AUTOMOBILE ENGINEERING

SUDHIR KUMAR SAXENA

1

INTRODUCTION

au'tō-mō-bile'" (or a-tō-mō' bil), n. [*auto-*, and L. *mobils*, movable.] a car, usually four-wheeled, propelled by an engine or motor that is a part of it, and meant for travelling on streets or roads; a motor car.

— ***Webster's New Twentieth Century Dictionary-Unabridged, Second Edition.***

The meaning of an automobile is a four-wheeled vehicle, carries a small number of passengers, driven by an engine or motor and independent of rails or tracks. The subject of automobile engineering is the study of engineering aspects and technical details of cars. There are hundreds and thousands of different types of cars that are available today. During the past century, tremendous development in this field has taken place. Apart from cars, vehicles for different usage have been developed. These range from commercial vehicles of different types—to public utility transport systems such as buses and coaches—to the carriers of different types—to tractors and similar machines meant to be used for specific purposes which are propelled by an engine or motor that is part of these machines. Though this study is meant for automobiles only but in the present scenario it can not be strictly confined to cars, and therefore, wherever felt necessary and relevant the other forms of automobiles meant for allied purposes will also be included.

1.1 CHRONOLOGY OF DEVELOPMENT OF AUTOMOBILES

The history of development of automobiles is not very old. The first self-propelled vehicle was built in France in 1769. In those times, steam engines were used as source of power to move the vehicles. In 1895, **Stanley** built a steam car 'Stanley Steamer' which could gain a considerable speed. Prior to this vehicles used to move at a slow speed. In France, **Lenoir** drove the first automobile with gas engine.

In those days, means of communication were not fast and there were not many interactions among the engineers and scientists. The development took place simultaneously in different parts of the world. In Germany, in the year 1885, two engineers built gasoline-powered automobiles. These engineers were **Daimler** and **Benz,** very big names in automobiles even today. They used engine based on 4-strokes developed by **Otto. Louis Renault** worked in France to develop the automobiles, and some have opinion that he was the first to drive an automobile. Whatever the truth may be but the last decade of nineteenth century witnessed the development in the field of automobiles, which formed the basis of what we see today.

In America, **Henry Ford** built a car running on four bicycle wheels, powered by two-cylinder gasoline engine. (shown in Fig. 1.1). **Seldon** built the first automobile manufacturing plant in New York in 1895. Another plant, at Detroit, was started around the same time. In 1897, this plant produced 425 cars. In London, motor bus service appeared in 1898. It became popular immediately. The reason being that in those days everybody could not afford to buy a car. The bus service was cheap and provided a faster mode of transport as compared to horse carts. This popularity of bus service resulted in quick increase in number of buses and in a span of five or six years, the number of buses rose considerably in London. The number of manufacturers of car rose to more than hundred in 1905. Some prominent manufacturers included **Cadillac, Ford,** and **Buick**—the names well known even today and some other names such as **Chrysler, Nash** and **Hudson.** In 1908, Buick company was converted into General Motors and absorbed Oldsmobile, Cadillac and nine other companies. The first World War, which continued for four years from 1914 to 1918, proved to be boom for automobile industry because quick movement was very important for any army to win.

