PARALA MAHARAJA ENGINEERING COLLEGE

BERHAMPUR, ODISHA

DEPARTMENT OF AUTOMOBILE ENGINEERING

Lecture Notes

(RAU4D001)

Two & Three Wheelers

Prepared By:-

Mr. Kamala Kanta Sahoo

Assistant Professor,

Department of Automobile Engineering

Contents

S no		page no
	INTRODUCTION	01
1.1	History of Automobile	01
1.1.1	History of Motorcycle	02
1.1.2	Modern Motorcycle Industry	04
1.2	Concept of Two Wheeler And Three Wheeler	06
1.3	Passenger Carrying Three Wheeler	09
1.4	Goods Transport Three Wheeler	09
1.5	Future of Two and Three Wheelers	10
1.6	Classification of Two Wheelers	10
1.7	Classification of Three Wheelers	11
1.8	Comparison between Two Wheelers and Three Wheelers	12
1.9	Main Components of Motorcycle	14
1.10	Main Components of Three Wheelers	18
	THE POWER UNIT	
2.1	Source Of Energy	23
2.1.1	Definition Of ‘Engine’	23
2.1.2	Heat Engine	23
2.1.3	Classification And Some Basic Details Of Engines	24
2.1.4	External Combustion and Internal Combustion Engines	25
2.2	Engine Components and Nomenclature	26
2.2.1	Engine Components	26
2.2.2	Nomenclature	30

2.3	Four–Stroke Engine	33
2.3.1	Valve Timing Diagram for Four Stroke Diesel Engine	35
2.3.2	Valve Timing Diagram for Four-Stroke Petrol Engine	36
2.4	Working Principle of Two Stroke Engine	39
2.5	Comparisons between Two Stroke and Four Stroke Engine	41
2.6	Merit and Demerits of Four Stroke Petrol Engine over Two Stroke	42
2.7	Symmetrical Port Timing Diagram for Two Stroke Engine	43
2.8	Asymmetrical Port Timing Diagram	44
2.9	scavenging	44
2.9.1	Cross Flow Scavenging	45
2.9.2	Loop Scavenging	46
2.9.3	uniflow scavenging	49
2.10	Scavenging Efficiency	50
2.11	Scavenging pump	50
	CHASSIS AND SUB SYSTEMS	
3	frame	54
3.1	Classification of Frames	54
3.1.1	Two wheelers frame	55
3.1.2	Three Wheelers Frame	55
3.2	Three Wheelers Frames	67
3.3	Frame materials	69
3.4	What should be the main consideration while selecting a Frame	69
3.5	Other Factors Considered For Designing Frame	74

3.6	Motorcycles Drive System	78
3.7	Clutches	79
3.7.1	Positive Displacement Type Clutch	80
3.7.2	Frictional Clutch	82
3.7.2.1	Single Plate Clutch	82
3.7.2.2	Multi plate dry clutch	87
3.7.2.3	Multi Plate Wet Clutch	90
3.7.2.4	Cone Clutch	91
3.7.2.5	Fluid Friction Clutch	93
3.8	Gearbox	94
3.8.1	Sliding Mesh Gearbox	94
3.8.2	Constant mesh gearbox	97
3.8.3	Gearbox of motorcycle	100
3.8.4	Synchromesh Gearbox	102
3.8.5	Epicyclical Gearbox	104
3.9	Suspension System of Motorcycle	105
3.9.1	Front suspension system	105
3.9.1.1	Conventional Type Telescopic Front Suspension System	106
3.9.1.2	Spring and Damper Front Suspension System	107
3.9.2	Rear suspension system	109
3.9.2.1	Plunger suspension system	110
3.9.2.2	Swing Arms Type Suspension System	111

FUEL SYSTEM

4.1	Fuel System	113
4.2	Classification of fuel system	113
4.2.1	S.I engine fuel supply system	113
4.2.2	C.I Engine Fuel Supply System	116
4.2.3	Motorcycle Fuel Supply System	120

LUBRICATION SYSTEM

5.1	Splash Lubrication System	122
5.2	Splash and Pressurized Lubrication System	123
5.3	Pressurized Lubrication System	124
5.4	Dry Sump Lubrication System	126

IGNITION SYSTEM AND STARTING SYSTEM

6.1	Magneto Ignition System	127
6.2	Battery Ignition System	131
6.3	Electronic Ignition System	136
6.4	Starting System	140
6.4.1	Kick starter system	140
6.4.2	Rope starting mechanism	144
6.5	Comparison between kick starting and self-starting mechanism	145

BRAKING SYSTEM

7.1	Mechanical Linkage Braking System	148
7.1.1	Drum braking system	148

7.1.2	Disc braking system	151
7.2.1	Combined Braking System	154
7.2.2	Antilock Braking System	155

WHEELS AND TYRES

8.1	Spooked wheel	159
8.2	Alloy wheel	161
8.3	Disc wheels	163
8.4	Tyres and Tubes	165
8.4.1	Bias- Ply Tyre	168
8.4.2	Radial Ply Tyre	170
8.4.3	Belted-bias tyre	171
8.5	Comparison between radial ply and cross ply tyre	173
8.6	Tubes	174

STABILITY CONTROL AND MANUFACTURING PROCESS OF AUTOMOTIVES

9.1	Gyroscopic effect	176
9.1.1	Gyroscopic effect on motorcycle	176
9.1.2	Steps should followed by driver to control stability	179

9.2	Stability Of Three Wheeler	178
9.2.1	Steps for stability control in three wheeler	180
9.3	Steps Involved For Manufacturing	182

CASE STUDY, TROUBLE SHOOTING AND MAINTAINANCE

10.1	Yamaha rx-100	185
10.2	KTM India	187
10.3	Royal Enfield	189
10.4	Hero Moto corps limited	190
10.5	Honda motorcycle limited	191
10.6	Piaggio ape	192
10.7	Bajaj RE Three Wheeler	193
10.8	Problems and Remedies in Two Wheelers	195
10.9	Problems and Remedies in Three Wheelers	199

INTRODUCTION

In recent century due to invention of new technology by inventers which is greatly helped mankind in different way. From all these invention automotive invention is the best technology which is helped mankind in transportation sector so people saved their money and effort which they later used for some other purpose so our great civilization flourished in all sector. There are different model of automobile available in market from all these models the best and cheap way of transportation is done by means of two wheelers and three wheelers. Because our planet have nearly nine billions of people all people are not afford big car and for short distance traveler two wheeler is the best mode of transportation and for group of people travelling to same location three wheeler is best mode of travelling with less charges. So now-a-days for highly populated continent like Asia or for recreational purpose of western country two wheelers widely used and due to low initial cost and cheap mode of transport three wheelers mostly used in Indian subcontinent and north eastern Asian countries.

1.1 History of Automobile:

Automotive industry first blossomed from European country i.e. Germany by great engineer carl Benz in the year (1886) he patented his first motor wagon.car becomes widely available to the mass in 20_{th} century in the year 1908 MODEL T an American car manufacturer by ford motor company widely accepted by people of America. Which replaced by horse driven cart rapidly but much later accepted by western European country Before him there is less development in this sector engineers like Nicholas august Otto’s four stroke Otto cycle (1876)

development and, Rudolf diesel(1897) diesel engine development got slow momentum due to lack of idea in advance automotive sector. People used only steam power and coal power engine to propel their cycle. So for first time Carl Benz fitted one gasoline engine two his motor wagon and after many difficulty and changes in design of motor wagon finally in the year (1886) he succeeded to showcase his invention of the motorwagon-3 in Paris expo. Which got great spectator and in the year 1888 the first commercial sell of Benz motor wagon sold in Paris.

1.1.1 History of Motorcycle:

The first internal combustion, petroleum fueled motorcycle was the Daimler reitwagon. It was designed and built by the German inventors Gottlieb Daimler and Wilhelm May Bach in Bad Cannstatt Germany in 1885. But this invention got less momentum due to difficulty for steering in turning and straight fork design. The inventors called their invention the Reitwagen ("riding car"). It was designed as an expedient test bed for their new engine, rather than a true prototype vehicle.

The first commercial design for a self-propelled cycle was a three-wheel design called the Butler Petrol Cycle, conceived of Edward Butler in England in 1884. He exhibited his plans for the vehicle at the Stanley cycle show in London in 1884. The vehicle was built by the merry weather fire engine company in Greenwich, in 1888.

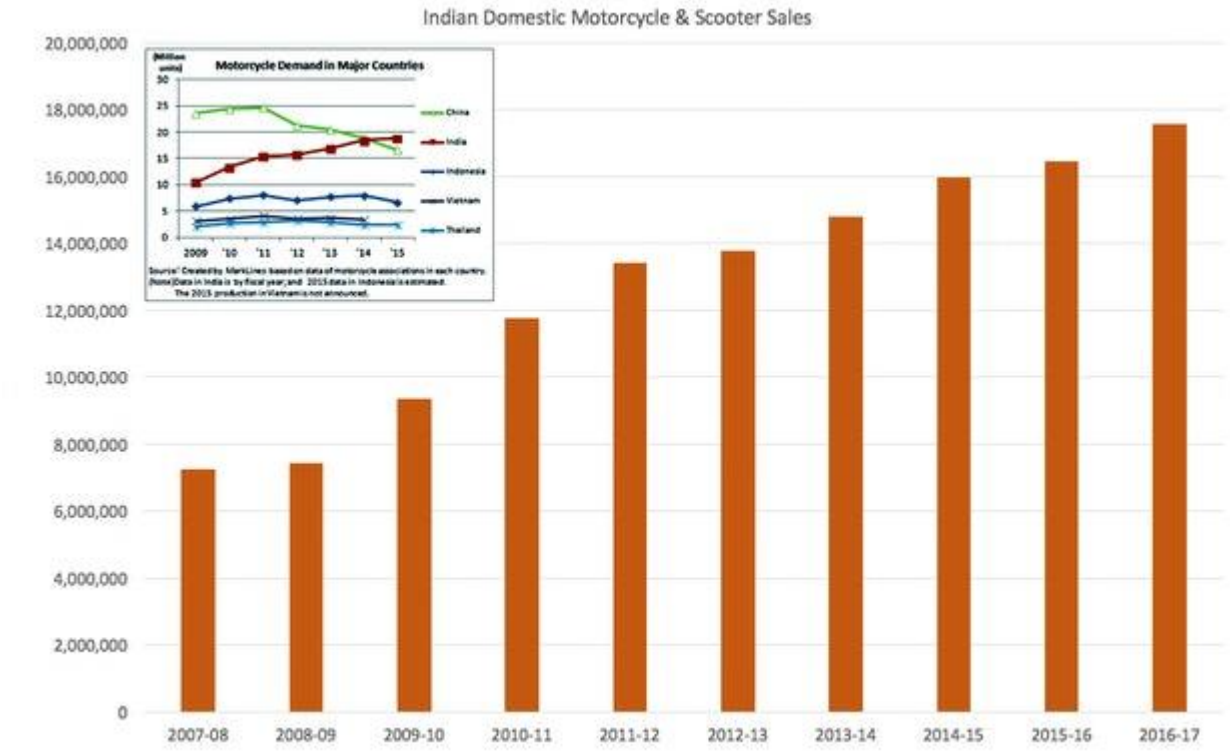
In 1894, Hildebrand & wilfmuller became the first series production motorcycle, and the first to be called a motorcycle. Excelsior Motor Company, originally a bicycle manufacturing company based in Coventry, England, began production of their first motorcycle model in 1896. The first production motorcycle in the US was the Orient-Aster, built by Charles Metz in 1898 at his factory in Waltham, Massachusetts.

In the early period of motorcycle history, many producers of bicycles adapted their designs to accommodate the new internal combustion engine. As the engines became more powerful and designs outgrew the bicycle origins, the number of motorcycle producers increased. Many of the nineteenth century inventors who worked on early motorcycles often moved on to other inventions. Daimler and Roper, for example, both went on to develop automobiles.

At the turn of the 19th century the first major mass-production firms were set up. In 1898, Triumph Motorcycle in England began producing motorbikes, and by 1903 it was producing over 500 bikes. Other British firms were Royal Enfield, Norton and Birmingham small Arms Company who began motorbike production in 1899, 1902 and 1910, respectively Indian began production in 1901 and Harley-Davidson was established two years later. By the outbreak of World War I, the largest motorcycle manufacturer in the world was Indian, producing over 20,000 bikes per year.

1.1.2 Modern Motorcycle Industry:

In the 21st century, the motorcycle industry is mainly dominated by the Indian motorcycle industry and by Japanese motorcycle companies. In addition to the large capacity motorcycles, there is a large market in smaller capacity (less than 300 cc) motorcycles, mostly concentrated in Asian and African countries and produced in China and India. A Japanese example is the 1958 Honda super Cub, which went on to become the biggest selling vehicle of all time, with its 60 millionth unit produced in April 2008. Today, this area is dominated by mostly Indian companies with Hero MotoCorp emerging as the world's largest manufacturer of two wheelers. Its Splendor model has sold more than 8.5 million to date. Other major producers are Bajaj and TVS Motors.



If you observe from the graph shown in above figure can see that Indian motorcycle company manufacturing motorcycle in increasing trend still there is a huge market waiting for low cost motorcycle manufacturer in western Asian country, African union and neighboring country of India like Srilanka, Bangladesh, Nepal etc.

