L and I engines. Inlet valve is in the head and exhaust val in the cylinder, both valves are operated by the same camshaft.

'T' Head Engine

In this case, the arrangement of the valve and cylinder resembles letter 'T'. valves are placed on either side of the cylinder. Separate cam shafts are required to ope them.

1.7.1 Special types of automobile engines

1. Square Engine
2. Wankel Engine
3. Automotive Gas turbine
4. Electric car
5. Hybrid car.

Square Engine

In this type of engine, the length of stroke is equal to the cylinder diameter. In the normal engines the Stroke/ Bore ratio is more than one. In square engines the piston speeds are lower than that of the corresponding engines of large strokes. The square engines develop more power with lesser fuel consumption than the larger stroke engines.

1.7.2 Wankel engine

This engine works on Otto-cycle. But this have a rotary piston of triangular shape. This has been developed on the basis of the design of FELIX WANKEL of N.S.U, Germany for commercial purposes. The figure 1.12 shows a simplified construction of Wankel Engine.

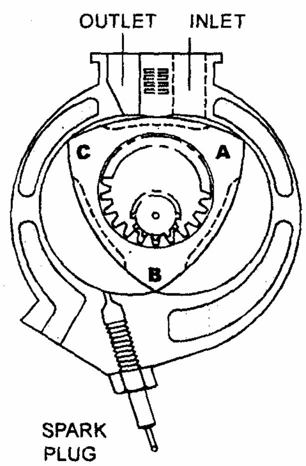


Figure 1.12

This consists of a Epi-trochoidal housing. A three lobe rotor rotates in this housing. The design and construction is in such a way that the tips of the rotor always remain in contact with the casing so as to maintain three different chambers. Inlet and outlet ports are provided as shown in the figure. The housing is surrounded by water- cooling system. The rotor is having internal teeth and rotates in meshing with the pinion in an epi-cyclic manner.

Operation

The sequence of operation are similar to that of the reciprocating I.C engine. It take place in three different chambers which is continuously varying by the rotation of the lobe The various positions are shown in the figure 1.13.

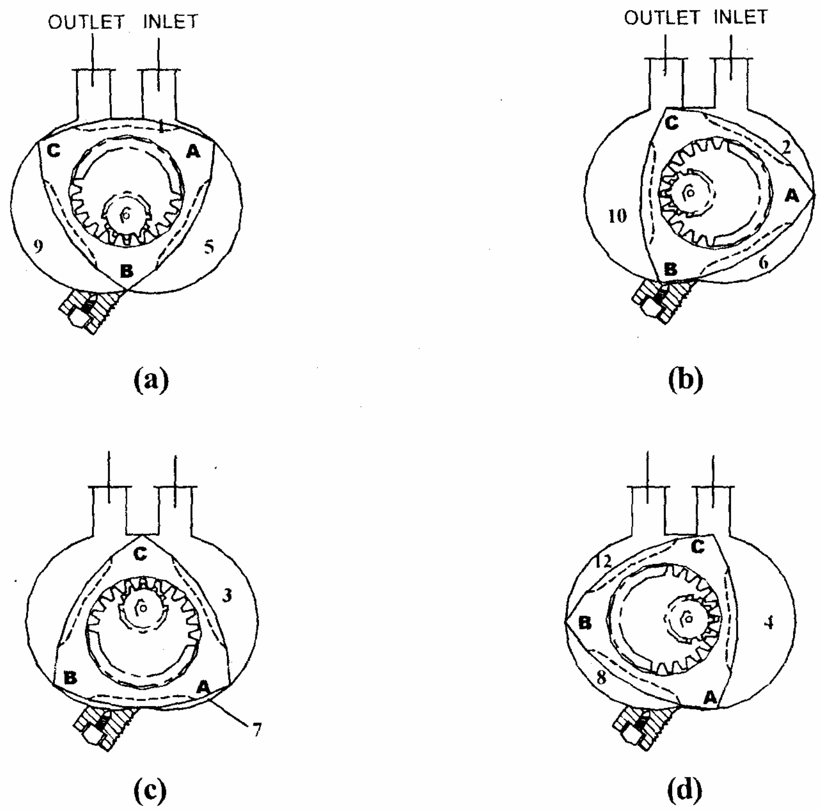


Figure 1.13

In figure 1.13(a) Induction process takes place which is supposed to be complete in Stage - 4 as in figure 1.13(d) Now, let us consider the side AB in figure 1.13(a); th compression process starts and it gets completed through the Stages 5, 6 and 7.

Now, when the side AB forms the chamber as in figure 1.13(d) a spark plug ignit and start the expansion process which proceeds, through the stages 9 and 10 as shown figure 1.13 (a) and (b). Now consider the side BC again in figure 1.13 (and (d). In stages 11 and 12, the exhaust process is being followed. Thus the cycle ge repeated. So one cycle of operation is completed in one revolution of the rotor. It is to l noted that when a particular side of the lobe is followed for the sequence of operations, the other two sides different sequence of operations are followed and similar process also takes place at the same time. Thus one full revolution completes three Otto-cycles. Therefore it leads to a compact size of the Wankel engine.

Advantages of wankel engine

1. For a given power output, Wankel engine is smaller in size and weight.
2. Volumetric efficiency is higher.
3. The balancing is easier as there are no reciprocating parts.
4. The construction is simpler with lesser number of working parts.
5. It can operate on low octane petrol with lesser NOx emissions.
6. With advanced materials Wankel engine is cheaper than I.C. engines.
7. It is cheaper in construction for mass production.

Disadvantages

1. Lesser torque at lower speed.
2. High specific fuel consumption.
3. Possibility of chamber distortion.
4. Lower braking effect.
5. Because of ignition troubles spark plugs are to be changed frequently.
6. Higher speed range leads to critical design of transmission system.
7. Chamber sealing problem is a difficult one.
8. It emits exhaust at very high temperature.

1.8 ENGINE CONSTRUCTIONS

Construction of an automobile engine

The main components of an Automobile Engine are: -

Cylinder block, Cylinder head, Cylinder liner, Piston, Piston rings, Crank Shaft Cam Shaft, Timing gears, Side valves, Overhead, valves and over head cam shaf mechanism.

Cylinder

A cylinder in an Internal Combustion Engine is the main part in which combustion takes place. The cylinder has to withstand high temperatures and high pressures.

Cylinder block

This is the main block of the engine. This contains the cylinder and provides housing for the crank, crank shaft and other engine parts. This is the basic frame for the engine, the other parts are fitted on it.

This block contains

1) Smooth cylinders
2) Ports or openings for valves and
3) Passages for cooling water.

Cylinder head

This is the top most part of the engine which covers the cylinder. It is bolted with cylinder block at the top.

Sandwich Gaskets made of soft copper and asbestos sheet are used so that a gas tight joint is formed. These joints will withstand high pressure and heat developed in the combustion chambers. This is usually cast as a single piece as shown in figure 1.14.

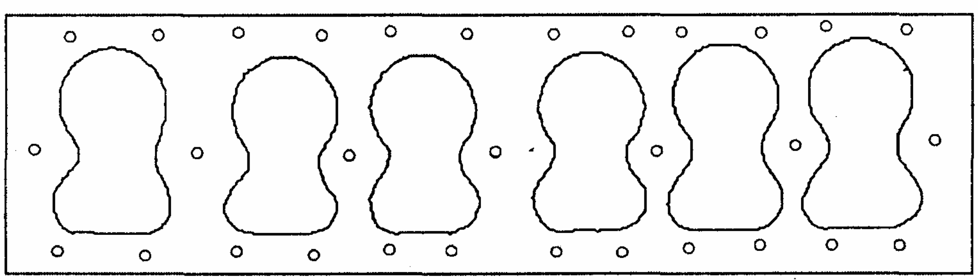


Figure 1.14 Gasket

The cylinder head provides cavities for valves, injectors or spark plugs, combustion chamber and bolt holes for the inlet and exhaust manifolds attached to it, with provision for flow of water.