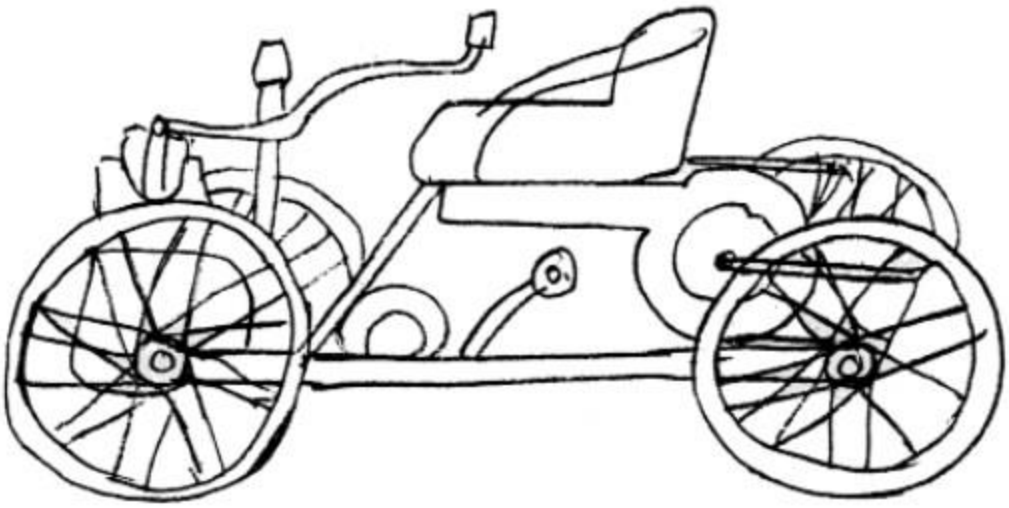


Fig. 1.1 *Sketch of early Ford Car built in 1896.*

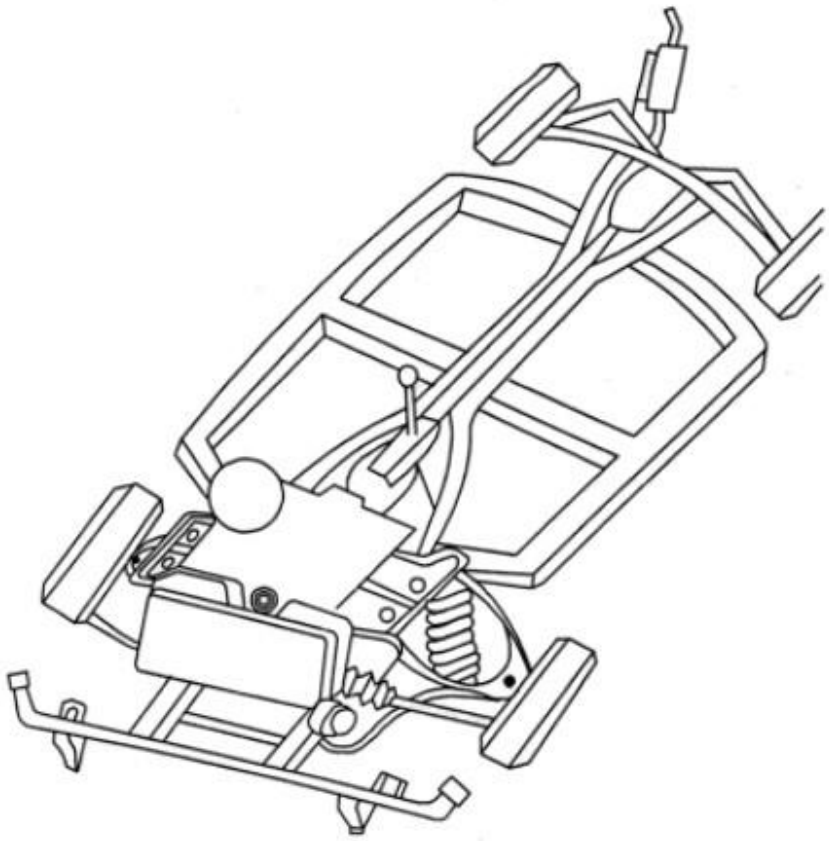
During the next four decades, the improvements in internal combustion engines caused tremendous improvements as the automobiles became light, compact, streamlined and water or air-cooled. These became well balanced and almost free from vibrations.

In India, the development in the field of automobiles was nil in the pre-independence era. The English rulers used to bring cars for their personal use from England. No body attempted to make the cars here until in 1942 when Hindustan Motors was established. Another company Premier Automobiles Ltd. (PAL) came into existence in 1944. Initially both of them were engaged in the manufacturing of auto parts. They started manufacturing cars later. In 1945, **Mahindra brothers, Kailash** and **Jagdish Chandra** formed Mahindra and Mahindra. They indulged in the manufacture of utility vehicles. They tied up with Wiley's and launched jeep in India. In the fifties another company Standard Motor Products of India Ltd. came into being and launched their car. But this firm could not continue in the face of competition offered by Hindustan Motors and Premier Automobiles Ltd. Another company Ashok Motors, which was later converted to Ashok Leyland, started manufacturing heavy vehicles in India. It was in 1954, when Tata, in collaboration with Mercedes-Benz, launched

1.3.1 The Chassis

The chassis of an automobile incorporates all the major assemblies consisting of engine, components of transmission system such as clutch, gear box, propeller shaft, axles, control system such as brakes and steering and suspension system of the vehicle. In other words, it is the vehicle without its body.