1.2 Concept of Two Wheeler And Three Wheeler:

"The term two wheeler is derived from the vehicle which is run by means of two wheel and can be controlled by a person sitting above it" Unlike four wheeler it doesn't have covering due to limited space for sitting purpose only. And it is a self-propelled vehicle which get its power from IC engine, electric motor etc. and the transmission system generally used as sprocket chain drive, now a days modern scooter used CVT for transmitting power from source to road wheel.

Some electric motor directly coupled with road wheel to transmit power and generation of electric power by means of regenerative braking system.

The above figure shows a basic configuration of two-wheeler motor cycle with engine space, road wheel, body, frame, and handle for driver control etc.

The comfort to driver and passenger in uneven road condition, road bumps, and potholes is achieved by front and rear suspension system which consist of spring, damper etc. Small battery might use for providing current to light systems, warning system some time starting and ignition system so due to low fuel consumption, easy to control, different color variant and cheaper cost of motorcycle it is widely used by low income group, off road sports vehicle, recreational vehicle for thrill riding

“The term three wheeler derived from the vehicle which is run by means of three wheel for better control, comfort and carrying more passenger in it” the control system is similar to two wheeler control system except the driver and passenger sitting place is covered by nylon covering or sheet steel which is helpful for saving from rain and sun light as shown in below figures.

Three wheelers get its power from either ic engine or electric motor and the transmission system is different from that of motorcycle transmission system, because instead of chain or cvt drive transmission system it uses transmission system like four wheeler from engine to gear box and from gear box to rear road wheel by means of differential and CV (constant velocity) joint

As shown in above figure the three wheeler is mainly classified according to types of load carried i.e.

1. Passenger carrying three wheeler.
2. Goods transport three wheeler.

1.3 Passenger Carrying Three Wheeler:

In case of passenger carrying three-wheeler the driver sat on front seat of vehicle and controls the vehicle handle like a two wheeler driver control his/her motorcycle. And also changes the gear and speed according to requirement or road condition. In front of the driver wind shield is fitted to see through front of vehicle and protect from rain and wind flow which is not possible in case of two wheeler. Near the driver there is all controlling components like gear changing lever, accelerator bar, brake pedal, parking brake situated which is helpful to driver during driving on road.

And rear of the vehicle consists of engine mounting, differential, gearbox assembly, CV drive and road wheel above all these components passenger seat fitted with some pressed steel sheet cladding which provide both strength and covering of engine and transmission system. The top covering of the three-wheeler generally covered by nylon or resin sheet which has the advantages of low cost and easy for installation.

The lower body of three wheeler is a single component made of pressed steel sheet joined together by spot welding and seam welding process so it gives the advantages of less sprung mass of the vehicle so initial cost of the three wheeler reduced and above the lower body steel pipes are bolted or welded for covering the vehicle with resin material.

1.4 Goods Transport Three Wheeler:

The construction of goods carrying three wheeler is similar to passenger carrying three wheeler but the main difference is instead of top covering with resin the body fitted with tray which is mounted above engine which is shown in above figure and the good which to be carried

is loaded on metal tray so that less volume of goods can be transported with less cost for a shorter distance.

1.5 Future of Two and Three Wheelers:

As we know that due to increasingly use of automotive vehicle there is a rapid depletion of petroleum products happening around world. Two wheeler and three wheelers consumes a fraction of fuel what burnt by big passenger and transport vehicle because of good fuel efficiency but this also impacting our mother earth because use of old two stroke powered motorcycle and unnecessary use of motorcycle by large population concentrated in a small geographical area. So there is an urgent need of solution to this problem by implementing battery powered motorcycle and three wheelers so we can save some fuel for future generation and can efficiently use our resources to check pollution level of environment.

So research activity is widely carried out by researchers and academician in worldwide and India itself to develop new motorcycle and three wheelers which is use electric power source to give power to road wheel and also sustainable to future generation and save our foreign reserve which is mostly spent for procurement of petroleum from petroleum producing country.

1.6 Classification of Two Wheelers:

Two wheelers are broadly classified according to

Types of power source used:-

1. i.c engine powered two wheelers
    a. Two stroke engine powered.
    b. Four stroke engine powered.
2. electric motor powered motorcycle:-

   a. in wheel mounted motor (regenerative braking type)
   b. Separate motor mounted type.

3. Hybrid powered motorcycle
   a. Hybrid scooter.

Types of transmission system used:-

1. Chain drive motorcycle
2. CVT drive system
3. Direct drive mounted motorcycle.

According to use of motorcycle:-

1. Sports bike
2. Dirt bike
3. Utility motorcycle.
4. Daredevil bike
5. Scooters and mopeds.
6. Off road use motorcycle.

According to types of fuel used.-

Diesel, petrol, hybrid, hydrogen fuel motorcycle etc.

There are many more types of custom bikes are available in market as per requirement and customer need.

1.7 Classification of Three Wheelers:

Three wheelers are mainly classified as

According to types of power source used:-

1. Two stroke engine powered vehicle.
2. Four stroke engine powered vehicle.
3. battery powered three wheelers

According to types of fuel used:-

1. diesel fuel powered vehicle
2. Gasoline powered three wheeler.
3. Gas powered engine.
4. Bio-fuel powered three wheelers.

According to purpose of use:-

1. Passenger carrying vehicle.
2. Goods transport vehicle.
3. Multipurpose three wheelers.

According to types of rear suspension system used:-

1. Independent type suspension three wheelers.
2. Trailing arm type suspension vehicle.

1.8 Comparison between Two Wheelers and Three Wheelers:

Two wheelers	Three wheelers
➢ Supported by two wheels which is controlled by driver sitting atop vehicle so controlling is difficult. ➢ Maximum two people can be travelled for comfort riding.	➢ Supported by three wheels so controlling is easier. ➢ More than two people can be able to travel. ➢ Both diesel and petrol engine widely used so more sound comes if diesel engine used.

➢ Only uses gasoline engine so compact engine size and smoother ride. ➢ Less dangerous if driver is experienced while turning. ➢ Both initial and maintenance cost is less compare to three wheeler ➢ Chain drive and CVT mostly used for rear transmission. ➢ Engine started by means of kick starter mechanism or self-starter using battery and starter motor. ➢ Only uses gasoline fuel. ➢ Gear changes by means of left foot of driver some motorcycle have CVT transmission so no need of gear changing. ➢ No safety to passenger from wind, rain and sun ray. ➢ No provision for backward travelling due to front steering handle.	➢ Dangerous if run in high speed in turning due to changes of center of gravity ➢ Initial as well as maintenance cost is higher. ➢ Differential and CV joint rear transmission implemented. ➢ Engine Started by using rope or self-starter. ➢ Gasoline, diesel, and gaseous fuels are widely used due to more space available. ➢ Shifting of gear done by using hand. ➢ Safety of passenger is better from sun, wind and rain due to nylon covering overhead in case of passenger transport three wheeler. ➢ Vehicle can move both forwarded and backward direction whenever required.

1.9 Main Components of Motorcycle:

1. I.C engine as power source.
2. Vehicle body.
3. Frame or backbone of motorcycle.
4. Road wheels.
5. Transmission systems.
6. Suspension system etc.

1.9.1 I.C Engine:-

Internal combustion engine is the heart of the motorcycle because if the motor cycle doesn't have the engine it is considered as scrap, Or in other word if the engine fails to start total motorcycle stops functioning. In earlier motorcycle two stroke engine widely used due to its compact design, less cost and availability of power stroke in every revolution of crank shaft etc. but due to less power output and less fuel economy slowly two stroke engines are replaced by four stroke engine so greater availability of power, higher fuel economy and can be operated in any condition achieved still research are going on to achieve to further reduce pollution, better fuel economy etc.

1.9.2 Vehicle Body:-

The body of the motorcycle consists of driver seat, fuel tank, thermoplastic cladding for better appearance and stylish front visor which also used for reduction of air drag, battery housing, air filter housing and storage space for goods in case of scooter model. Generally body is made of hard plastic material, fiber glass or aluminum alloy for long lasting and good appearance from outside.

1.9.3 Frame or Backbone of Motorcycle:-

The main function of frame is to support the passenger load and give stability to vehicle and absorb all shock load from road while motorcycle in operation. It should have high strength, toughness, good resilience property, easy to manufacture and good machining property.

There are different types of frame used in motorcycle according to necessity of driver i.e. if driver wants stylish looking or comfortable to riding. So accordingly he/she choose the vehicle frame. The motorcycle frame made of mild steel, pressed steel or aluminum alloy for good looking and light weight purpose. Material which to be joined together to became frame of a motorcycle are to be welded together which should be properly checked for quality and durability of joint.

1.9.4 Road Wheels:-

The function of the road wheel is to carry all load of vehicle i.e. sprung mass and unsprung mass of the motorcycle. The front road wheel is freely rotates and the rear road wheel connected with transmission system so that it can give angular velocity to wheel. Due to friction produced between road wheel and road surface motorcycle moves to forward direction. As we know that rubber material has high coefficient of friction so it is used for making tyres along with some filler material and steel wire to increase strength and rigidity of tyre.

Generally the wheel is mounted on hub of the motorcycle by means of bearing and bush for freely rotation of wheel. Old motorcycle used spooked wheel or rim which is three part construction i.e. Inner hub, spoke, and rim which also required tube inside tyre to maintain proper inflation pressure which has disadvantages of leakage prone. But now a days wheels are comes with single piece or in engineering term called as alloy wheel which is more efficient than

spooked wheel because wheel is made of single component, lighter and stronger material used, the usage of tube inside tyre eliminated so by in turn the chance of flat tyre drastically reduced. And the tyre can be quickly repaired without dismantling the tyre from the rim of wheel.

1.9.5 Transmission Systems:-

The transmission system is the main component of motorcycle for maintaining torque and speed for different load and road condition. Motorcycle transmission system mainly classified as

1. Manual transmission system.
    I. Direct centrifugal clutch and chain drive system.
    II. Constant mesh gear and chain drive system.
    III. Direct rear wheel mounted transmission system.
2. Automatic transmission system
    I. CVT transmission system.

Old motorcycles or mopeds used manual transmission system for transmitting torque from engine to rear wheel by means of centrifugal clutch .when speed is low or during starting of moped the rear wheel chain drive disengaged from the engine by help of centrifugal clutch but when the speed starts to increases the driver pulley got engaged due to centrifugal action of clutch. But now a days modern motorcycle equipped with multiplate wet clutch, constant mesh gearbox, chain sprocket drive and gear changing mechanism so that large torque difference can be possible according to condition of driving. Some old scooters transmission system directly coupled with rear wheel hub so that chain drive system eliminated but due to one sided engine and gear box mounting the motorcycle try to pull one side while driving so to drive this type of scooter experienced driver required.

Now a day's almost all scooter manufacturer using automatic transmission instead of manual transmission for their scooter so the intricate gearbox, multiplate clutch and chain drive eliminated which in turn reduces weight of scooter. Automatic transmission mostly uses CVT for transmitting direct engine power to road wheel the cvt system consists of automatic adjustable type centrifugal belt drive pulley and spring loaded driven pulley in which diameter of pulley also changes by means of centrifugal action of dead weight and toothed rubber belt for connecting two pulley. In automatic transmission small fixed speed reduction gearbox also mounted on rear wheel hub so the speed of road wheel further reduced.

Comparison between Manual and Automatic Transmission System:

Manual transmission	Automatic transmission
➢ Speed and torque of motorcycle changes manually ➢ More numbers of components so initial cost is higher. ➢ Less fuel consumption ➢ Difficult to control in stop and go traffic. ➢ Maintenance cost also higher. ➢ Frequent observation required. ➢ Power transmitted through Clutch and gearbox	➢ Speed changes automatically according to load condition. ➢ Less number of component so initial cost is lower. ➢ Fuel consumption is higher due to cvt. ➢ Easy to drive in stop and go traffic. ➢ Maintenance cost is lower compare to manual transmission system. ➢ No frequent observation required. ➢ Clutch and gearbox eliminated for power transmission.

1.9.6 Suspension System:-

In every vehicle small road vehicle to locomotive suspension system is crucial for providing comfort to passengers, absorb shock during travelling in uneven road, to carry total sprung mass of vehicle without suspension system the vehicle might not favorable for transportation of passenger and goods by human being.

The motor cycle suspension system also similar to large vehicle but due to space constraint mostly few types of suspension system widely used in motorcycle these are

1. Telescopic front suspension system.
2. Side suspension system.
3. Swing arm rear suspension.
4. Twin shock absorber rear suspension system.
5. Single center suspension system.

For front wheel telescopic suspension system universally adopted by motorcycle manufacturer due to its light weight, easy of steering and load transferring capability. But now a days for rear wheel of motorcycle many types of suspension system used i.e. twin shock absorber suspension system, single center mounted suspension system, swing arm suspension system etc.

The absorber of suspension system also different types such as

- Oil and spring loaded shock absorbers.
- Nitrous suspension system.

1.10 Main Components of Three Wheelers:-

Three wheeler have also more or less similar components alike two wheeler except some extra components added. These are:-

1. Rope/self-started engine.
2. Pressed steel vehicle lower body.
3. Frame.
4. Suspension systems.
5. CV joint transaxles.
6. Integral gearbox and differential assembly.