Cylinder liner

The cylinder may wear out after frequent use. Hence the cylinders have to be replaced, but this is very costly. Therefore, instead of replacing the complete cylinder, it is better to fit a parallel sleeve in the block (just like a bush) This sleeve is known as cylinder liner (refer to the figures - 1.15).

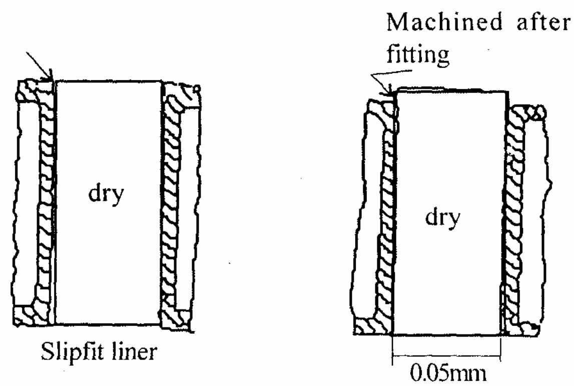


Figure 1.15 (a) Dry liner

These liners provide suitable wear resisting surfaces within the cylinders.

These are manufactured by centrifugal casting method.

Cylinder liners are of two types,

1) Dry liner. 2) Wet liner.

Dry liner

The dry liner is directly inserted in to the cylinder block. Cooling water is not in contact with the dry liner. This type of liner is machined very accurately and pressed into the cylinder block. The outer surface of the liner rests against the cylinder block.

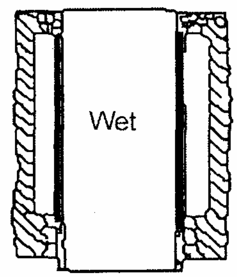


Figure 1.15 (b) Wet liner

Wet liner

In this case, cooling water is in direct contact with the outer surface of the liner. this type, the liner is machined only on the inside and the outer surface is in contact w water. There is a flange at the top of the liner acting as a shoulder by which it is fixed i the groove made in the cylinder block. At the bottom, synthetic rubber sealing rings provided around the liner to prevent water leakage.

These types of liners are generally used in diesel engines. If the size of the piston a bore clearance exceed the standard limit both the liner and piston are to be replac simultaneously. In case the cylinder bore exceeds the maximum size limit, the standard s of piston is fitted with installation of a new liner. These are thicker than dry liners.

Piston

The piston is the main active part of the engine. It has a close fit with the cylinc The movement of the piston changes the volume in the cylinder and provides the combust space. Generally, the pistons are made up of aluminium alloy. The aluminium alloy is lightest one and has good heat conduction properties, A hole is centrally provided insert a pin to connect the small end of the connecting rod. Circumferential grooves provided on the surface of the piston.

Functions

1) The piston receives the thrust produced by combustion and transmits the pov to the connecting rod.
2) It reciprocates to cause different strokes.
3) It acts as bearing to the small end of the connecting rod and bears side thrust.

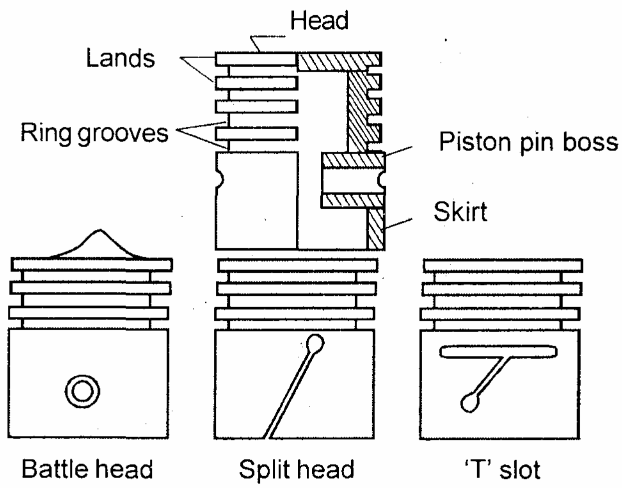


Figure 1.16 Piston

The piston diameter is slightly smaller than that of the cylinder. The gap between the piston and the cylinder wall is known as the piston clearance. This clearance is provided to avoid seizing of the piston in the cylinder. This clearance also provides the gap for a film of lubricant between the piston and the cylinder wall. A simple piston is shown in figure 1.16.

Piston rings

These are made of special steel alloys which retain elastic properties at high temperature. These are circular rings fitted in the circumferential grooves of the piston. There are two sets of rings. Upper rings are known as compression rings which provide gas tight seal. This will prevent the leakage of the burnt gases into the casing. The lower rings are called oil scraper rings. These are provided to remove the oil film from the engine cylinder and prevent the leakage of oil into the cylinder. Refer figure 1.17.

Functions of piston rings

1. Prevention of leakage of gas into the crank case.
2. Prevention of lubricating oil film
3. Prevention of lubricant entry into the combustion chamber above the piston head.
4. Removing unnecessary and excessive lubricating oil from cylinder wall.

5. Prevention of carbon deposits and other impurities on the piston head.
6. Easy transmission of heat from piston to cylinder wall
7. Balancing of side thrust of the piston.

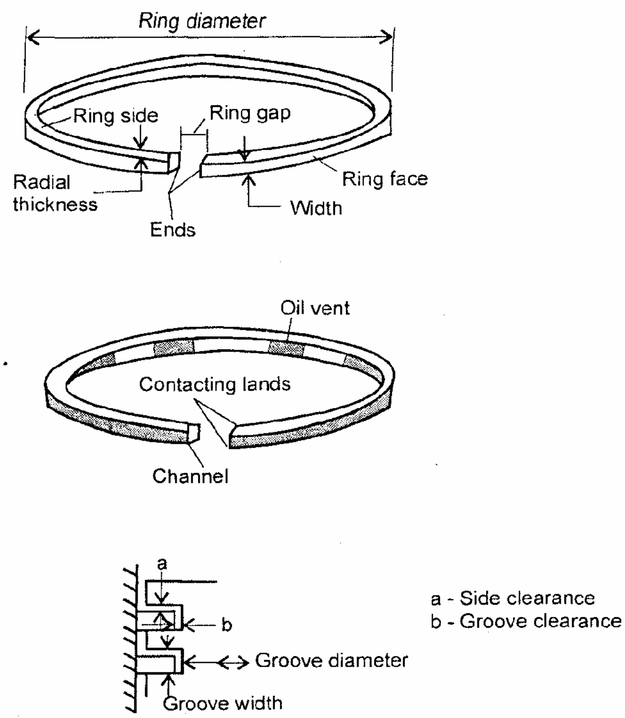


Figure 1.17 Piston ring

Connecting rod

This is the connecting link between the piston and the crank shaft, as shown i figure 1.18. By the oscillating movement of the connecting rod, reciprocating motion c the piston is converted into rotary motion of the crank shaft. The upper end of th connecting rod is called the small end, which carries the piston by means of a floating pi called piston pin or gudgeon pin as shown in figure 1.19. The lower end is called the bi end of the connecting rod, which connects the crank shaft through a crank pin.