The chassis of an automobile has the frame, suspension system, axles and wheel as the main components (Shown in Fig. 1.2 (*a*)). The frame could be in the form of conventional chassis or unit construction may be adopted. In conventional chassis frame, the frame forms the main skeleton of vehicle. It supports engine, power transmission and car body. The frame is supported on wheels and axles through springs. The frame carries the weight of the vehicle and passengers, withstands engine, transmission, accelerating and braking torques. It also withstands the centrifugal forces while cornering and takes up stresses due to rise and fall of axles. In unit construction type there is no frame (Shown in Fig. 1.2 *(b)*). The structure of body of the automobile is first formed and then different components such as engine, transmission system and other parts are placed at suitable places in the body structure. The transmission system itself consists of a number of parts such as clutch assembly, gear box, propeller shaft, differential and axles. The other parts include the interior details which are utilized by the passengers and driver of the vehicle. Through suitable designing, the parts are so arranged that they provide maximum comfort and make journeys in the automobile enjoyable.



used for the transportation of goods smooth transmission process is essential as otherwise it may cause damage to goods.

Gear box is the component of transmission system next to clutch. It has got gear train and it provides different gear ratios. These ratios determine the rotary speed of output shaft from gear box. The torque transmitted to the road wheels give rise to a propulsive force (or tractive effort) between these and the road. When starting from rest large tractive effort is required. This makes essential the introduction of considerable 'leverage' between engine and the wheels so that torque from engine, which is almost constant, produces large tractive effort. This 'leverage' is provided by the gear box. Different gear ratios available in the gear box can provide the required tractive effort to overcome the resistance faced by the automobile under different conditions.

Propeller shaft transmits the output from the gear box to the axle. This axle may be in the rear or in the front or in some cases both the rear and front axle may receive output from gear box (Shown in Fig. 1.3 (*a, b, c*). The output from the gear box is in the form of rotary motion of the shaft and this motion is transferred to the axle.