1.10.1 Rope/Self-Started Engine:-

Unlike two wheeler three wheeler uses different types of engine as main power source of vehicle i.e. diesel engine, petrol engine/gas engine etc. old model vehicle engines are mostly run by two stroke engine but as the time advanced and to increase fuel economy and decreasing pollution two-stroke engine become absolute instead four stroke engine widely used by all three wheeler manufacturer. The engine generally mounted on the rear portion of vehicle which is connected to frame by means of rubber bush to absorb shock and vibration of engine. The engine now a day can be started by using rope or electric starter motor.

1.10.2 Pressed Steel Vehicle Lower Body:-

The lower body of the three wheeler is made of sheet steel joined together by means of spot and seam welding process and different shape of lower body obtained by different sheet metal work process such as bending, blanking, piercing, perforating etc. the finished welded sheet

metal body joined to frame of three wheeler by means of bolted joint some three wheeler body directly welded to frame for making temporary joint less vehicle body.

1.10.3 Frame:-

Frame is the backbone of any vehicle without it the stiffness of vehicle body reduces and unable to carry more load. So frame should be made of such stronger material which can absorb the shock load and gives stiffness to vehicle. Elliptical or rectangular mild steel pipe welded together to make frame of three wheeler. At the front side of the frame steering support welded and at the rear of the frame two extended beam either welded or pin jointed to both side for mounting wheel and rear suspension system.

1.10.4 Suspension Systems:-

The front suspension system is similar to the suspension system of scooter suspension system which is connected by means of trailing arm and coil spring and the rear suspension for old three wheeler is independent type swing arm suspension system but now a day due to advancement in suspension system rear suspension system are independent type which is mounted between frame and wheel axle. Dampers also used for damp down the spring vibration during motion of vehicle in different road condition.

1.10.5 Integral Gearbox and Differential Assembly:-

The gear box is directly mounted on engine which the output shaft of engine directly connected with the input shaft by means of integral key. Multi plate clutch also inserted between gear box and engine to connect and disconnect the engine power to gear box. At the output shaft of the gear box connected to small differential housing in which the output shaft of gear box rotates the crown wheel by means of driver pinion and finally power transmitted to road wheel

by the principle of differential mechanism. At the output of differential have inner spline too easy of mounting for transaxle shaft.

1.10.6 Cv Joint and Transaxles:-

In detail CV joint called as “constant velocity” joint which means the velocity of drive axle always remains constant irrespective of load and road condition because we know that while the vehicle moving on road due to bump, pot hole and uneven road condition the height of wheel always changes so the angle of transmission also changes if ordinary shaft connected between differential and road wheel it might not work properly so CV joints are widely used to transmit motion in any condition. The main component of CV joint has a male spherical bulb having three or four number of teeth around its periphery and another female spherical socket having three to four slot for mounting the male part so when the angle changes automatically the spherical bulb rotates so it can capable to transmit torque in any angle. Rubber dust cover also used to protect the joint from dust particle.

Review questions:

1. What is heat engine and how it is classified?
2. Differentiate between two wheeler and three wheelers?
3. Explain why i.c engines are mostly used in automotive? What are the advantages of it.
4. What are the main components of motorcycle? Explain in detail with diagram.
5. How power transmitted in two and three wheelers?
6. Comparisons between two stroke and four stroke engine.
7. Why C.V joint are necessary for power transmission in three wheeler.
8. What is suspension system and how is it helps passenger and goods?
9. Classify three wheelers.
10. What are the main components of three wheeler, explain in details?

THE POWER UNIT

2.1 Source Of Energy:

We are getting some form of energy for doing useful work for our daily lives so without energy the living beings are motionless. So mainly we get our entire energy requirement from sun by means of direct or indirect conversion. At a time the primary source of power for work was chiefly man's muscles. Later animals were trained to help man for doing his work afterwards wind power, steam power harnessed. But the main step taken when man learned the art of energy conversion from one from to another. The system which does this conversion is called an engine.

2.1.1 Definition Of 'Engine':

An engine is a device which transforms one form of energy into another form, normally most Of the engine converts thermal energy into mechanical energy and therefore they are called 'heat engine'. While converting energy the efficiency plays an important role.

2.1.2 Heat Engine:

Heat engine is a device which transforms chemical energy of a fuel into thermal energy and utilizes this thermal energy to perform useful work. Thus thermal energy converted to mechanical energy in heat engine.

Engine can be broadly classified into two categories:

a) Internal combustion engine(IC engine)

b) External combustion Engine(EC engine)

2.1.3 Classification And Some Basic Details Of Engines:

Whether internal combustion or external combustion are of two types:

(i) Rotary engine (ii) Reciprocating engine

A detailed classification of engine is given in below fig of the various types of engine, the most widely used ones are the reciprocating internal combustion engine, the gas turbine and the steam turbine. Now a days the steam engine is become absolute. The reciprocating internal combustion engine have some advantages over the steam engine due to the absence of heat exchanger. So internal combustion engine is simple in construction.

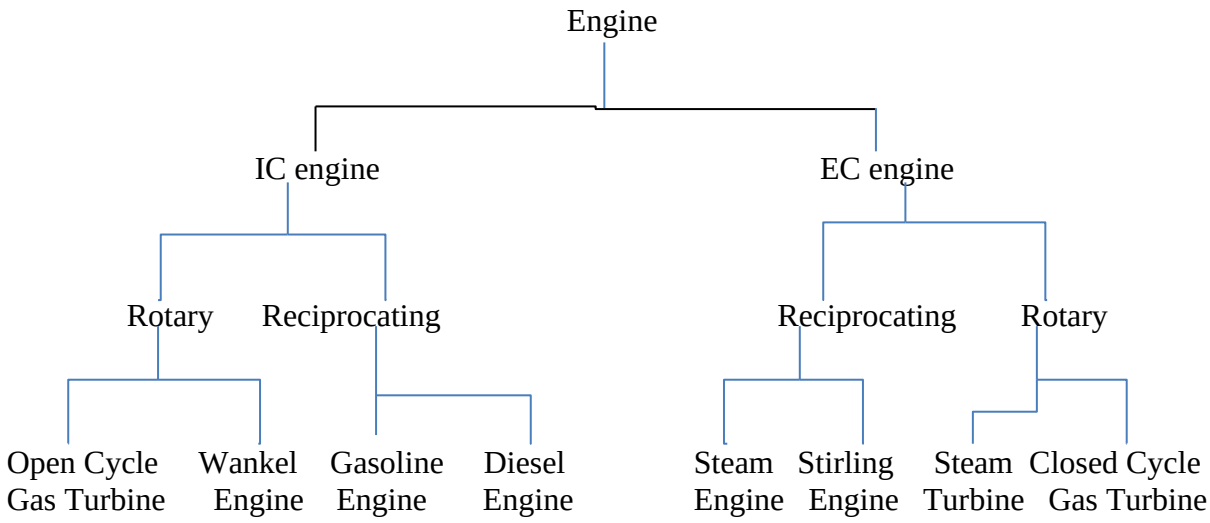


Fig. 2.1 Classification of engines

Another advantage of internal combustion reciprocating engine over the other two types is that all its components works on average temperature which is much below the working temperature of working fluid. Therefore, very high temperature working fluid can be employed resulting in higher thermal efficiency.

Further, in internal combustion engines, higher thermal efficiency can be obtained with moderate maximum working pressure of the fluid in the cycle and therefore the weight to power ratio is very less. And also it is possible to develop small size internal combustion is as per requirement.

The main disadvantage of this type of engine is the problem of vibration caused by the reciprocating components. Also it is not possible to use a variety of fuels in these engines. Only liquid or gaseous high quality fuel can be effectively used. So these fuels are expansive.

Considering all these advantages and disadvantages the reciprocating internal combustion engines have been found suitable for use in automobiles, motorcycles and three wheelers, scooters, locomotives and power units of relatively small output.

2.1.4 External Combustion and Internal Combustion Engines:

External combustion engine s are those engine in which combustion take s place outside the engine where as in internal combustion engine combustion takes place within the engine cylinder. For example, in a steam engine the heat generated by the combustion of fuel is employed to generate steam outside turbine. But in internal combustion engine the product of combustion generated by the combustion of air fuel mixture within engine cylinder.

2.2 Engine Components and Nomenclature:

As we can observe from outside internal combustion engine looking simple, but they have highly complex machine. There are hundreds of components which have to perform their function effectively to produce output power. There are mainly two types of engine e.g. spark ignition engine (SI) and compression ignition engine (CI). Some of the important engine components and the nomenclature associated with it discussed below.

2.2.1 Engine Components:

A sectional cross section of a single cylinder compression ignition engine with overhead valves is shown in Fig.2.2 the main components and their functions are briefly discussed below.

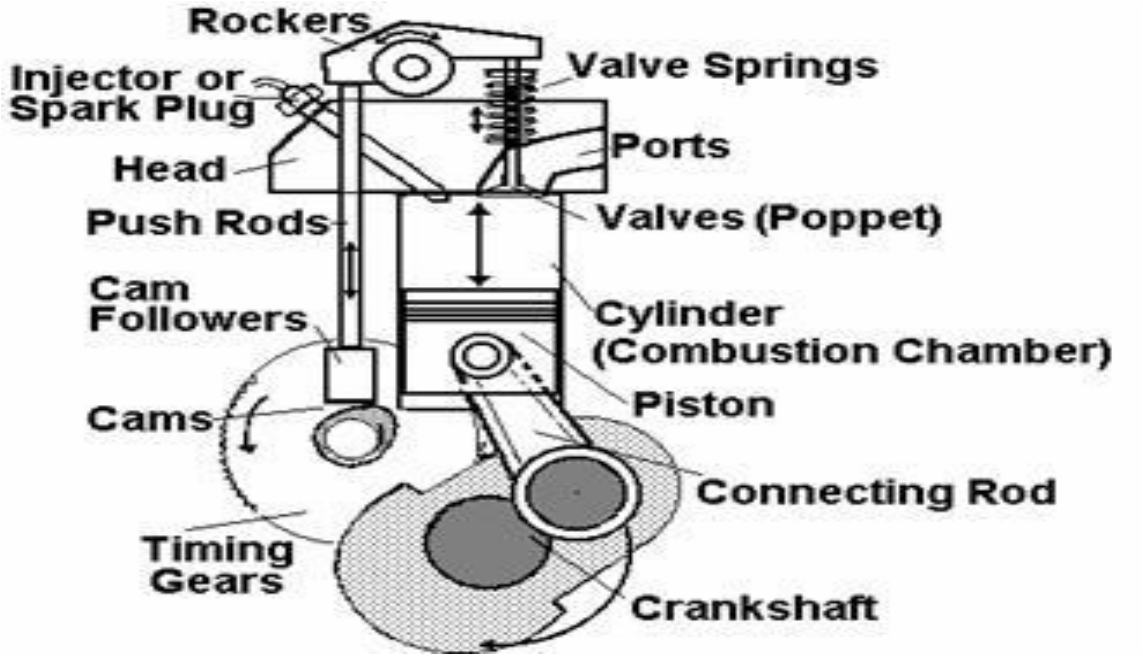


Fig. 2.2 Cross-section of a single cylinder engine

Cylinder Block: The cylinder block is the main supporting structure for the various components. The cylinder of multi cylinder engine are casted together as a single unit, called cylinder block. The cylinder head is mounted on the cylinder block. The cylinder block and cylinder head are provided with water jackets in the case of water cooling engine or cooling fins in the case of air cooled engine. Cylinder head gasket incorporated between cylinder block and head to make leak proof joint between two parts. The cylinder head fixed to

cylinder block by means of number of studs. The bottom portion of cylinder block is called crank case inside crank shaft fitted by means of main journal bearing and cup. Below crank case oil sump fitted to cylinder block by means of small screw in which lubricant drop and collected at one point for recirculation of lubrication system. The cylinder either directly machined used in smaller engine or liners fitted for large engine for smooth movement of piston inside cylinder. The crankcase made of cast iron material due to its easy of machining property, easy to cast, corrosion resistance and higher thermal conductivity.

Cylinder: As the name implies it is a hollow cylindrical vessel or space in which the piston makes reciprocating motion. The cylinder either casted directly with crank case or separate part supported by cylinder block. The volume of engine measured by the size of cylinder. The cylinder either also made of cast iron or some time made of aluminum alloy for weight reduction purpose if liner used super finishing of inner cylinder is not required.

Crank shaft: The main function of crank shaft is to convert reciprocating motion of piston to useful rotary motion of the output shaft. In the crankshaft of a single cylinder engine there are a pair of crank arms and balance weight. The balance weight are provided for static and dynamic balancing of the rotating system. The crank shaft is fitted in the crank shaft by means of journal bearing. The crank shaft is either made of forging and casting process after that machined to require shape by special turning machine. The material mostly used for making crank shaft is chrome steel due to its strength and rigidity.