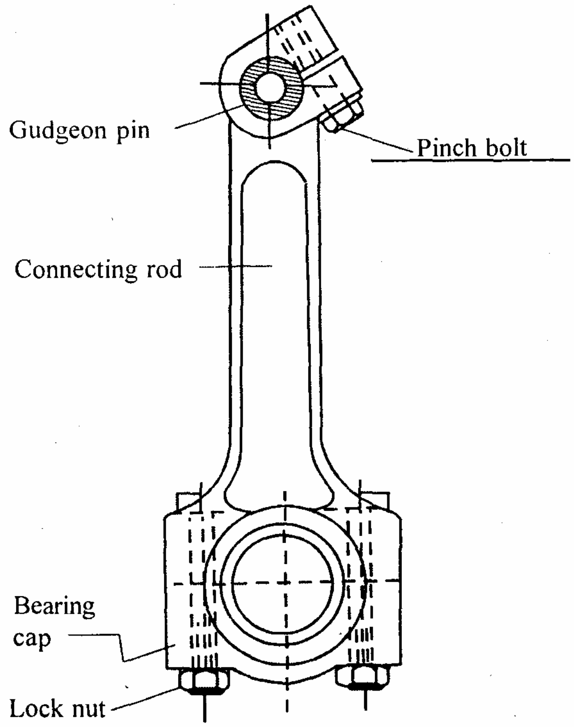


Figure 1.18 Connecting rod

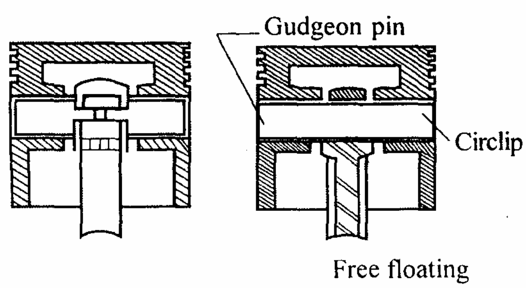


Figure 1.19 Gudgeon pin

Crank shaft

This is the main shaft in the engine as shown in figure 1.21. All the other working parts are directly or indirectly coupled to it. This converts reciprocating motion of the piston into rotary motion and then transmits to the clutch. The main parts of the crank shaft are crank pins, main journal, balance weight and flywheel flange. Oil holes are drilled for lubrication purpose as shown in figure 1.20. The crank shaft is made from a steel forging and machined.

1.9 ENGINE OPERATION

1.9.1 Working of four stroke petrol engines

The four stroke petrol engine works on the Otto cycle. It gives a power stroke i every set of four strokes of the piston or two revolutions of the crank shaft. The workin substance in the petrol engine is petrol vapour and air.

The different strokes are explained as below:

1) Suction stroke - Figure 1.31 (a)

The position of the piston and other arrangements are as shown in figure 1.31(a During this stroke the piston descends and the inlet valve starts opening. The exhaus valve remains closed. The movement of the piston sucks the mixture from the carburetto

2) Compression stroke - Figure 1.31(b)

This is shown in figure 1.31 (b) During this stroke, the piston moves from th bottom dead centre to the top dead centre. The inlet and exhaust valves remain closed The air fuel mixture sucked in during the suction stroke is compressed. The heat which i produced by compression helps in combustion. Before the compression stroke is completed the mixture is ignited by a spark produced by the spark plug. During this operation external work is being done by the piston. So it is termed as negative work.

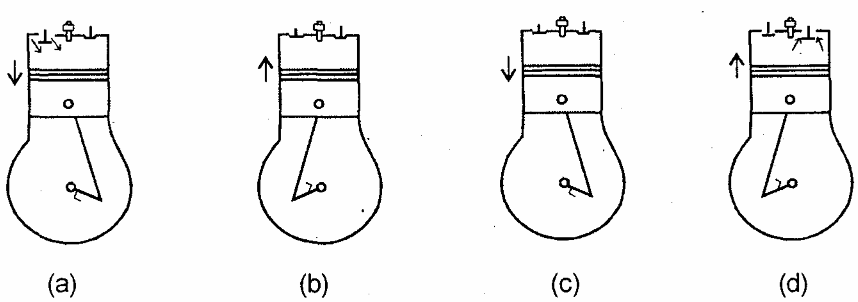


Figure 1.31 Four strokes of petrol engine

3) Working or power stroke - Figure 1.31 (c)

During this stroke, the piston moves from the top dead centre to the bottom dead centre. Both the inlet and exhaust valves still remain closed. Because of the combustion of the fuel air mixture, the burnt combustible mixture expands. This expansion forces the piston down. Under this impulse, the piston moves downwards doing useful work. During this power stroke, work is being done on the piston.

4) Exhaust stroke - Figure 1.31(d)

Due to the inertia achieved and the crank movement, the piston is made to travel upwards. During this stroke, the piston moves from the BDC to TDC. Before the start of the stroke, the exhaust valve starts opening. The products of combustion escape through the exhaust valve. As the piston reaches near TDC. (slightly before TDC), the inlet valve will open again for the start of the next cycle. The cycle of events takes place continuously, thus delivering work.

1.9.2 Working of four stroke diesel engines

The diesel engine, the ignition of the fuel takes place in the compressed air at high temperature and pressure. The temperature of the compressed air itself is sufficient to ignite the fine particles of fuel. The various strokes are explained as follows:

1) Suction stroke - Figure 1.32 (a)

Refer figure 1.32(a). The piston moves from the top dead centre to the bottom dead centre. The inlet valve starts opening before the piston is very near to the TDC. Exhaust valve remains closed. As the piston descends, because of the variation in pressure within the cylinder and that at atmosphere, air alone is sucked in through the inlet valve, which closes at the end of the stroke.

2) Compression stroke - Figure 1.32 (b)

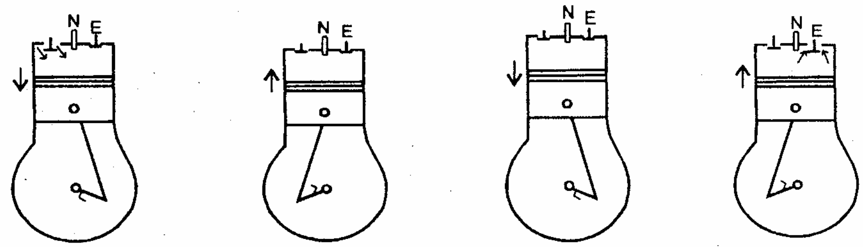
During this stroke, the piston moves from BDC to TDC, both the valves remaining closed. The air drawn into the cylinder during the previous stroke is now compressed by the upward movement of the piston. Because of high compression ratio and high pressure, at the end of the compression stroke, the temperature within the cylinder is high enough to ignite the fuel injected.

Combustion

When both the valves remain closed, fuel is injected into the compressed air which is at a very high temperature and pressure. Ignition takes place within a homogenous mixture formed in the combustion chamber. The combustion reaction forces the piston downwards.

3) Power stroke - Figure 1.32(c)

The expansion of the gas forces the piston downwards. During this stroke, the piston moves from TDC to BDC. Both the valves remain closed. As the work is done on the piston, it is termed positive. This is the useful work required. The stroke is completed as the piston reaches BDC.



(a) (b) (c) (d)

Figure 1.32 Four strokes of diesel engine

4) Exhaust stroke - Figure 1.32 (d)

Now the piston moves once again towards TDC. During the start of the stroke, the exhaust valve starts opening. The upward movement of the piston removes the remaining gases through the exhaust valve. The exhaust valve closes at the end of the exhaust stroke. Before the piston reaches TDC, very near to TDC, the inlet valve will start opening for the next cycle.