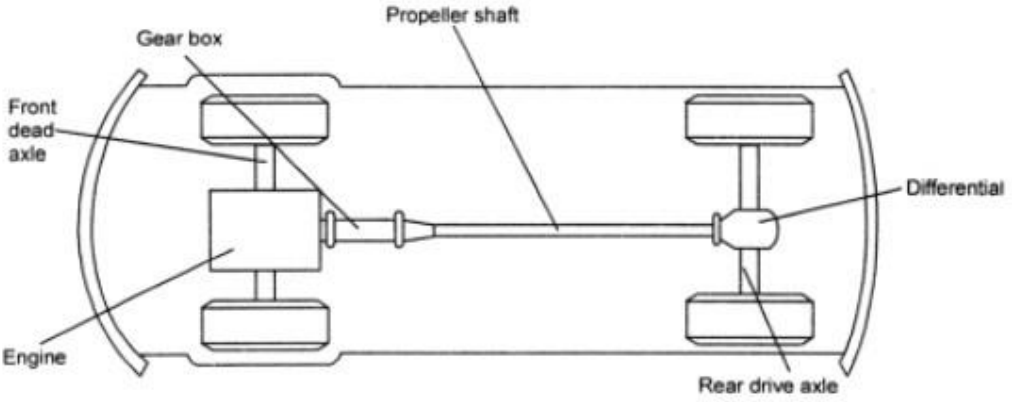


Fig. 1.3 (*a*) *Rear-wheel drive.*

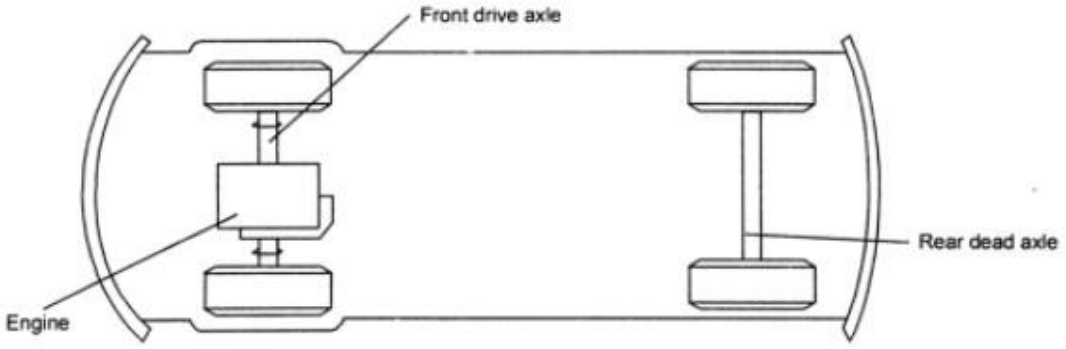


Fig. 1.3 (*b*) *Front wheel drive.*

and at the same time enhance the speed of outer wheels by the same amount. This is required when the automobile is moving on a curved path. On a curved path, the outer wheels are required to traverse a circle of bigger radius than the inner wheels. This means that the outer wheels are required to traverse larger distance as compared to inner wheels. As the automobile is to move as a single unit, all the four wheels must travel together. Therefore the outer wheels should travel larger distance and inner wheels should travel smaller distance in the same time period. Hence the variation in speed of inner and outer wheels is needed. This is performed by the differential with the help of sun and planet gear system. Further details of differential to be taken up later.

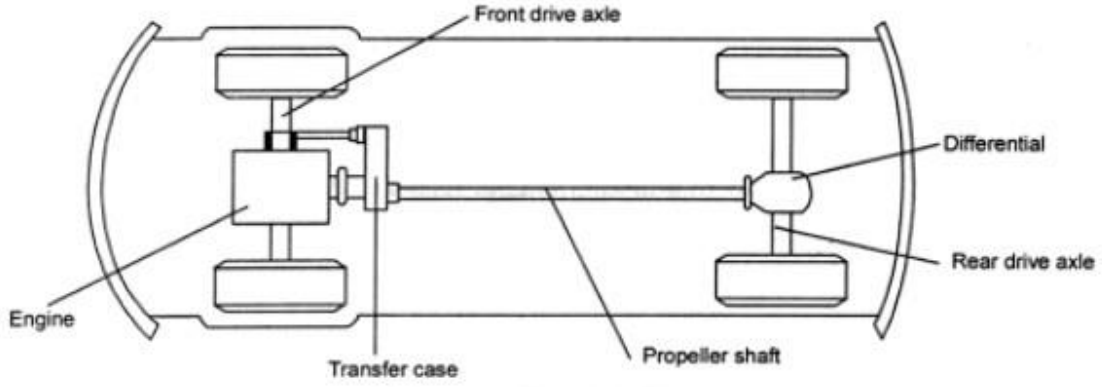


Fig. 1.3 (*c*) *Four wheel drive.*

Axle is the next component of transmission system. The axle receiving power from the engine is termed as 'live' axle. It is in two halves. The ends of the axle have road wheels connected to it. These road wheels are in direct contact with the road surface. The body of the automobile is above the axle. The axle also takes up the various loads including the weight of the automobile. It also transmits motion to the road wheels.

1.3.4 The Body

The use of a separate frame to which the body structure is attached is now almost obsolete except for some applications for commercial heavy duty vehicles. Many heavy vehicles now use 'sub-frames' of simple construction to which the engine and gear box is attached. The sub-frame is supported on the main frame and is fixed on it through some suitable rubber connections to isolate the engine vibrations.

Due to development in spot welding and sheet pressing techniques most of the vehicles have integral construction. All the assembly units of the vehicles are attached to the body which also acts the frame. It makes the vehicle *compact, light weight and also its cost is reduced*. Some intermediate designs using a light chassis and a pressed steel body are also in use. The light chassis, in such designs, is strengthened by using platform made of sheet of steel.