Piston: It is a cylindrical component fitted into the cylinder forming the moving boundary of combustion system. It fits perfectly into the cylinder providing a gas tight space with help of piston ring and the lubricant. The materials used for making piston are cast-iron, aluminum

alloys, steel etc. and made by means of die casting process for better finish and durability. A hole drilled parallel to piston face for mounting small end journal and connected by gudgeon pin. The top face of piston have slight contour which serves as combustion chamber some two stroke engine have integral deflector which is useful for scavenging operation.

Combustion Chamber: the space enclosed in the upper part of the cylinder, by the cylinder head and the piston top during combustion process, is called as combustion chamber. It should be thermally strong enough to absorb the heat output of combustion process.

Inlet Manifold: the pipe which connects the intake system to inlet valve of engine and through which air or air-fuel mixture is drawn into the cylinder is called inlet manifold. It is made of aluminum alloy and corners are trimmed for better mixture flow into cylinder without any obstacle.

Exhaust Manifold: the pipe which connects exhaust valve and silencer or muffler and through which the product of combustion escapes to atmosphere is called as exhaust manifold. Due to passing of hot burnt gases and to avoid corrosion problem it is made of cast iron material.

Inlet and Exhaust valves: the valves are generally mushroom shaped poppet type. They are provided either on the cylinder head or on the side of the cylinder for regulating the charge coming into cylinder or removal of exhaust gas from the cylinder. In all four stroke engine the size of the inlet valve is larger than exhaust valve for supplying more charge into combustion chamber.

Spark Plug: it is the component to initiate the combustion process in spark ignition engine and it is usually located on cylinder head.

Injector: It is the component of compression ignition engine through which high pressure diesel fuel sprayed into combustion chamber at the end of compression stroke so the burning of mixture started due to high pressure and temperature inside combustion chamber.

Connecting Rod: It interconnects the piston and crank shaft and transmits the gas force from the piston to crankshaft. The two end of the piston is called as small end and big end journal the small end connected to piston by gudgeon pin and big end connected to crank shaft big end journal by means of bushed cap.

Piston Rings: Piston rings fitted into the slot around the piston which helps to make a gas tight movable link between piston and cylinder thus preventing the leakage of flue gas into crankcase. Two type of rings are used in a piston i.e. compression rings and oil rings so oil ring mounted at crank shaft side slot for wiping out extra oil from engine cylinder

Camshaft: The camshaft and its associated parts control the opening and closing of inlet and exhaust valve at proper time and angle. The associated parts are rocker arm, push rod, valve springs, tappets etc. the shaft also provides drive to ignition and lubrication system .it is driven by the crank shaft through timing gear. The shaft is made of forged steel.

Cams: these are made as integral parts of the camshaft and are so designed to open the valve at the correct timing and to keep them open for the necessary duration.

Flywheel: As we know that four stroke engine have one power stroke at every two revolution of crankshaft so the engine fluctuates causing a change in the angular velocity of the shaft. In order to achieve uniform torque an inertia mass in the form of fly wheel is attached to crank shaft so it can absorb energy during surplus and release back when there is

shortage of energy so maintain uniform angular velocity throughout the cycle.so the wheel is called fly wheel and is made of either cast-iron or mild steel.

Gudgeon Pin: it links the small end of connecting rod and the piston .the gudgeon pin freely rotated inside piston hole by means of needle roller bearing or bush.

2.2.2 Nomenclature:

Cylinder Bore (d): The nominal inner diameter of the working cylinder is called the cylinder bore and is designed by the letter d and is usually expressed in millimeter (mm).

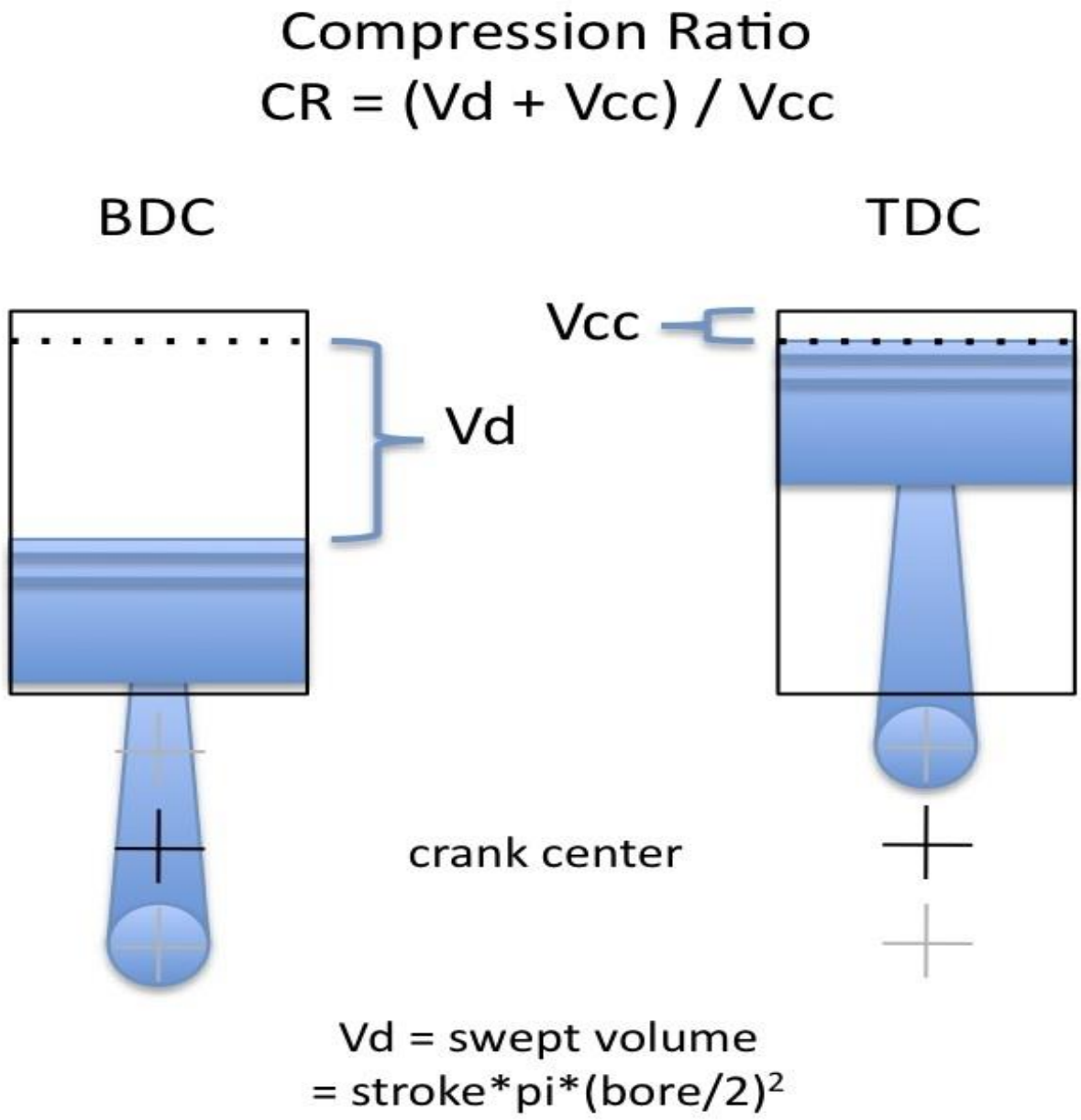
Piston Area (A): The area of a circle of diameter equal to the cylinder bore is called the piston area and is designated by the letter A and is usually expressed in square centimeter (cm^2).

Stroke (L): The nominal distance through which a working piston moves between the two successive reversals of its direction of motion is called stroke and is designated by the letter L and is expressed usually in millimeter (mm).

Stroke to Bore Ratio: L/d ratio is an important parameter for classifying the size of the engine. If d < L, it is called as under square engine. If d = L, it is called square engine. If d > L, it is called over- square engine. An over square engine can be operate at higher speeds because of larger bore and shorter stroke.

Dead Centre: The position of the working piston and the moving parts which are mechanically connected to it, at the moment when the direction of the piston motion is reversed at either end of the stroke is called the dead center. There are two dead center in an engine as indicated in fig. 2.3. They are:

(i) Top dead Centre (ii) bottom dead Centre



(i) Top dead Centre (TDC): It is the dead Centre when the piston is farthest from the crankshaft. It is designated as TDC for vertical engines and inner dead center for horizontal engines.

(ii) Bottom Dead Centre (BDC): it is the dead center when the piston is nearest to crankshaft. It is designated as BDC for vertical engine and outer dead center for horizontal engines.

Displacement or swept Volume (V_s): The nominal volume swept by a piston when moves from BDC to TDC is called displacement volume. It is expressed in terms of cubic centimeter (cc) and given by,

$$V_s = A \times L = \pi r^2 / L \qquad (2.1)$$

Cubic Capacity or Engine Capacity: the displacement volume of a cylinder multiplied by numbers of cylinder in an engine will give the cubic capacity of engine. For example, if there are K cylinders in an engine, then

$$\text{Cubic capacity} = V_s \times K$$

Clearance Volume (V_c): The nominal volume of the combustion chamber above the piston when it is at the top dead center is the clearance volume. It is designated as V_c and expressed in cubic centimeter (cc).

Compression Ratio (r): it is the ratio of the total cylinder volume when the piston is at the bottom dead center, V_T, to the clearance volume, V_c. it is designated by letter r.

In this book we only cover about reciprocating internal combustion engines due to these engines only used in motorcycle and three wheeler as the main power source. So we already know that internal combustion engine classified as:-

1. four-stroke engine
    (a) Four- stroke diesel engine.
    (b) Four- stroke petrol engine.
2. Two-stroke engine
    (a) Two-stroke diesel engine
    (b) Two-stroke petrol engine

2.3 Four–Stroke Engine:

Four stroke engine is named after according to the number of working stroke or cycle of an engine. E.g. suction stroke, compression stroke, and expansion stroke, exhaust stroke, in this engine the cycle of operation completed by two revolution of crank shaft or 720^0 of crank rotation that means in every two revolution one cycle of operation would complete. So the main cycles of operation discussed elaborately below.

Suction stroke: At the starting of an engine the piston is at TDC and moves towards BDC. At the same time inlet valve is in open position and exhaust valve in closed position, due to movement of piston from TDC to BDC vacuum created inside engine cylinder as the chamber is below atmospheric pressure so fresh air in case of compression ignition engine and air fuel mixture in case of spark ignition engine enters into cylinder vacuum space through inlet manifold. In some compression ignition engine supercharger is used for

charging enough air to increase the volumetric efficiency of engine. Below figure shows the position and movement of piston during suction stroke.

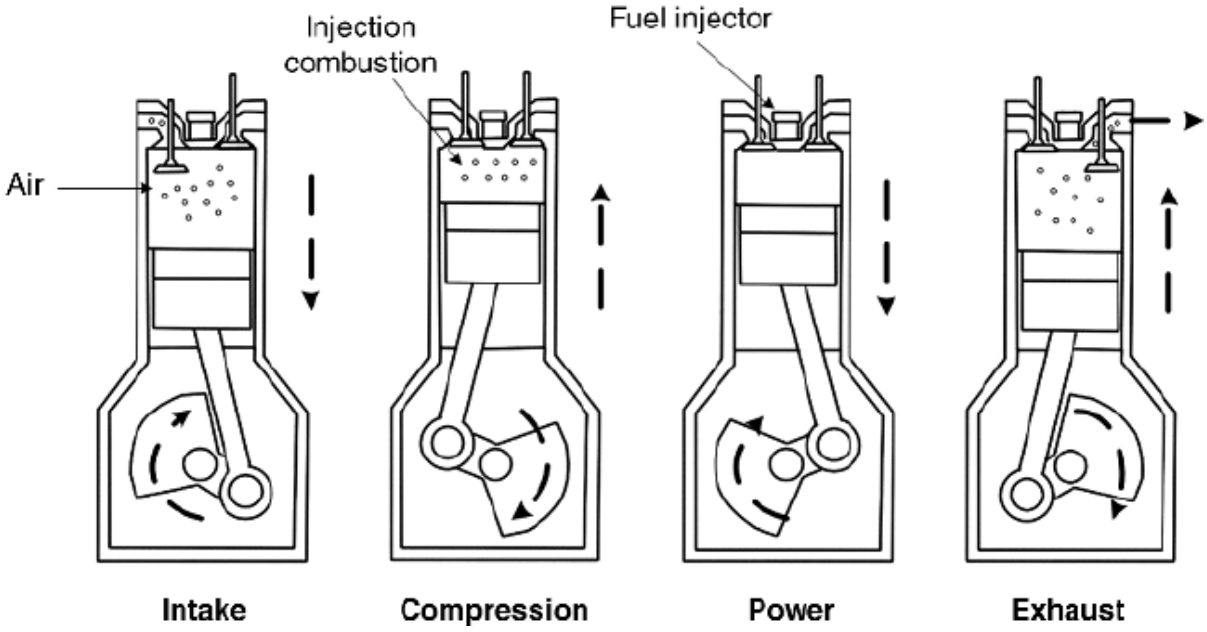
Compression stroke: During compression stroke of engine now the piston moves from BDC to TDC, at the same time both inlet and exhaust valve is in closed position so the amount of charge inducted into cylinder get compressed so increasing its temperature and pressure keeping the volume of charge constant so the charge can be easily ignited if it is a gasoline engine by the initiation of spark by the help of ignition system and diesel fuel injected into combustion chamber just before the end of compression stroke. Due to burning of air fuel mixture inside combustion chamber the pressure and temperature of gas further increases. Below figure shows the position and direction of piston movement during compression stroke.