1.9.3 Two stroke engines

Two stroke engine performs only two strokes to complete the cycle. Suction stroke and exhaust stroke in a four stroke engine can be eleminated in this design. Rather they are combined with the working and the compression strokes. The principle of operation is the same as four stroke engine. There is one working stroke for every revolution of the crank shaft.

The construction is shown in figure 1.33 (a). It consists of a cylinder covered at the top and a hermitically sealed crank case at the bottom. Instead of valves, three ports are provided, on the walls of the cylinder. Exhaust port is placed slightly above the inlet port. Another port called transfer port is placed diametrically opposite, but slightly at a lower level to the exhaust port. Similar to the four stroke engine, crank shaft, connecting rod, piston, piston rings, piston pin are assembled as a link.

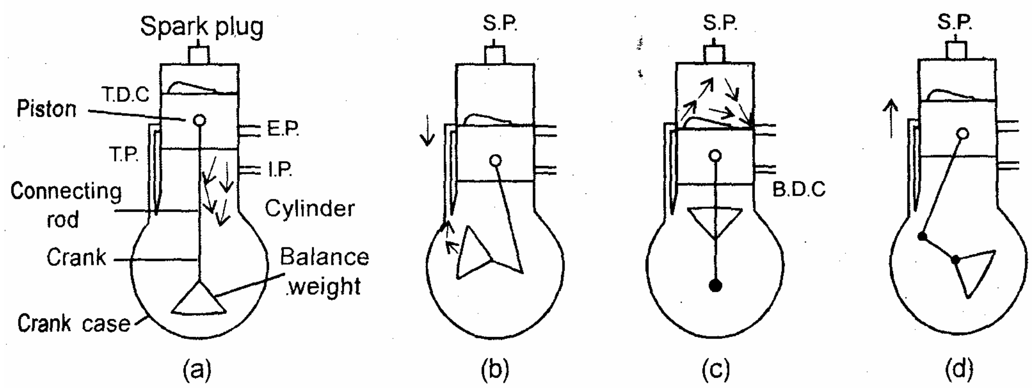


Figure 1.33 Two stroke petrol engine

The crown of the piston is deflected upwards to avoid mixing of fresh mixture with the exhaust gas and also to help to deflect the fresh mixture upwards (to drive the exhaust). These engines are air cooled by cooling fins arranged around the outer surface of the cylinder. Spark plug is screwed on the top of the cylinder head for petrol engine and a fuel injector in case of a diesel engine.

Working of two stroke petrol engine

First stroke

Two stroke petrol engine works on the principle of Otto cycle. The two stroke petrol engine consists of cylinder and piston arrangement, so that it can function as a pump in conjunction with the piston. At the beginning of the first stroke let us assume the piston is in the highest position at the end of the compression stroke. When the piston is at the top dead centre as in figure 1.33(a), the transfer port and exhaust port are covered by the bottom portion of the piston. This allows the fresh mixture of petrol and air to enter beneath the piston. When the piston descends, it compresses and forces the mixture through the transfer port to the other side of the piston. The downward movement of the piston will completely close the inlet port as in figure 1.33(b). Now first stroke is completed and the position is as that shown in figure 1.33(c).

Second stroke

The burnt gases still escape through exhaust port. The mixture transferred into the cylinder drives out the exhaust gases. This driving out of the exhaust gas is termed as scavenging. Now for the second stroke, the piston starts moving up. When it closes the transfer port and the exhaust port, the mixture in the cylinder will get compressed as shown in figure 1.33(d) and when the piston reaches the top dead centre the second stroke is completed by completing the compression. At this stage the spark plug initiates the high intensity spark. Now spark ignition takes place to carryout the combustion of the mixture. The expansion of the burnt gases will now push the piston downwards to perform the working (power) stroke. The cycle gets repeated.

Working of two stroke diesel engine

First stroke

Two stroke diesel engine works on the principle of diesel cycle. The two stroke diesel engine consists of cylinder and piston arrangement, so that it can function as a pump in conjunction with the piston. At the beginning of the first stroke let us assume the piston is in the highest position at the end of the compression stroke. When the piston is at the top dead centre as in figure 1.34(a), the transfer port and exhaust port are covered by the bottom portion of the piston. This allows the air only to enter beneath the piston. When the piston descends, it compresses and forces the air through the transfer port to the other side of the piston. The downward movement of the piston will completely close the inlet port as in figure 1.34(b). Now the first stroke is completed and the position is as that shown in figure 1.34(c).

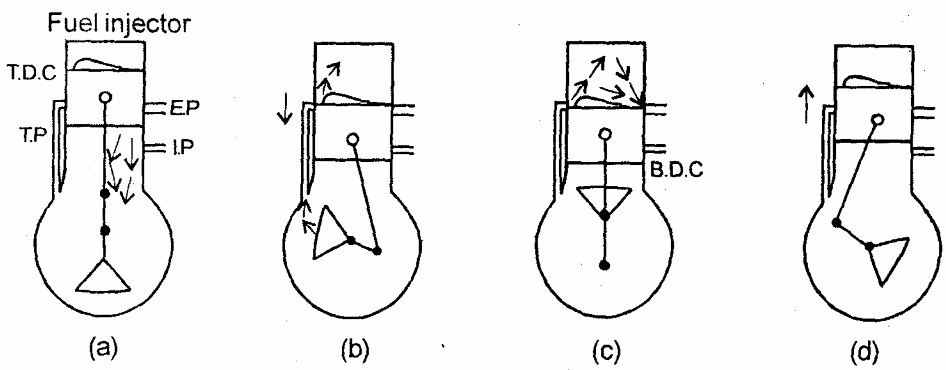


Figure 1.34 Two stroke diesel engine

Second stroke

The burnt gases still escape through exhaust port. The air transferred into the cylinder drives out the exhaust gases. This driving out of the exhaust gas is termed as scavenging. Now for the second stroke, the piston starts moving up. When it closes the transfer port and the exhaust port the air in the cylinder will get compressed as shown in figure (d) and when the piston reaches the top dead centre, the second stroke is completed by completing the compression. At this stage the fuel injector injects the diesel oil into the compressed air in the cylinder in the form of fine spray. Now compression ignition takes place to carryout the combustion of the mixture. The expansion of the burnt gases will now push the piston downwards to perform the working (power) stroke. The cycle gets repeated.

1.10 ENGINE PERFORMANCE

Engine Performance refers to the variation of the output over the entire range of its operation. To have a complete study on engine performance., both the power and torque characteristics are to be considered. It is obvious that the engine is an energy conversion device. So the performance also refers to verify how effectively energy conversion is carried out. Moreover the engine performance study also indicates the efficiency and specific fuel consumption. Though there are many variables to be considered, the engine speed, load, air-fuel ratio and mean effective pressure are the important ones.

1.10.1 Performance of an engine

The Working of any mechanism, system or an engine is to be satisfactory for proper use and to meet the changes in demand of load and other requirements. Such suitable functioning of the engine is termed to be the performance. This performance can be tested, whenever required to note down the working condition and also to determine certain engine characteristics ,either by varying the load on the engine and or speed.

The performance of the engine can be judged by

1. Indicated power and brake power – Mechanical efficiency
2. Fuel and air ratio – Volumetric efficiency
3. Speed
4. Thermal efficiency and heat balance sheet
5. Exhaust gas analysis

1.10.2 Terminologies

Indicated Power (I.P.)

The indicated power of an engine is power developed in the cylinder. It is measured by a form of pressure indicator connected to the cylinder head.

Brake Power (B.P.)

The brake power of an engine is the useful power available at the crank shaft of the engine for doing external work. This power is less than the actual power (indicated power) developed in the engine cylinder.

Frictional Power (F.P.)