Apart from the four basic components described above, the automobile has the control systems and auxiliaries. The control systems are used to control the motion of an automobile and therefore are essential in an automobile. These include (*a*) Steering system and (*b*) Braking system or brakes.

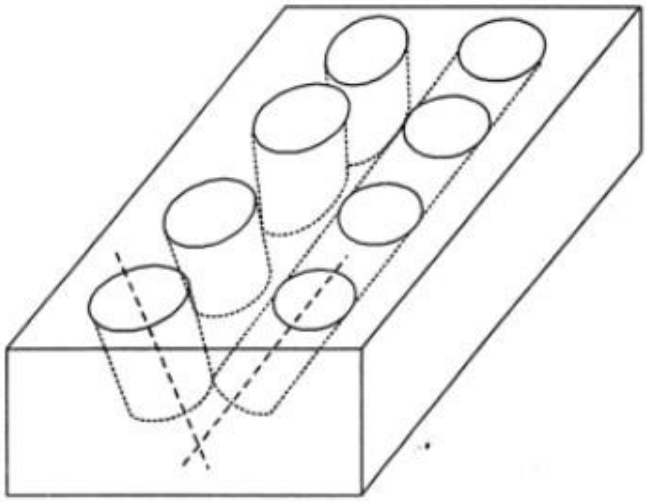


Fig. 2.2

The cylinder blocks are also provided with passage for coolant. The hot gases at high pressure push the piston down in the cylinder. This causes maximum heating of cylinder block due to unutilised thermal energy. The coolant flowing through the passage takes away this heat.

Most cylinder blocks are made through casting using cast iron. Sometimes iron mixed with nickel or chromium is also used. Aluminium alloy is also used to cast the cylinder block.

2.2.2 Crank Case

It forms the lower part of the engine. It accommodates crankshaft. *The crankshaft is a long straight piece of metal in a vehicle that connects the engine to the wheels and helps turn the engine's power into movement.* It is supported at its ends in the walls of crank case. The crank case has the provision to support the crankshaft. In some engines where the crankshaft is too long, it is supported in the middle portion also and crank case has provision to provide support. Apart from this, the crank case acts as sump for lubricating oil. Generally the upper part of crank case is an integral part of cylinder block, the lower part of crank case is bolted to it.

Aluminium alloy is the most suitable material for crank case. It is light weight and has good thermal conductivity. Earlier cast iron was also used as material for crank case (Fig. 2.3).

2.2.3 Cylinder Head

The cylinder head has provision for fixing the inlet and exhaust valves. This also forms the top of combustion chamber. The combustion chamber is given different shapes. Each shape produces effective combustion of fuel.

The material of cylinder head is cast iron or aluminium alloy. Machining is done so that various components can be installed smoothly.

To prevent noise and vibration reaching the body of the automobile the cylinder heads are provided with cover. The cover is made of three-layer sheet. The outer two layers are metallic and middle layer is that of plastic. This plastic layer does not allow the transmission of noise and vibration from the engine.