Expansion stroke: As the temperature and pressure of the burning gas increasing rapidly inside cylinder it pushes the piston to downward direction from TDC to BDC as the piston moving towards BDC to decrease pumping load on piston during exhaust stroke exhaust valve opened early so it helps to escape some burnt gases to atmosphere due to pressure difference between inside and outside chamber. The energy produced during expansion stroke stored in fly wheel for uniform rotation of crankshaft during non-power stroke of engine so constant speed of four stroke engine maintained. Below figure shows the piston direction of motion during expansion stroke.

Exhaust stroke: this stroke completes the cycle of operation of four stroke engine below diagram showing the movement and direction of piston in this stroke. The piston moves from BDC to TDC and the inlet valve is in closed position and the exhaust valve is in open

position so when piston moves upward direction it pushes the flue gas out of the engine through exhaust manifold when the piston reaches near the TDC again cycle of operation repeated from suction to exhaust.

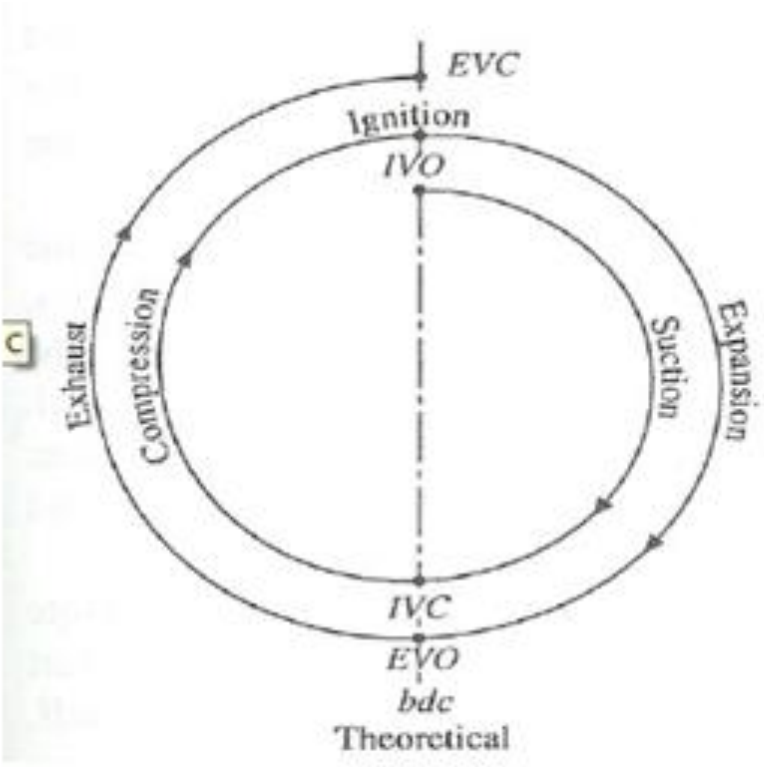
Four-stroke cycle (Diesel)



2.3.1 Valve Timing Diagram for Four Stroke Diesel Engine:

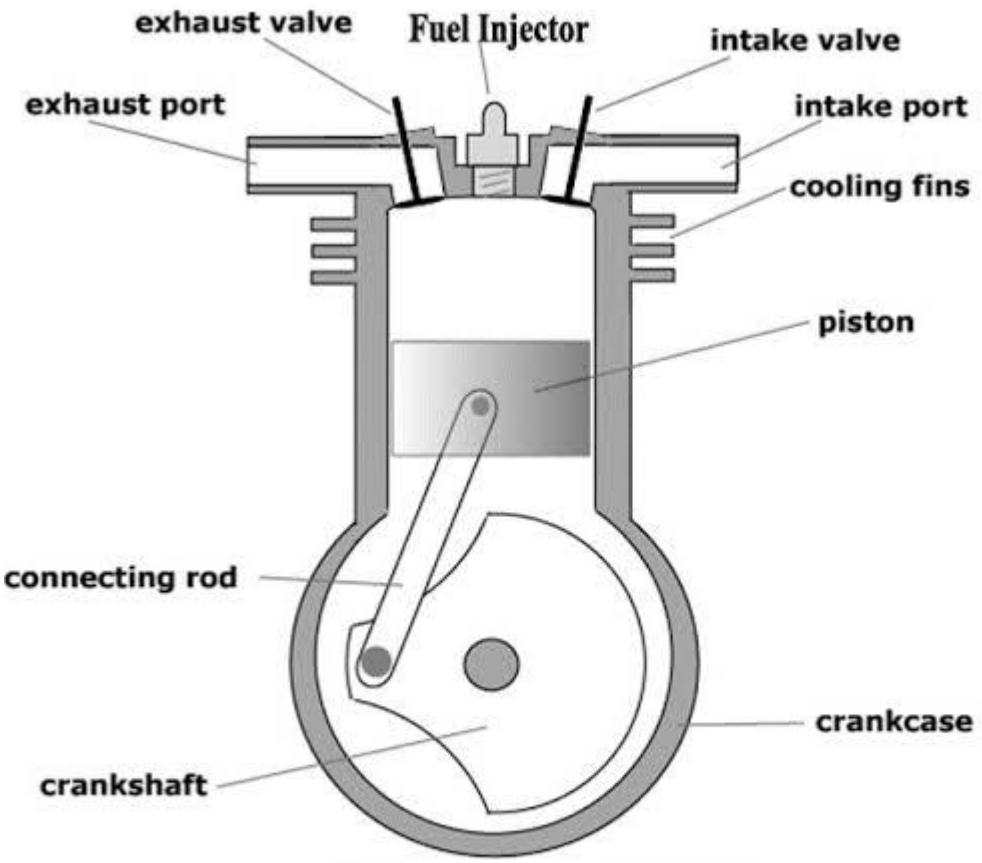
The valve timing diagram consists of the timing of opening and closing of valve during a cycle of operation of four stroke internal combustion engine. We know that the inlet and exhaust valve should be opened at proper time so the cycle of operation can be successfully achieved. Below fig. shows the theoretical valve timing diagram of four stroke engine. In this diagram the inlet valve opens at TDC and when the piston reaches to BDC the inlet valve closed so suction stroke completed in half revolution of crankshaft i.e. 180^0 rotation .

During the next half revolution of crankshaft both valve is in closed position so this is called as compression stroke of engine. And crank shaft rotated another 180^0 from TDC to BDC. When the piston again moves from TDC to BDC still both valve is in closed position and crank shaft rotated final 180^0 rotation so in total 720^0 of crank rotation achieved during the cycle of operation. Or two revolution of crank shaft.



But actual valve timing diagram is totally different from theoretical valve timing diagram in many aspect of engine operation such as engine doesn't start if valves open or close when is at TDC or BDC so actual valve timing diagram is used by engineers for manufacturing engine. In actual valve timing diagram suction valve opens 20^0 before piston reaches to TDC and closes around 35^0 after BDC because of downward movement of air so enough air can be inducted into combustion chamber during suction stroke. As air supplied for more time

period so diesel engines are called as lean burn engine. Below figure shows the position of different valve opening angle during cycle of operation of four stroke diesel engine. After closing of inlet valve actual compression of air starts when the piston moves from BDC to TDC at the end of compression stroke before 35^0 of TDC injection of fuel starts so due to high pressure and temperature of compressed air auto ignition of diesel fuel possible.



4 STROKE DIESEL ENGINE

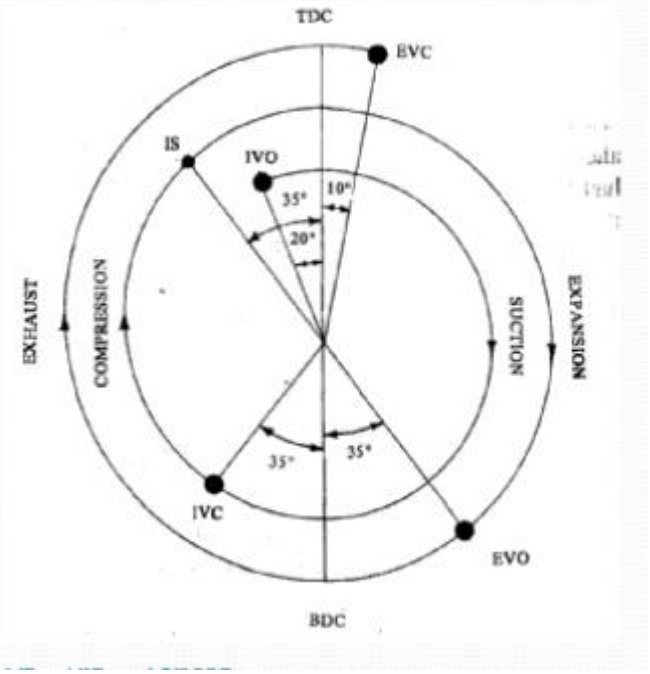
And injection of fuel continued for around 10^0 after TDC at that time all injected fuel properly mixed and become highly combustible mixture so high pressure and temperature

burnt gases pushes the piston from TDC to BDC so due to expansion of gas inside cylinder chamber this stroke is called as expansion stroke and before the end of expansion stroke when piston is 35^0 before BDC exhaust valve opens so that some exhaust gas automatically comes out to atmosphere through exhaust manifold and the exhaust stroke continues 10^0 after BDC so all gases should remove from combustion chamber. And the cycle of operation again repeated from suction to exhaust for subsequent rotation of crank shaft.

2.3.2 Valve Timing Diagram for Four-Stroke Petrol Engine:

The theoretical valve timing diagram for four stroke petrol engine is similar to four stroke diesel engine .only there is a slight difference for valve opening and closing time and ignition time. Below fig shows the valve timing diagram of four stroke petrol engine.

IVO – Inlet valve Opens
IVC – Inlet Valve Closes
IS – Ignition Starts
EVO – Exhaust Valve Opens
EVC – Exhaust Valve Closes
TDC – Top Dead Center
BDC – Bottom Dead Center



In four stroke s.i engine the working cycle starts with opening of inlet valve 20^0 before TDC at the same time piston moves from TDC to BDC so the stroke is called as suction stroke due to vacuum created inside engine cylinder fresh charge (air fuel mixture) inducted into

combustion chamber. And 35^0 after reaching BDC of piston inlet valve closes so due to charge velocity enough charge could be inducted inside combustion chamber at the same time piston moves in upward direction from BDC to TDC and both the inlet and exhaust valve is in closed position so the air fuel mixture get compressed to high pressure and temperature in such a way that it become very combustible when at the end of compression stroke 35^0 before piston reaching TDC ignition starts by means of ignition coil and spark plug. So the temperature and pressure of burning mixture further increased. As still both the valve is in closed position so the high pressure gas force the piston towards downward direction from TDC to BDC so the process is called as expansion process in this stroke the extra energy produced stored in fly wheel which is mounted on crank shaft and releases the energy during non-power stroke. 35^0 before end of expansion stroke the exhaust valve opened so some gases releases into atmosphere due to higher pressure inside engine cylinder.

Now at the last stroke i.e. exhaust stroke the piston moves to upward direction from BDC to TDC at the same time inlet valve is in closed position and exhaust valve is in open position so the burnt flue gases released to atmosphere through inlet manifold. Like this the cycle of operation repeated.

2.4 Working Principle of Two Stroke Engine:

The operation of two stroke engine is totally different from four stroke cycle engine because the four operation of four stroke engine is completed in one revolution of crank shaft instead of two revolution in four stroke engine.so every revolution have one power stroke. In this engine the working cycles combined in such a way that i.e. suction stroke

combined with expansion stroke and exhaust stroke combined with compression stroke by means of some special mechanism such as inlet valve connected into crankcase of engine, transfer port connecting crankcase, combustion chamber and deflector on piston for removal of exhaust gas and port mechanism instead of valve mechanism.

2.4.1 Downward Stroke:

When the piston moves from TDC to BDC or in downward stroke the burning gases get expanded so this process called as expansion stroke so in turn it pushes the piston downward. Due to downward movement of piston negative pressure created inside cylinder so to fulfill the vacuum space air fuel charge or only air enters into combustion chamber through transfer port from crank case of engine which is sealed for prevent any leakage of charge. So for first half revolution of crank shaft suction of charge and expansion of burnt gases completed in one stroke of piston.

2.4.2 Upward Stroke:

In upward stroke the piston moves from BDC to TDC we know that in upward stroke compression and exhaust process carried out. first of all the burnt gases removed from combustion chamber by means of scavenging action inside cylinder .and after exhaust process over all ports closed by the movement of piston upward and the charge inducted in downward stroke now get compressed by further movement of piston and at the end of compression stroke the mixture get ignited by means of spark plug if si engine else the diesel fuel injected if the engine is works on diesel cycle. Further during the compression stroke as piston moves towards upward direction vacuum created inside crankcase so fresh charge get inducted into crankcase through spring loaded check valve.