The frictional power of an engine is the power loss in the cylinder and crankshaft due to friction between moving parts. It is the difference between indicated power and brake power.

Specific Fuel Consumption (SFC)

It is the amount of fuel consumed per unit power developed per hour.

Efficiencies

Mechanical Efficiency

It is the ratio of brake horse power to indicated horse power

$$\eta_{Mech} = \frac{\text{Brake power}}{\text{Indicated power}}$$

Thermal Efficiency

It is the ratio of BHP(or IHP) to the heat energy supplied by fuel. It is called brake thermal efficiency if calculated with BHP and indicated thermal efficiency if calculated with IHP.

$$\eta_{bth} = \frac{\text{BHP}}{\text{Heat supplied}}$$

Volumetric efficiency

It is the ratio of volume of air fuel mixture to the volume swept by the piston.

$$\eta_{Vol} = V_a / V_p$$

Relative efficiency

It is the ratio of indicated thermal efficiency to the corresponding ideal air standard efficiency.

$$\eta_{Rel} = \eta / 1-(1/r)^{\gamma}$$

1.10.3 Testing of I.C. Engines

Purpose of testing an I.C. Engine

1. To determine the information which can not be obtained by calculations.
2. To confirm the validity of data used in design.
3. To find out the power developed under certain operating conditions.
4. To determine the fuel consumption in Kg/hr
5. To determine the quantity of lubricating oil, cooling water required per Whr.
6. To obtain information about the sources of loss.
7. To prepare heat balance sheet.

1.10.4 Load test

The Performance characteristics of an engine can be determined by applying load on it. Normally the engine fitted and used for Agriculture, Automobile, and Power generations etc. is subjected to varying and flexible loads and sudden demand. To test the suitability of the engine, on an experimental setup, the engine is subjected to different applied loads.

The performance characteristics like specific fuel consumption, Brake horse power, Frictional horse power, Indicated horse power and various efficiencies are calculated.

The Load is applied on the engine by any one of the following three methods

1. Mechanical load.

2. Electrical load.

3. Hydraulic load.

1.11 PERFORMANCE CURVES

Testing of engines is mainly to find out the Brake horse power, torque, fuel consumption, frictional horse power and specific fuel consumption at different engine speeds. The above relation and their variations with respect to the independent variable selected can be plotted by means of some performance curves. These curves can be utilized to compare the performance of different engines according to the service suitability.

Some of the important performance curves are shown in figure 1.37.

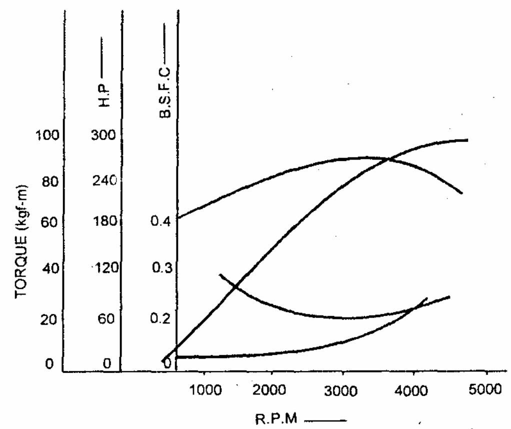


Figure 1.37 Performance curves

1.11.1 Torque vs engine speed

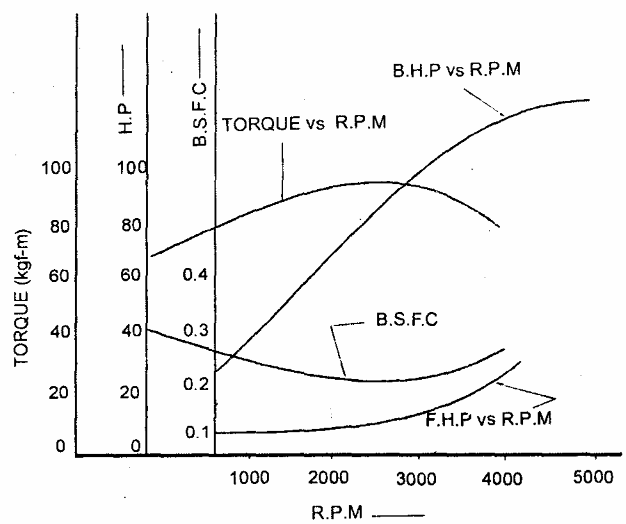


Figure 1.38

From the figure 1.38 during medium speeds, torques increases with speed. The volumetric efficiency is higher during this period, since cylinders get enough fuel-air mixtures to burn. Higher combustion pressure is needed to produce more power. At high speeds, the engine cylinders induct less amount of fuel-air mixture reducing the combustion pressures and hence the torque. Therefore the curve drops down.

Figure 1.38 indicates the torque curves for a diesel engine. By comparing the torque curves for petrol engine, the following facts are noted :

1. Diesel engine gives high torque at low engine speed.

2. Diesel engines operate almost at uniform torque over a higher range of operating speeds.

1.11.2 Brake horse power vs speed

The performance curves indicate that the Brake horse power steadily increases with the increase of engine speed, till a particular speed. The decrease in engine torque at higher speeds may be due to

(i) The volumetric efficiency decreases at high speeds producing lower combustion pressure and hence lower engine power.

(ii) Frictional losses increases with increase in engine speeds, decreasing the brake power.

1.11.3 Specific fuel consumption vs RPM

The specific fuel consumption decreases with increase of engine speed in both the petrol and diesel engine for the same swept volume. But the fuel consumption per horse power in case of diesel engine is lesser when the engine load decreases; the specific fuel consumption in petrol engine increases considerably. But in case of a diesel engine with the decrease in engine load, the specific indicated fuel consumption decreases, but the specific fuel consumption increases slightly.

1.11.4 Engine ratings

R. A. C Rating

The road tax is levied on automobiles according to R.A.C. formula or Royal Automobile Club formula.

According to this, horse-power $= D^2 \times N / 2.5$

Here D = Cylinder bore in inches

N = Number of cylinders

2.5 = a constant

The constant depends upon the following factors :

Mean effective pressure = 90 psi

Piston speed = 1000 ft. per. min

Mechanical efficiency = 75 percent

Modern engines develop nearly three times the rated power owing to high piston speeds.

1.11.5 Improvement of engine performance

The engine performance can be improved

1. by increasing the input energy
2. by increasing the engine efficiency.

The input energy can be increased by increasing the fuel consumption per unit time. This could be done by increasing the engine speed taking care that the volumetric efficiency at higher speeds is not affected. By super charging also the intake of Air-fuel mixture could be increased.

Increase in efficiency could be obtained by increasing the compression ratio. But beyond certain limit the increase in compression ratio will cause detonation and increased friction losses. So an optimum value of compression ratio has to be adopted.

1.12 ENGINE BALANCING

The automobile engines have reciprocating parts like piston and connecting rod. These creates vibrations while the engine is running. Moreover in case of four-stroke engine, there is one power stroke for every two revolutions of the crankshaft, so fluctuation is created. Therefore for smooth running of an engine, balancing is essential. This can best be solved in Multi-cylinder engine with proper firing order.

1.12.1 Types of balancing

Engine balancing is of two types

1. Power Balance
2. Mechanical Balance.

An Engine is considered to be in power balance if the power impulses occur a regular intervals with respect to the revolution of the crank shaft and each power impuls exerting the same force.

An engine is considered to be in mechanical balance when both the rotating an reciprocating parts are arranged in such a way that they counterbalance in operation an minimize the vibration.

The mechanical balance of an engine can be obtained by bringing the rotating part of an engine into static and dynamic balance. The rotating parts can be balanced convenientl but the balancing of reciprocating parts is not so easy. This is due to the weight of th pistons and connecting rods which reciprocates in different directions, producin considerable vibration.