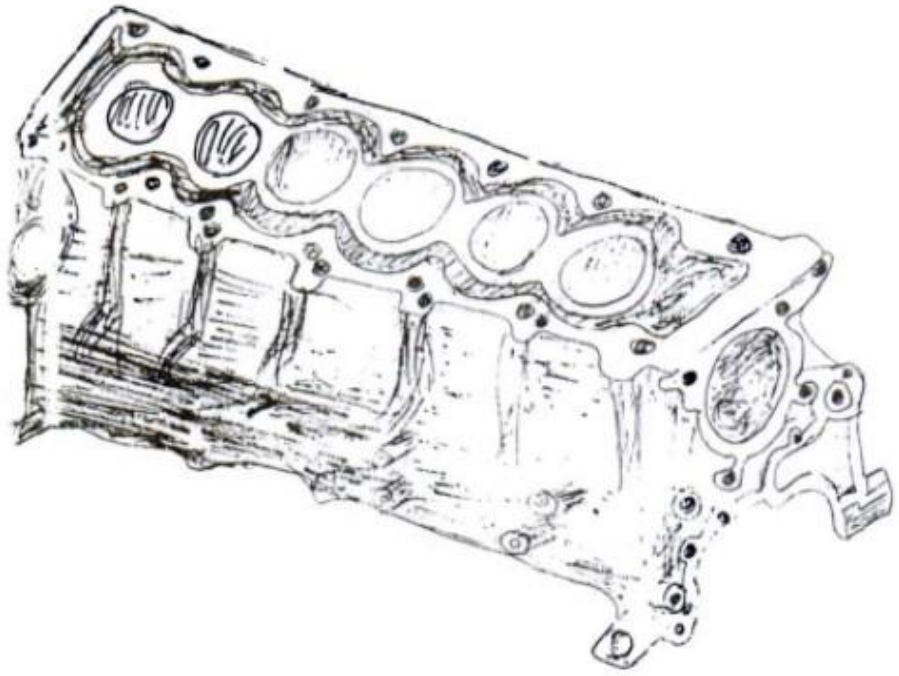


Fig. 2.3

In wedge shape combustion chamber the turbulance of burning mixture is enhanced. The cup shaped combustion chamber prones turbulance and is particularly suitable for diesel or turbo-charged engines. In hemispheric combustion chamber combustion of fuel is relatively slow. Figure 2.4 represents wedge shaped and hemispherical combustion chambers.

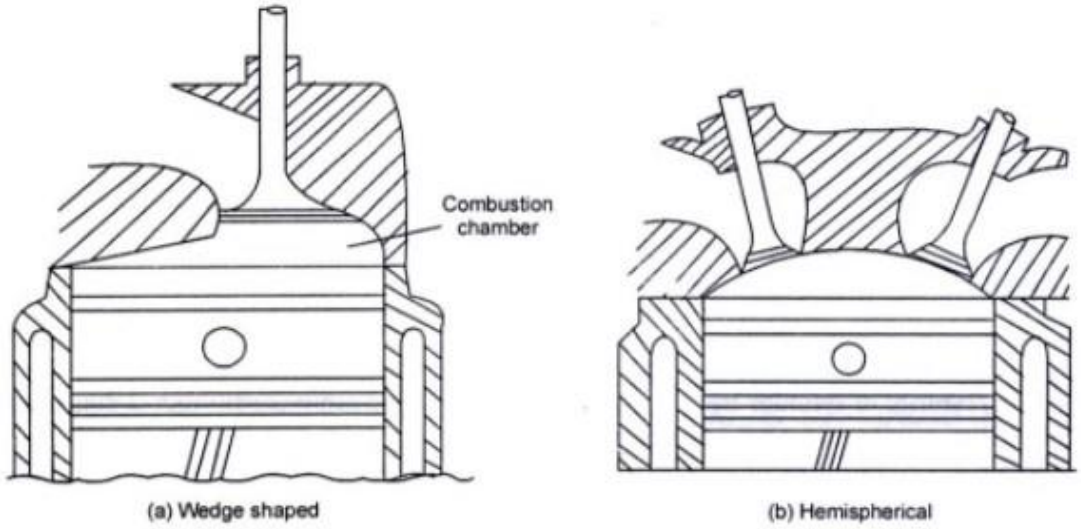


Fig. 2.4

2.2.4 Piston

The piston moves inside the cylinder and has reciprocatory motion. It is air tight and does not allow the leakage of charge and hot gases with the help of rings which form a part of piston ring assembly. It also transmits the impact produced by the gases at high temperature and pressure. It accommodates the small end of the connecting rod and takes the lateral thrust due to obliguity of connecting rod.

The top portion of the piston is known as crown. Piston rings and piston pin form integral parts of piston assembly. The lower most part of piston is known as skirt. A slot is provided in the piston. The slot accommodates the expansion of piston material when hot. This helps in reducing the clearance between skirt and cylinder bore when cold. When hot, the slot accommodates the expansion of piston material.

Aluminium alloy is the most commonly used material for piston. The alloy contains about 12% silicon which has less co-efficient of expansion as compared to aluminium and cast iron. Addition of phosphorus enhances the fatigue resistance. Addition of cobalt and chromium further reduces the co-efficient of expansion which makes piston suitable for use when proper cooling many not be possible.