2.5 Comparisons between Two Stroke and Four Stroke Engine:

Two stroke engine	Four stroke engine
1. The cycle of operation completed in one revolution of crankshaft i.e. 360^0 rotation of crank shaft.	1. The cycle of operation completed in two revolution of crank shaft i.e. 720^0 of crank rotation.
2. Light in weight due to non-availability of valve mechanism and smaller fly wheel.	2. Heavier than two stroke engine due to more number of components...
3. Fuel consumption is more due to every revolution have one power stroke.	3. Fuel consumption is lower.
4. Fly wheel not required due to every rotation have power stroke.	4. Fly wheel required due to intermittent power produced.
5. Thermal efficiency is lower.	5. Thermal efficiency is higher than two stroke engine.
6. Compact in construction.	6. Size is larger.
7. Mist lubrication system used for lubricating various components.	7. Wet lubrication implemented.
8. Emission of engine is higher than four stroke engine.	8. Emission of engine is lower compare to two stroke engine.
9. Exhaust gas removes from combustion	9. Exhaust gas removed through exhaust manifold.

chamber by means of Scavenging process. 10. Higher power to weight ratio. 11. used for small power requirement application such as lawn mower, moped etc.	10. Lower power to weight ratio. 11. used in heavy power requirement application like marine and locomotive applications.

2.6 Merit and Demerits of Four Stroke Petrol Engine over Two Stroke Engine:

Merits:

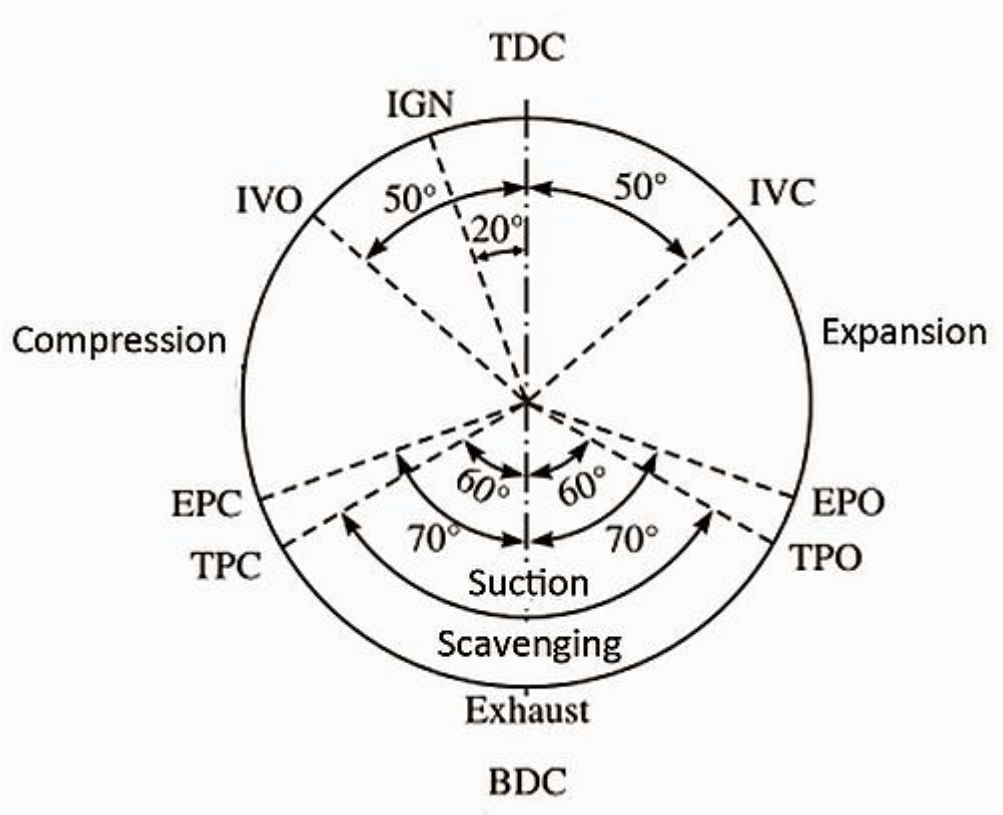
- Higher fuel efficiency.
- Higher thermal efficiency.
- The power output of this engine is higher.
- Pollution of engine exhaust is minimum.
- Can be controlled by means of ECU and electronic sensor systems.
- Can be used for various purpose applications.

Demerits:

- Heavier fly wheel required.
- Difficult to maintain idle speed.
- Maintenance cost is higher.
- Timing mechanism is very crucial.

2.7 Symmetrical Port Timing Diagram for Two Stroke Engine:

As we know that two stroke engine uses ports instead of valves to complete the cycle of operation so the diagram made taking into consideration of opening and closing of ports by movement of piston is called as port timing diagram. So it is the graphical representation of working cycle of two stroke engine. As the exhaust port opens before opening of transfer port and closes after closing of transfer port so this diagram also called as symmetrical port timing diagram. Because the angle of opening and closing to both side of BDC is also equal as shown in below diagram. the angle of opening and closing different ports for a complete revolution of crank shaft, as you can observe from diagram inlet valve which is connected to crankcase of engine opens at 50^0 before piston reaching TDC and closes around 50^0 after TDC so in this period all charges entered into crankcase of engine at the same time 20^0 before TDC inside combustion chamber the mixture is get ignited by means of spark plug if s.i engine or fuel get injected if it works on diesel cycle.



Due to burning of air fuel mixture the pressure and temperature of charge further increased so it pushes the piston towards downward direction from TDC to BDC. When the piston moving downward at 60^0 before BDC exhaust valve opens due to movement of piston it uncovers the exhaust port after 10^0 of crank rotation it also uncovers the transfer port so when the flue gas exhausting to atmosphere through exhaust port at the same time fresh charge enters the combustion chamber and it further pushes the exhaust gas from combustion chamber. “The process of removal of exhaust gases from combustion chamber by help of fresh charge is called as **scavenging** process”

After reaching BDC the piston moves in upward direction from BDC to TDC. After 60^0 of crank rotation transfer port closed and after 10^0 of crank rotation exhaust post also closed so maximum flue gas removed from combustion chamber. After closing of all ports

compression of charge started and the cycle of operation repeated. So in two stroke engine there is a power stroke in every revolution of crank shaft.

2.8 Asymmetrical Port Timing Diagram:

But in case of asymmetrical port timing diagram all working cycle is similar to symmetrical port timing diagram, instead the main difference is that the exhaust port opens before transfer port opens and closes before the closing of transfer port so the amount of fresh charge wasted during symmetrical port timing diagram saved in this type of port timing diagram as shown in below fig. so for real engine operation asymmetrical port timing diagram implemented.

2.9 Scavenging:

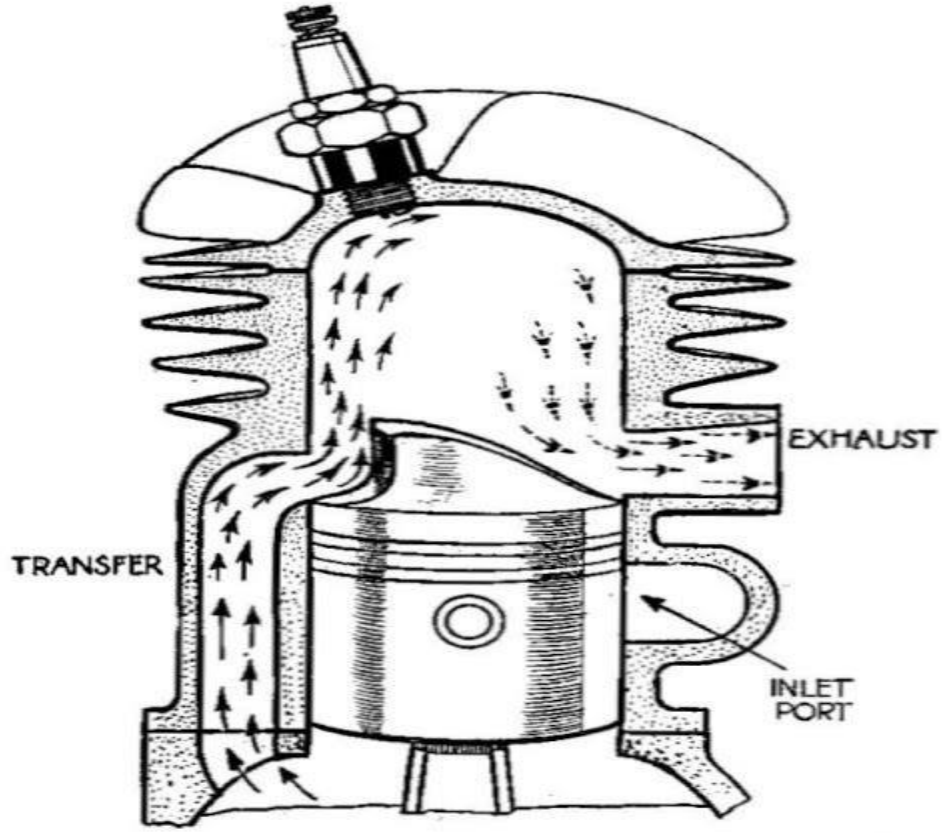
It is the process of removal of exhaust from engine cylinder of two stroke engine by the help of fresh charge and deflector of piston. This process On the basis of air flow classified as:

1. Cross flow scavenging
2. Loop scavenging.
3. Uni flow scavenging.

2.9.1 Cross Flow Scavenging:

In this method, the transfer port (or inlet port for the engine cylinder) and exhaust port are situated on the opposite sides of the engine cylinder, so that the burnt gases would be pushed out from cylinder chamber by the cross flow action of fresh charge. The piston crown was usually shaped with a raised rib called as a “deflector” so that the fresh charge was intended to move

upwards into a vertical loop, then downwards with the exhaust gas. The rib of the deflector piston also gave a poor shape for the combustion chamber with long flame paths and excessive surface area. This method of scavenging has now been almost entirely replaced by loop scavenging.



Advantages and disadvantages of cross flow scavenging:

Advantages:

1. Manufacturing cost is lower.
2. Good scavenging at low speed and part throttle operation.

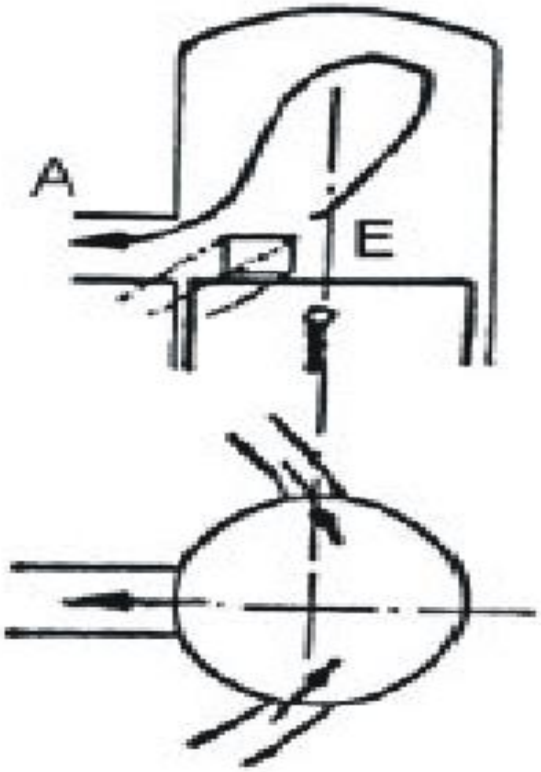
3. Best for multi cylinder arrangement due to small space requirement.

Disadvanges:

1. The size of piston is larger.
2. High tendency to knocking.
3. Poor performance at high speed and full throttle operation.
4. Air cooling of engine is not efficient so due to water cooling bulky in construction.

2.9.2 Loop Scavenging:

Similar to cross flow scavenging but the inlet and port situated at the same side of cylinder the gases are encouraged to flow in loop therefore this types of scavenging used specially designed transfer ports to rise the fresh charge first to upward later downward to exhaust port which is situated slightly above the inlet port. It has a flat or slightly doomed type piston crown. This type of scavenging widely used in two stroke engine.



Advantages and disadvantages of loop scavenging system:

Advantages:

1. Less maintenance.
2. Due to compact design better cooling achieved.
3. Efficient at full throttle operation.
4. Water cooling system not required.
5. Lesser pollutant released to atmosphere.

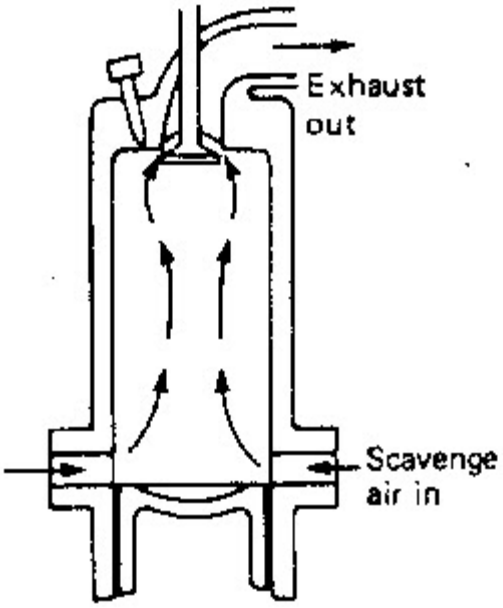
Disadvantages:

1. Poor scavenging at part throttle operation.

2. Scavenging time is too short.

2.9.3 Uni-Flow Scavenging:

Uniflow scavenging is called so because both the fresh charge and burnt gases moves in same upward direction towards exhaust port which is situated at top of cylinder. Inlet port situated at lower portion of cylinder so when fresh charge enters inside cylinder it pushes the burnt gases to upward direction. This type of scavenging process implemented in large two stroke diesel engine



Advantages and disadvantages of uniflow scavenging:

Advantages:

1. Increased power output.
2. Most efficient from other method of scavenging process.
3. Low fuel consumption compare to other type of process.
4. Engine emission reduced.