The crank shaft is subjected to shocks while bringing the reciprocating parts to stop at the end of each stroke. These shocks over the crankshaft are termed as 'Primar Inertia Forces'.

The engines also have 'Secondary Inertia' forces due to the angularity of th connecting rods which produce secondary vibration.

It is to be noted, that for a perfect balance that every piston and a connecting ro are to be of same weight. Apart from this, the assembly of the crankshaft and flywheel als need a perfect dynamic balance to minimize vibration.

1.12.2 Firing order

The firing order refers to the sequence in which the power impulses occur in engine or in other words a firing order refers to the order in which the cylinders delive their power stroke.

The firing order plays a vital role to obtain the best engine performance and engi balance.

1.12.3 Engine balancing and firing order

Engine balancing is very closely related to the firing order. It is a well known fact that engine balancing could be improved by increasing the number of cylinders. With increase in number of cylinders, the power impulses for each revolution of the crank shaft also increases, giving a more uniform torque and smoother operations. In multi-cylinder engines if the power impulses are spaced equally, the power flow is continuous and less work is to be done by the flywheel in storing and releasing the energy, thereby reducing the vibration.

1.12.4 Four-cylinder engine : Balancing

Just for comparison and to study the engine balance an example of four-cylinder engine is considered. The arrangement of a four-cylinder engine with 180° crankshaft is shown in figure 1.39.

The movement of the piston 1 and 2 and that of 3 and 4 are in opposite direction. Thus, they balance each other, neutralizing the primary inertia forces and maintaining good mechanical balance.

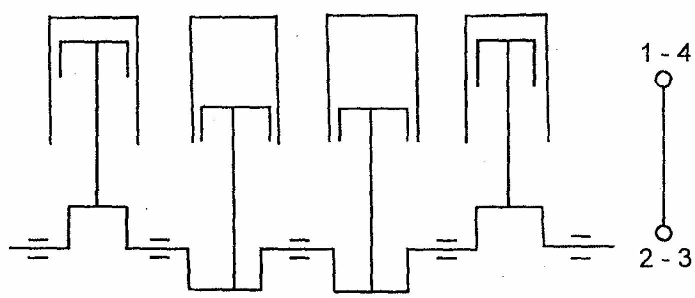


Figure 1.39 Four-cylinder engine : Balancing

But in case of four cylinder engine the secondary inertia forces acting on the reciprocating parts are not properly balanced. These unbalanced inertia forces bring secondary vibration at higher speeds. This defect is minimized to the maximum best in six-cylinders and eight-cylinder engines.

The table shows the power balance with different firing orders :- 1, 3, 4, 2 for table (1) and 1, 2, 4, 3 for table (2). Table(1) indicates the power balance with piston no. 2 moving upwards for exhaust stroke and piston no. 3 for compression. Table(2) indicates the power balance for the piston no.2 moving upward on compression and piston no. 3 for exhaust. Thus in both cases the power impulses are evenly distributed.

In other words, they are at 180° apart.

	I					II			
Cylinder	1	2	3	4	Cylinder	1	2	3	4
First	P	E	C	S	First	P	C	E	S
Revolution	E	S	P	C	Revolution	E	P	S	C
Second	S	C	E	P	Second	S	E	C	P
Revolution	C	P	S	E	Revolution	C	S	P	E

1.13 ENGINE TROUBLE SHOOTING

In order to keep the vehicle in perfect rolling and functioning condition, troubles or disturbances whenever felt, should be immediately diagnoised and removed. This process of identifying the causes and the remedial action is termed as trouble shooting. The probable causes for improper functioning of the vehicle may be either in the power unit or in the transmission unit or in other auxiliary systems explained so for. Just like giving first aid, it is preferable to locate the troubles and reduce their effects instantly. For slightly major repairs, it is better to take it to a Auto garage or service station. Of course, most of the difficulties in an Automobile can be settled by proper adjustments and replacements with some minor repairs. So it is essential to have a thorough knowledge of the process of trouble shooting charts of various components. In short, trouble shooting is a means of analysis, diagnosis and rectification of troubles.

The trouble shooting procedure informs what to do, when to do, and what is the order, etc., Mostly the troubles occur in ignition, electrical and transmission systems, which need immediate attention. The other common troubles arise in braking, steering, fuel, cooling, and the chassis systems.

The sluggish running of the motor vehicle is a frequent experience to all. The main reasons for such running, apart from lack of power are defects in the following:-

1. Ignition system, 2. Fuel system, 3. Starting system and 4. Cooling system

Trouble shooting - systems

For any particular vehicle, it is better to obtain or prepare a trouble shooting chart as a safe record. It is beyond the scope of this book to provide the chart for all the causes and remedies. Only some important troubles are analysed in this unit.

1. Engine does not start

Causes : a) Choked fuel supply, b) sticking of needle valve, c) flooded carburettor, d) dirty spark plug gap, e) discharged battery, f) ineffective opening of contact breaker points, f) poor compression.

2. Engine starts but stops suddenly

Causes : a) Choked filter and silencer, b) loose connection in ignition circuit, c) faulty fuel pump of carburettor over flow, d) fuel leakage in the line.

3. Engine misfiring

Causes : a) Faulty carburettor, b) dusty air cleaner, c) choked silencer, d) sticking of valves, e) defective spark plugs, f) defective wiring. g) defects in ignition circuit - incorrect timing.

4. Engine continues to run after switching off:

Causes : a) Engine overheating, b) defective ignition switch, c) carbon deposit in combustion chamber, d) spark plugs of incorrect heat value.

5. Engine overheating

Causes : a) Retard timing, b) too lean fuel mixture, c) leakage of water in the cooling system, d) loose fan belt, e) lack of lubrication, f) tight engine, g) brakes binding, h) excessive carbon deposit in engine cylinder.

6. Engine producing abnormal noises

Causes

a) Worn out gudgeon pins and small end bearings,

b) Worn out piston and rings,

c) Worn out big - end bearings,

d) Worn out crank - shaft main bearings,

e) Ignition too far advanced,

f) Wrong grade of spark-plugs,

g) Loose flywheel or crank pulley,

h) Excessive tappet clearance,

i) Loose timing chain,

j) Defective water pump bearing,

k) Fan brakes striking radiator or hose,

l) Slipping fan belt.

7. Excessive fuel consumption

Causes :

a) Improper adjustment of the carburettor

b) Dirty air cleaner, leakage in the fuel line

c) Excessive idling

d) Dragging brakes

e) Under inflated tyres

f) Vehicle overloaded

g) Unnecessary use of low gear

h) Operating with partially closed choke

i) Tight wheel bearings

j) Incorrect wheel alignment.

k) Incorrect spark plugs

8. Engine does not run slow or idling problem

Causes :

Choke valve partly closed, Incorrect idle adjustment, dirty air cleaner, damaged idle passage.

9. Engine does not pick-up speed

Causes :

Restriction in throttle valve operation, Restriction in fuel supply, Float level too low, Carburettor overfloating, Poor compression.

10. Clutch slipping

Causes:

No free play of pedal, worn out clutch plate, Oil grease or other such material on clutch facings, Excessively worn out pressure plate and flywheel.

11. Clutch dragging or spinning

Causes :

Oil or grease on clutch plate linings, clutch shaft out of line with engine, Clutch plate distorted, Cushion springs damaged.

12. Clutch judder

Causes :

Linings not making even contact, Pressure plate not parallel with flywheel, Bent clutch shaft.

13. Clutch rattling

Causes:

Worn out release bearing, worn out release fork, disconnected pedal return spring.