Piston rings and piston pin are the components of piston sub-assembly. The outer surface of the piston ring is in close contact with the inner surface of the cylinder. The ring becomes perfect circle in the cylinder. In unassembled state, when left free, it is slightly oval. The rings are known as compression rings when these prevent leakage of hot flue gases during expansion. In addition to compression rings, there are oil rings meant for lubrication of piston sub-assembly, particularly in big engines.

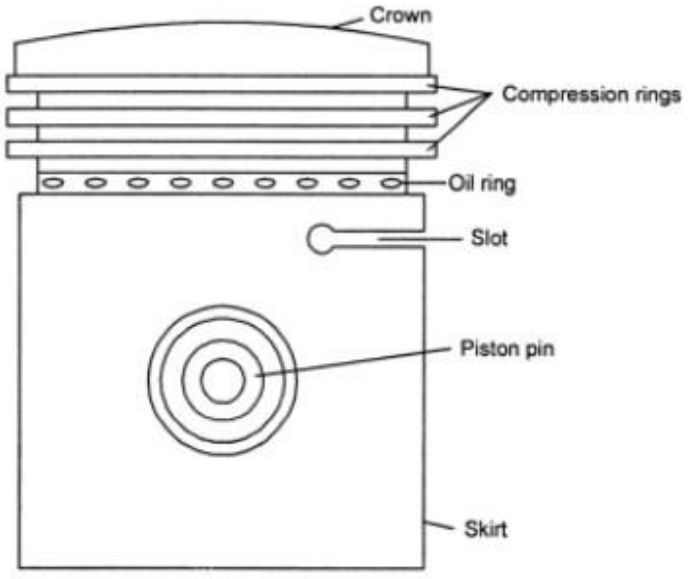


Fig. 2.5

2.2.5 Connecting Rod

As the name indicates it connects the piston with crankshaft. Its one end holds the piston pin and is known as small end. Other end, known as big end, holds the crank pin. It may have circular, rectangular, I, T or even H section. It is a steel forging and is highly polished for enhanced endurance strength. It is provided with a passage for transferring lubricating oil from the big end bearing (crank pin) to small end bearing (piston pin).

2.2.6 Crankshaft

The crankshaft requires detailed study as it is important component of the engine used in an automobile. Multicylinder engines are used in automobiles. The crankshaft of a multicylinder engine due to its shape and loading requires special attention of designers.

Basically a crankshaft converts the reciprocating motion of the piston(s) to rotating one. It applies the principle of simple machine known as wheel and axle. The crankshaft is made from steel forging or casting and is machined to provide suitable journals for connecting rod and main bearings. The parts of the crankshaft from main bearing journal to the connecting rod bearing journals are called crank arms or cheeks. The length of the crank arm determines the stroke of the engine. From the centre of the main bearing journal to the centre of the connecting rod bearing journal is half the engine stroke. The part of the crank shaft inside the connecting rod bearings is called the crank pin and those inside the main bearings are called the main journals (Fig. 2.6).

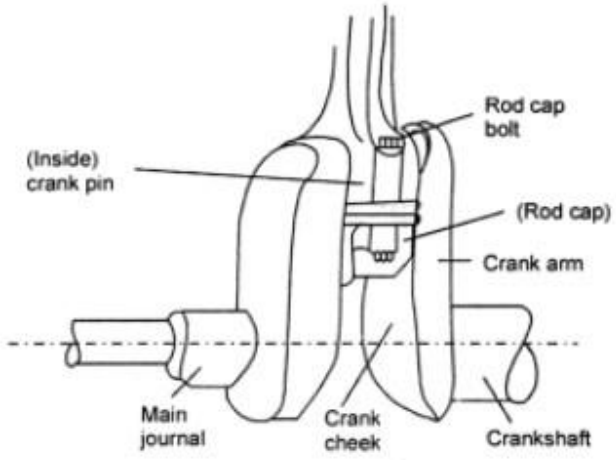


Fig. 2.6

The number of main bearings varies with the design of the engine and number of cylinders. There must be atleast two *i.e.,* one at the front and another at the rear of the crankshaft. More main bearings mean, less possibility of vibration and distortion of crankshaft of given size. To minimise the vibration in the engine crankshaft and flywheel are balanced separately and then often tested for balance when mounted together.