5. Good scavenging at all speed and throttle position.
6. Mixing of gases avoided due to uniflow motion.
7. Extended time for valve operation.

Disadvantages:

1. Costly construction due to valve mechanism.
2. Difficult to cool the piston.

2.10 Scavenging Efficiency:

Scavenging efficiency can be defined as volume of air present at the start of compression to volume of air swept by the piston from the top edge of the port to end of stroke. And is denoted by "η_s".

$$\text{Scavenging efficiency } \eta_s = \frac{\text{swept volume}}{\text{air volume after closing of port}}$$

For cross flow and loop flow type scavenging method the efficiency of scavenging is lower compare to uniflow type scavenging process. Because there is less time for closing of exhaust port. So scavenging efficiency is dependent on position of ports.

2.11 Scavenging Pumps:

For increasing the scavenging efficiency of two stroke engine external air compressor used for removing the burnt gases from engine cylinder as quickly as possible so more volume of charge could compressed in turn increases the scavenging efficiency.

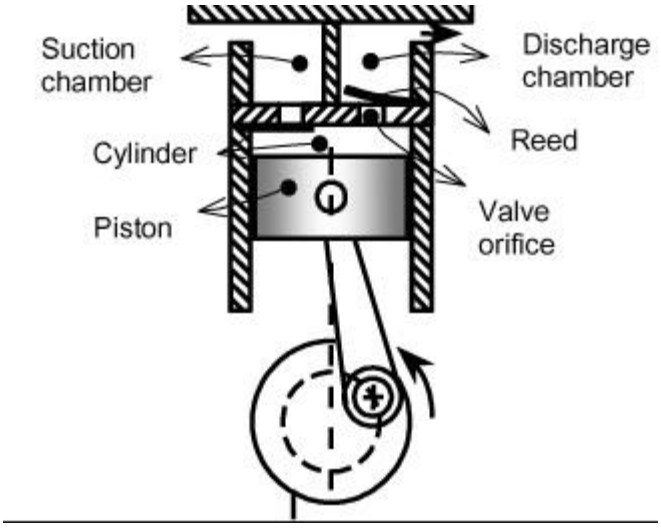
The pump or compressor gets power from either crank shaft or external power source. Mainly scavenging pump implemented in large two stroke diesel engine. So the pumps used are:

1. Reciprocating type.
2. Rotary type.

Reciprocating Type:

This type of scavenging pump used where high pressure and low discharge is the mail criteria. We know that for scavenging process in large capacity engine high volume of air required to supply air quickly so this type of pumps rarely used for scavenging.

The reciprocating type pump is nothing but reciprocating compressor below diagram shows the construction of reciprocating compressor.



The construction of reciprocating type compressor is similar to ic engine except it uses reed valves for supplying and discharging air at appropriate pressure and no ignition system used.

Working:

It has two chamber named as suction and discharge chamber. The crank shaft of compressor gets power from external power source such as electric motor, engine crank

shaft etc. By rotation of crank shaft it tends to move the piston. For first half rotation of crank shaft it moves the piston from top to bottom of cylinder. the suction reed valve or check valve opened at the same time discharge valve closed so sufficient amount of atmospheric air enters into cylinder chamber. Similarly for another half rotation of crankshaft the piston moves upward at the same time the inlet valve closed and exhaust valve ready to open .it tends to compress the air to high pressure and temperature. by attaining a sufficient pressure build up the exhaust valve opened so the compressed air supplied to inlet manifold of engine for scavenging. The hot air need to cool down by intercooler so that more volume of air can be compressed at low temperature.

Rotary Pump:

For most scavenging pump rotary type compressor used as we know that rotary compressor have high discharge capacity compare to reciprocating pump so it can quickly fill the cylinder space during scavenging process. There are different types of rotary pump used such as centrifugal type, vane type, gear type, lobe type, radial flow type etc. Mostly centrifugal type, radial flow type pumps are used due to higher efficiency and low back flow propensity.

Comparison between reciprocating and rotary scavenging pump:

Reciprocating scavenging pump	Rotary scavenging pump
1. Having high discharge pressure with low volume. 2. Positive displacement type.	1. High discharge with low pressure. 2. If the pressure of output increase the efficiency of pump reduces.

3. Used where high pressure of supply air is the main consideration 4. Used in small capacity engine. 5. The efficiency of pump is lower.	3. Used where air requirement is higher. 4. Used for large capacity engine. 5. Higher efficient.

Review questions:

1. Classify engine used for automotive.
2. What are the cycle of operations for ic engine?
3. Write components of engine in details.
4. What is mean by clearance volume?
5. Differentiate between two stroke and four stroke engine.
6. What is mean by scavenging? And explain its types.
7. What is the efficiency of otto cycle and diesel cycle?
8. Why valve time and port time diagram are important for ic engine?
9. What is scavenging efficiency?
10. What are the types of pump used for scavenging purpose?

CHASSIS AND SUB SYSTEMS

3. Frame:

Frame is the backbone or main supporting member of a vehicle chassis on which all mechanical components of vehicle loaded so that it can give strength and rigidity to the vehicle body. The motorcycle frame consists of steel pipes or rods welded together to get a stiff structure under the driver seat and fuel tank. There is provision for engine mounting, front and rear wheel mounting and other components connected by means of temporary bolted joint and vibration damper materials such as rubber mountings, spring washers.

Unlike two wheelers the frame of three wheelers are more rigid and simple in construction because in three wheelers more numbers of passenger transport is the prime consideration so stylish looking is not a design consideration of three wheelers. The frame is made of steel pipe or channel on which thin metal sheet cladded for increasing the area of sitting compartment. Generally engine mounted on rear of frame for transmitting power to rear wheel directly. The front wheel connected to front vertical shaft and rear wheels connected to frame by means of pin type joint for easy of suspension system.

3.1 Classification of Frames:

Now a day in motorcycle many types of frame used according to market requirement and stylish considerations such as:

3.1.1 Two wheelers frame:

1. Backbone Frame.
2. Diamond Frame.
3. Single Cradle Frame.
4. Double Cradle Frame.
5. Trellis Frame.
6. Perimeter frame.
7. Monocoque Frame.

3.1.2 Three Wheelers Frame:

1. Custom made frame.
2. Unibody frame.
3. Hollow rectangular frame.

Backbone Frame:

The Hero Honda CD100 series of bikes of yore used to feature a “Backbone” frame. It looks like skeleton of motorcycle and has a long bent pipe extended from front steering column to lower portion for mounting the engine and its accessories. From center portion of the bend pipe another rod extended towards rear of the motorcycle for driver sitting arrangement. From the engine mounting position rear wheel connected by means of pin type joint.

Not the best frame out there for sporty handling. The design and construction of this type of frame is fairly simple though. The frame consists of a “backbone” structure that is connected to the steering. The engine is also bolted on the frame and so is the sub-frame (*which supports the seats*).

Advantage:

Construction is simple.

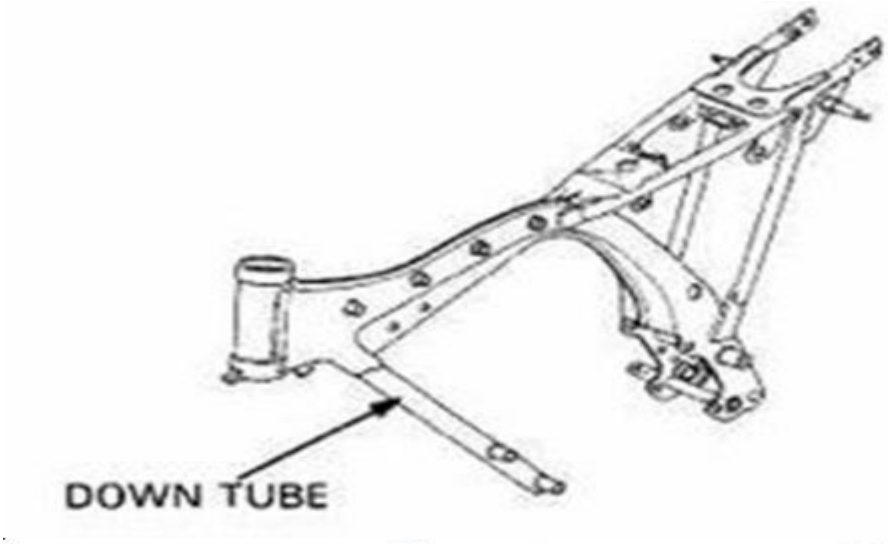
For the customer, such frames don’t add much to the cost of the bike.

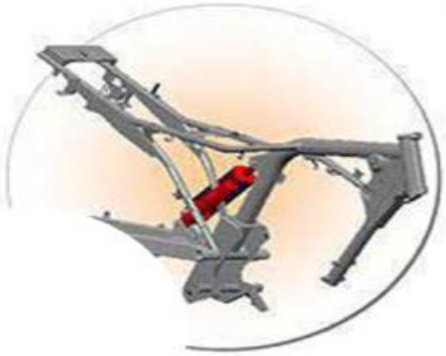
Engine and transmission mounting is simple.

Diamond Frame:

It is one of the most common type of frame found on Indian bikes. The diamond frame gets its name from the frame on a bicycle, where the shape that the frame makes is that of a diamond. Uneven diameter Steel pipes interconnected with each other by means of welded joint.

On a motorcycle there is a down tube which is attached to the steering head at one end and to the engine on the other end. Here the engine adds to the rigidity and is a “stressed member” of the chassis.





List of Indian bikes with Diamond frames are.

Bajaj: Pulsar 135LS

Hero: CBZ Xtreme, Hunk, Achiever & Karizma R/ZMR

Honda: CB Twister, CB Shine, CBF Stunner, CB Unicorn, CB Unicorn Dazzler, CBR150R, CBR250R

Royal Enfield: Bullet 350, Bullet Electra, Classic 350/500, Thunderbird 350/500

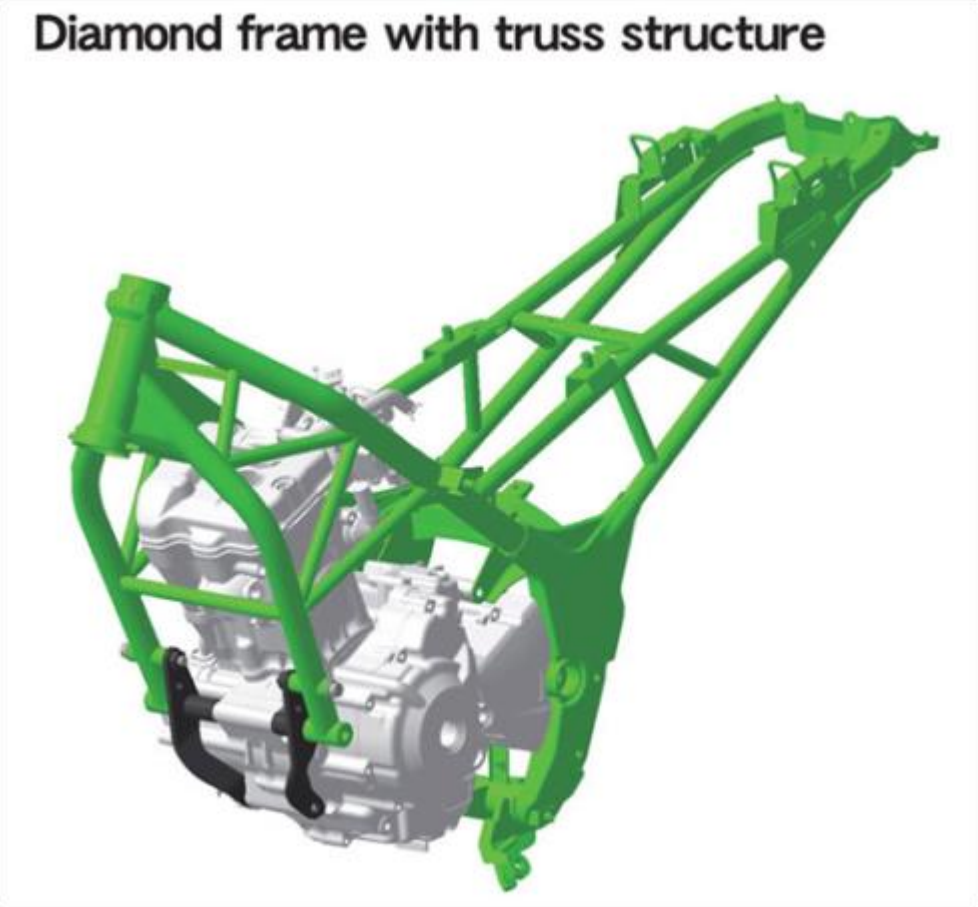
Suzuki: Slingshot, GS150R

TVS: Flame, Jive, Max 4R, Sport, Star City

Yamaha: YBR125, SS125, SZ, FZ, Fazer

Advantage: Construction is not very complex, cost savings

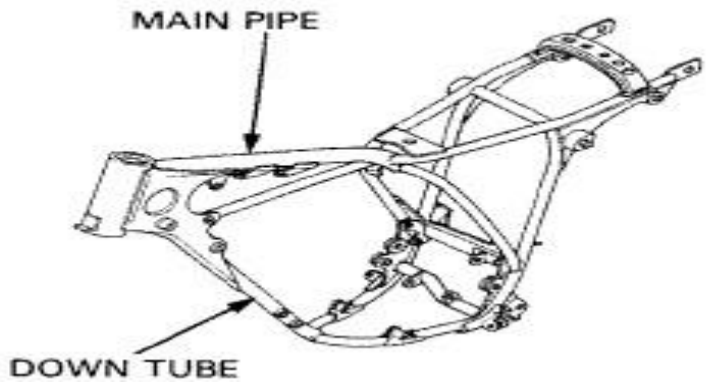
Benefit: Such frames are mostly light in weight



CBR250R Frame

Single cradle frame:

Cradle frames are another one of those very common type of frames found on Indian bikes. Along with the backbone/top tube + down tube(s) these frames also have tubes which run down the engine. It's like cradling/supporting the engine. Unlike a diamond frame, the engine is NOT a "stressed" part of the frame on this frame.