14. Gear slipping out of mesh

Causes:

Damaged ball races , plunger or spring locking selector shaft or fork, Bent shifter fork, Worn out grooves of selector shaft.

teeth for alignment of different gears on the respective shafts is carried out. The position and the number of shims are noted for proper refitting. The teeth of all the gears are inspected for roughness and any cracking. The crown wheel is checked for any distortion. All the oil seals are renewed.

While assembling, thrust washers, shims and distance pieces must be positioned correctly. Then using a dial test indicator on the casing, the position of the pinion shaft is checked for end wise movement. The clearance allowed in the design is adjusted by means of screw and nut provided in the casing. Thus, all sort of adjustments are made for proper clearance and smooth contact between the crown and the pinion wheel.

Other Automobile Overhauling Systems

The following assembly units are also to be inspected for overhauling.

1. Valve and valve operating mechanism
2. Carburettor
3. Pump
4. Ignition systems
5. Distributor
6. Brake system
7. Steering assembly
8. Shock absorbers
9. Steering wheel centering, wheel alignment, and suspension system.
10. Cooling system
11. Radiator (thermostat, fan belt, water pump)
12. Electrical systems
13. Lubrication systems
14. Wheels and Tyres.

1.14 GAS TURBINES

A gas turbine is an external combustion engine. The fuel used in a gas turbine may be Gasoline, Kerosene or diesel without any octane or cetane requirements, methanol Gasoline. A gas turbine in general consists of two sections - A gasifier section and a power section. Gasifier section includes compressor, combustion chamber; Power section includes the turbine and the transmission. This works on Brayton cycle. The circuit diagram is shown in the figure 1.40.

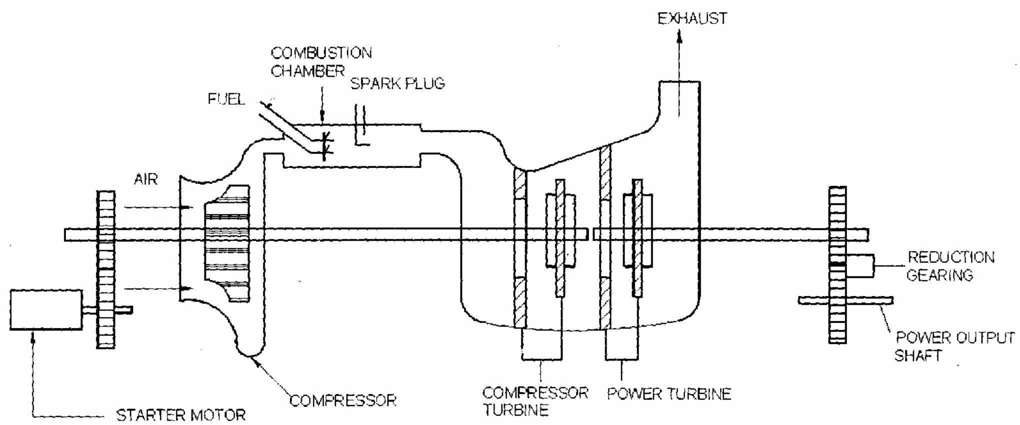


Figure 1.40 Principle operation of a gas turbine for automotive use

Initially atmospheric air is drawn into the compressor which may be of centrifugal or axial type. A multistage compressor would be needed to obtain the pressure ratio of 4 : 1 as required for automobile applications. The air gets compressed in the compressor, then the high pressure air enters into the combustion chamber. Can type combustion chamber is mostly used.

An inner chamber in the combustion chamber admits the primary air through swirl vanes. An injector nozzle is placed near the vane. The combustion chamber is divided into three zones - Primary, Intermediate and Secondary. A spark plug or burner is fitted to ignite the Air-fuel mixture. The main combustion occurs in the primary zone and the combustion reaction continues to release energy in the intermediate zone.

In the secondary zone, an additional quantity of air is supplied to reduce the temperature of products of combustion, to a safer limit.

The high pressure and high temperature gas then passes through the gasifier nozzle. The hot combustion gases passes through the compressor turbine and then through the power turbine where it further expands to give power. The compressor turbine is just to run the compressor, but the major motive power is developed by the power turbine.

The rotor of the compressor and the compressor turbine is mounted on the same shaft. A reduction gear has to be used for effective control of the turbine speed, because the turbine speed is much more than the conventional automotive engines. A starter electric motor is also included to run the compressor. To increase the thermodynamic efficiency of the turbine a heat exchanger is also included.

1.14.1 Advantages of gas turbine

1. Since there are no reciprocating parts it is easy to balance and free from vibrations.
2. Starting is very easy.
3. No need of cooling system.
4. Lesser consumption of lubricating oil compared to I.C. Engines.
5. Higher mechanical efficiency.
6. It is simple in design, light in weight and compact in shape.
7. Combustion is continuous without the necessity of further ignition.
8. It is smooth in operation with continuous performance.
9. Any distillate and cheaper fuels can be used.
10. The turbine exerts a smooth and continuous torque on the shaft.

Disadvantages of gas turbine

1. There is no engine braking and acceleration.
2. Since the speed varies from 25.000 to 50.000 rpm braking is not effective.
3. Difficult to obtain an effective transmission speed on road.
4. A high speed self starter with a large battery is required.
5. The large quantity of exhaust gases is a nuisance and hazardous in traffic.

1.15 AIR POLLUTION

Transportation is the main reason for air pollution especially in urban areas, where 60% of the air pollution is caused by automobiles only. The problem is of much concern in our country as the vehicular population is increasing at an accelerating rate every year.

The exhaust from the automobile engine contains serious pollutants of oxides of Nitrogen (NOx) which are toxic. The oxides of Nitrogen react with the hydrocarbons in sunlight to form photochemical smog. The smog is a mixture of smoke and fog. Smog and other chemical on earth in the form of a dome are very harmful for eyes, throat and lungs. Smog can be seen in the atmosphere, but other pollutants like lead compounds, hydrocarbons and carbon monoxide may not be visible.

The contribution of NOx from Petrol engine is higher than from the diesel engine and gas turbines.

Automobile pollutants

The main sources of pollutants in automobile are as follows :

1. Fuel tank - Gasoline vapour
2. Carburettor - Gasoline vapour
3. Crankcase - unburnt air-fuel mixture blown through the piston rings.
4. Tail pipe - unburnt gasoline, hydrocarbon, Carbon monoxide, nitrogen oxide and sulphur oxide.

The very high temperature in the automobile engines is the main reason for the pollution.

Main pollutants

The main pollutants contributed by automobiles are

(1) Carbon monoxide (CO)

(2) Unburned Hydrocarbons (UBHC)

(3) Oxides of Nitrogen (NOx)

(4) Lead and other particulate emissions.

The contribution of pollutants, by source are as follows:

	Sources	**Methods**	**Pollutants**
1.	Fuel tank		
2.	Carburetor	Evaporative loss	15 to 25% of HC
3.	Crank case	Crank case blow by	20 to 35% of HC
4.	Exhaust system	Tail pipe exhaust	50 to 60% of HC and almost all CO and NOx.

The pollution from the fuel tank is due to the temperature changes. When the temperature increases some portion of air and fuel vapour mixture from the tank is forced out through vent holes. The pollution from the carburetor is due to the evaporation of the fuel stored in the float bowl, due to engine heat. This leak of gasoline vapour from carburettor enters into the atmosphere.

The evaporative losses are the direct losses of raw gasoline from the engine fuel system; the blow by gases are the vapors and gases leaking into the crankcase from the combustion chamber and the pollutants from the exhaust pipe are due to incomplete combustion.

Air-fuel mixture trapped in the top land clearance and behind the top ring are unable to burn due to wall quenching effect. The cylinder forces this quenched gas past the piston ring and into the crankcase, along with some burned gases.

Most of the VOC (volatile organic compounds) emissions are from the tail pipe, these are controlled using catalytic reactors and by injecting air at the exhaust ports of the engine to burn emitted hydrocarbons in this high – temperature zone. However more than 20% of the uncontrolled automobile engine VOC emissions are from the crankcase vent and from the carburetor vent to the atmosphere. These emissions are controlled using a crankcase vent pipe to the engine air intake duct and a "carbon canister" absorption unit

Exhaust emissions are greatly affected by air-fuel ratio, ignition timing and design of engine.

Carbon monoxide : Carbon monoxide occurs only in engine exhaust. It is a product of incomplete combustion due to insufficient amount of air in the air-fuel mixture or insufficient time in the cycle for completion of combustion. The percentage of CO increases in idle range and decreases with speed. In passenger cars CO percentage has been found to be as high as 7 percent with rich mixtures and 1.25 percent with near stoichimetric mixtures. The complete elimination of CO is not possible and 0.5 percent CO should be considered a reasonable goal.

Carbon monoxide emissions are high when the engine is idling and reach a minimum value during deceleration. The are lowest during acceleration and at steady speeds. Closing of the throttle which reduces the oxygen supply to engine is the main cause of CO production, so deceleration from high speed will produce highest CO in exhaust gases.

Hydrocarbon : Unburnt hydrocarbon emissions are the direct result of incomplete combustion. Two of the important design variables are induction system design and combustion chamber design, while main operating variables are air-fuel ratio, speed, load and mode of operation.

Particular matters : Organic and inorganic compounds of higher molecular weights and lead compounds resulting from the use of TEL are exhausted in the form of very small size particles. About 75 percent of the lead burned in the engine is exhausted into the atmosphere in this form and rest is deposited on engine parts. Other constituents are phenols, acids, ketones, ethers, formaldehyde and acetaldehyde etc.,

Oxides of Nitrogen (NOx) : Oxides of nitrogen which also occur only in the engine exhaust are a combination of nitric oxide (NO) and nitrogen dioxide (NO_2). The combustion of HC and NO_x in the presence of sunlight and certain atmospheric conditions produce photochemical smog.

ENGINE EMISSION CONTROL

The best way to control air pollution is not to produce the pollutants. For example, burning non-leaded fuels eliminates lead emission from automobiles, and nitrogen oxide emissions per mile of travel have been significantly reduced by redesigning engines. A possible alternative is to shift the location of the nitrogen oxides emissions – for example, from the automobile tail pipe to the stack of an electric generating station, by using electric or hydrogen-fueled cars.

Automobile pollutants can be controlled by,

1) Alternation in induction system.
1) Periodic servicing of ignition and carburetor systems.
2) The installation of a fuel tank with a built in chamber to provide an assured thermal expansion volume for the fuel.
3) Treatment of exhaust gas.
4) Reduction of lead in gasoline.
5) Fuel modification
6) Retarding ignition timing
7) Modification of combustion chamber configuration to reduce quench areas.
8) Lower compression ratio.
9) Reduced valve overlap.

Exhaust emission can effectively be controlled, by fuel modification. CO emission can be effectively reduced with reduction of HC and NOx; and by selecting from propane to methane, the CO and HC emission can be greatly reduced.

Other solution include reducing emissions by using "add-on" devices. In the case of automobile, carbon canisters are used to adsorb hydrocarbon vapors emitted from the carburetor and the gas tank. The vapors are subsequently returned to the engine for burning. Use of fuel injection system is better way to reduce carburettor emission because it does not require venting to the atmosphere and it offers the potential for slightly improved fuel efficiency .in the automobile exhaust system, catalytic converters and air injection chemically reduce emissions of hydrocarbons.

Control of Nitrogen Oxides : By reducing the peak cycle temperature the effect of Nitrogen Oxides can be greatly reduced. The following are the common methods for controlling NOx emission

a) Exhaust gas recirculation (EGR)
b) Water injection
c) Cartelist

Catalytic Converter : This is used control the harmful exhaust emission by converting into other forms of harmless gases and liquid. As catalysts are used for emission conversion this is known as catalytic converter. There are two kinds of catalytic converter.

1. Two-way type and 2. Three way type.

In two way converter only hydrocarbons and carbon monoxide are converted nitrogen oxide remains same. But in three-way catalytic converter all the three are converte into carbon dioxide, nitrogen and water vapor. A catalytic converter is fitted in the exhaus system of the vehicle. This consist of a heated O_2 sensor and activated charcoal filter.

HEALTH HAZARDS OF AUTOMOBILE EXHAUST

The major pollutants as discussed above, in general cause burning of eyes, re eyes, irritated throat, trouble in breathing, nerve and brain damage etc.

CARBON MONOXIDE

Carbon monoxide inhalation in excess produces poisoning. It has an affinity fo hemoglobin about 300 times that of oxygen and combines with hemoglobin to form carbox hemoglobin-thus reducing the oxygen carrying capacity of blood. It may also combin with myoglobin and have effects on cytochrome oxidases. Most dangerous effect of CC poisoning manifests on central nervous system and myocardium. CO causes lung, kidne and cancer problems. It is responsible for increased carbon in blood, decreased oxyge transport, and heart disease. The other significance effects are:

1. Cardiac arrhythmias, 2. Hypotension, 3. Myocardial infarction

The other changes on Central Nervous System are;

1. Loss of intellect
2. Confusion and agitation
3. Headache
4. Irreparable brain damage
5. Coma
6. Cerebral edema
7. Cerebral infarction

SULPHUR DIOXIDE

SO_2 is highly soluble, and gets absorbed in respiratory system. This causes asthmatics, coughs, and bronchitis and fatigue problems. More over it is also responsible for acid rains.

Health effects of sulfur dioxide include exacerbation of asthma and COPD and respiratory tract irritation. Major health effects include effects on breathing, respiratory illness, breakdown of lung defenses, aggravation of existing respiratory and cardiovascular disease, influenza or asthma.

CARBON DIOXIDE

Carbon dioxide is a natural constituent of air. It does not take part in any significant chemical reaction with other substances in the air. However, its global concentration is rising above the natural level by an amount that could increase global temperature enough to affect climate markedly.

LEAD

Lead is added in the petrol as anti knocking agent.

Health effects of lead are mainly on central nervous system and impaired neuropsychological development occurs in children. Lead affects on cells to cause gametotoxicity and carcinogenicity, on embryo to cause embroyotoxicity and teratogenixcity. High lead exposes cause seizures, metal retardation, and behavioral disorders, high blood pressure and heart diseases.

OXIDES OF NITROGEN

This is a reddish-brown highly reactive gas. Health effects of oxides of nitrogen are respiratory tract irritation, bronchial hyperactivity, and impaired lung defenses, bronchiolitis obliterans causes bronchitis and pneumonia, lowers resistance to respiratory infections, and plays a major role in troposphere ozone formation.

HYDROCARBONS

Hydrocarbons exert their pollutant action by taking part in the chemical reactions that cause photochemical smog. Carcinogenic potential of hydrocarbon is the main health effect.

OZONE

This colorless gas reduces lung function associated with coughing, sneezing, chest pain and pulmonary congestion. High concentration of ozone causes eye irritation. Ozone is one of the strongest oxidizing agents released from automobile exhaust causes cough, substernal discomfort, bronchoconstriction, decreased exercise performance, respiratory tract irritation.