List Of Indian Bikes With Cradle Frames Are:

Bajaj: Platina 100, Discover 100/125/150, Pulsar 150/180/220, Avenger 220

Hero: CD Dawn/Deluxe, Splendor, Splendor NXG, Passion, Super Splendor, Glamour

Honda:(None)

Suzuki: (None)

TVS: Apache RTR 160/180

Yamaha: Crux, YBR110

Advantage: Construction is simple

Benefit: Such frames probably can take abuse much better (*off road/dirt bikes have cradle tubes running down their engines*).

Double Cradle Frame:

Double cradle frame is similar to single cradle frame except instead of single down tube it uses two down tube for mounting the engine. So that better and rigid support to the engine achieved.

Trellis Frame:

Trellis frames are formed by welding pipes into a cage like arrangement. Unlike the simpler type of frames mentioned above, trellis frames do not have a backbone, down

tube or cradle elements. The engine is held by the frame which kind of encircles the engine while connecting the steering head to the swing arm in the shortest way. The frames are light in weight and handling is much sportier on this type of frame.

Trellis frames are a favourite among European bike makers like KTM, Ducati. The only made in India bike with a Trellis frame currently is the **KTM 200 Duke**. The construction of such frames are a bit complex though as tubes have to be welded together. Such type of frame is also cost intensive.

Advantage: Apart from giving sporty handling, the frame can stand apart as a part of the bike's styling

benefit: Handling is sharper/sportier and the bike can be made lighter in weight

Perimeter Frame:

Perimeter frames also known as Twin spar/beam frames. These frames are currently the favourite among Moto GP teams. Like the trellis frames, perimeter frames connect the steering head to the swing arm in the shortest distance while the engine is suspended from the frame. The engine can be said to be held around the "perimeter" of the frame.

The only two bikes with perimeter frame currently in India are the **Bajaj Pulsar 200NS** and the **Yamaha R15**. No wonder why the R15 is so much appreciated for its handling and the Pulsar 200NS is getting rave reviews from auto publications for its handling prowess. Such frames are comparatively costly to manufacture though.

Advantage: One of the best/sportiest/advanced frames that one can put on a bike

Benefit: Race track bike like sharp and stable handling and braking.

Monocoque Frame:

Modern cars have monocoque frame construction where the body panels form the chassis and there is no separate frame. Ducati has recently ditched their traditional trellis frame to put an innovative monocoque frame on their 1199 Panigale model. There is no separate frame constructed but the bike parts like the air-box and engine form a part of the chassis/frame.

Even prior to the 1199 Panigale such type of frame had been tried on bikes but Ducati has probably for the first time put it on a production bike. Such an innovative frame is supposed to reduce the weight of the bike considerably (*which the 1199 Panigale definitely has shed*) and aid in very good handling.

But in terms of handling Ducati still prefers a perimeter/twin spar frame on its MotoGP bikes. Just before the international launch of the 1199 Panigale, Ducati did try out a MotoGP bike with monocoque frame but soon switched back to the perimeter layout. The development of such a frame is currently quite complex though therefore forget about getting to see any Indian maker to experiment with such a frame.

3.2 Three Wheelers Frames:

Custom made frame:

In three wheelers custom made frames are widely used as per requirement of customers. These frames are similar to four wheeler frame except front of vehicle supported by single wheel as shown below figure. As easy of manufacturing and installation of other components this type of frame are widely used in three wheelers.

Advantages:

1. Easy of construction and installation of auxiliaries.
2. Able to carry heavy load.
3. As the frame is wider so mostly used for goods transport.

Single piece box type frame:

The single piece box type frame mostly used in passenger transport three wheelers because of small in size and robust design with auxiliaries mounting provision. So above the rectangular box thin steel sheet can be easily mounted by means of welded or riveting. Below figure shows the frame of Indian model piaggio Ape three wheeler on which all auxiliary components are bolted.

Advantages:

1. Overall weight greatly reduced so fuel economy increased.
2. As less number of components so very strong in construction.

3.3 Frame materials:-

Carbon (High-Tensile) Steel:

Steel is the most commonly used material in bike frames. Carbon or high-tensile steel is a good, strong, long-lasting steel, but it isn't as light as its more high-tech counterpart, called as chromyl steel.

Chromyl (Chrome Molybdenum) Steel:

A workhorse of the industry, chromyl is a light, strong steel. When it is butted and shaped to take off excess weight, it can deliver a fairly light frame that will last through years of hard use. Chromyl is responsive and offers good flex while maintaining its form.

Aluminum:

Having come a long way from the oversized tubes of old, aluminum is now less expensive and very widely used on today's bikes. It's light, strong and stiff. With proper design it can give a solid ride for climbing, or lively handling in tight situations.

Titanium:

Lighter than steel but just as strong, this more-expensive metal is found on high-end road or Cross-country Mountain bikes. It flexes so well while maintaining its shape that some very high-end bikes use the metal itself as a shock absorber.

Carbon Fiber:

Take a bundle of parallel continuous fibers and bind them together with glue. This creates a ply. Several plies are made up to form a laminate (just like plywood). And the laminate, if designed right, can be very tough. It's also light. So why aren't all bikes made out of carbon fiber? It tends to be brittle. The fact that metal can bend and regain its shape is what makes it last. Because of this, carbon fiber bikes are built even stronger than needed.

3.4 What should be the main consideration while selecting a Frame?

Manufacturing processes and market trends continue to literally shape the bicycle frame. While not as common as it used to be, the process of butting is still used in the manufacture of

bicycle frames. Meanwhile, steel, the long-running workhorse, is being replaced more and more by aluminum—its hardy cousin that grows less expensive every year. So what do you look for in a frame? Is next year's frame necessarily better than this year's?

Weight:

Striving to shave precious grams from frame designs, manufacturers have employed all sorts of exotic metals and methods. Essentially, though, what you pay for is inversely proportional to the weight of your bike. The more you pay, the less it weighs.

Geometry:

In theory, aggressive angles lead to aggressive ride characteristics. Relaxed angles lead to more casual ride characteristics. Which is best for you? The answer really depends on how much time you spend in the saddle. If you ride a lot and aren't interested in attacking the road or trail, go for a relaxed geometry of about 70 or 71 degrees on the head tube. More aggressive bikes have a head-tube angle of 72 or 73 degrees.

Plain-Gauge Tubing:

Even with advances in materials, manufacturing processes and design, the best frame tubing for the buck is plain-gauge. These are tubes that don't rely on butting (see below) or oversizing or exotic blends, but are straight and strong and easy to manufacture. As a consequence they are cheaper. Those who are "serious" about cycling may point out that plain-gauge tubes weigh more than butted tubes. This is true, but the difference is sometimes only a matter of three or four

pounds. If you're just out enjoying the town or trail and not attacking mountains, then this weight difference is of no consequence.

Butting:

The goal of any good bike manufacturer is to put the material where you need it. And you need the material where the bike frame undergoes the most stress—at each end of the various tubes. This process is known as butting.

Internal Butting—Looking at the tube, you won't notice butting because it's hidden within the tube. So how do you know if the bike is butted? Bike manufacturers will certainly tell you, as it's a big selling point.

External Butting—the older, more expensive way is to add material onto the outside of the tube. This is rarely done anymore. However, you sometimes will see an extended weld. (See below.)

There are two methods used to butt a frame tube.

Double Butting—as the tube is shaped, extra material is allowed internally at each end of the tube. By increasing these areas of the tube, the overall tube wall thickness can be reduced, thus saving weight.

Triple Butting—to save even more weight, the double butting process is refined by stepping down the material at the ends of the tube. This means the butting starts out in the standard,

double-butted manner but then is thinned before stepping down again to the normal tube wall thickness. In a cutaway, the inside of the tube looks like three terraced rice paddies on a hillside.

Welding:

There are essentially 3 ways to join frame tubes:

- Weld them using the same material as the tube (TIG welding).
- Braze the tubes together using silver or brass.
- Use lugs to join the tubes.

Each method has its proponents, yet nearly all but the very high-end bikes use the TIG welding method. This approach is relatively inexpensive and creates a good, solid weld. However, look closely at a bike's welds. You'll see that quality bikes offer a thick, even weld that goes around the entire tube. On department store bikes the welds are thin and spotty, dabbed down generally on the top, bottom and sides, but leaving open areas in between.

Extended Welds: One inexpensive way of adding material to the end of a tube is to simply add welding material. Generally, this is an elliptical circle or a double line extending from the joint to about an inch or so down the tube where it fades out. What's the problem with this method? The heat used in this process can actually weaken the tube. After welding, manufacturers will again heat-treat the entire tube—baking it, essentially—to bring the metal back up to par. While effective, this is a less substantial method than actually building the butting while the tube is being drawn out.

3.5 Other Factors Considered For Designing Frame:

Life of motorcycle:

Steel will oxidize (rust) faster than aluminum. However, steel can take more stress over the long run than aluminum. Which is better? If you live in a wet climate, aluminum may be the better choice. Dry climate? You can do well with steel.

Weight of the Motorcycle:

If you go much above the 170-pound mark, you'll want a bike with a higher strength. This may take an added pound of frame weight to achieve, but it's worth it in the long run. Also, steel and titanium are generally better for bigger riders due to something called elongation. They can flex more without breaking.

Overall Cost of the Vehicle:

Though aluminum and titanium have come down in price, steel is still the least expensive metal. But since most cyclists like the lighter weight of aluminum or carbon fiber, manufacturers are creating bikes that are aluminum or carbon fiber and more affordable. Titanium? Still expensive.

Chassis of the Motorcycle:

Chassis of motorcycle is the combinations of all fixed and driving members these are consist of frame, suspensions, and wheels, braking systems, seat and accessories. Each of these components described briefly below.

Frame:

Motorcycles have a frame made of steel aluminum or an alloy. The frame consists mostly of hollow tubes and serves as a skeleton on which components like the gearbox and engine are mounted. The frame also keeps the wheels in line to maintain the handling of the motorcycle

Suspension systems:

The frame also serves as a support for the suspension system, a collection of springs and shock absorbers that helps keep the wheels in contact with the road and cushions the rider from bumps and jolts. A swing arm design is the most common solution for the rear suspension. On one end, the swing arm holds the axle of the rear wheel. On the other end, it attaches to the frame via the swing arm pivot bolt. A shock absorber extends upward from the swing arm pivot bolt and attaches to the top of the frame, just beneath the seat. The front wheel and axles are mounted on a telescoping fork with internal shock absorbers and internal or external springs.

Wheels:

Motorcycle wheels are generally aluminium or steel rims with spokes, although some models introduced since the 1970s offer cast wheels. Cast wheels allow the bikes to use tubeless tires which, unlike traditional pneumatic tires, don't have an inner tube to hold the compressed air. Instead, the air is held between the rim and the tire, relying on a seal that forms between rim and tire to maintain the internal air pressure.

Tubeless tires are less likely to blow out than a tube-type tire, but on rough roads, they can be a problem because even a small bend in the rim can cause a deflation. Tires come in a variety of designs to match the needs of terrain and driving conditions. Dirt bike tires, for example, have deep, knobby treads for maximum grip on dirt or gravel. Touring bike tires, made of harder rubber, usually provide less grip but last longer. The tires of sport bikes and racers (generally steel-belted radials) deliver astonishing gripping power, especially considering the small area that is in contact with the road surface.

Braking Systems:

The front and rear wheels on a motorcycle each have a brake. The rider activates the front brake with a hand lever on the right grip, the rear brake with the right foot pedal. Drum brakes were common until the 1970s, but most motorcycles today rely on the superior performance of disc brakes. Disc brakes consist of a steel braking disc, which is connected to the wheel and sandwiched between brake pads. When the rider operates one of the brakes, hydraulic pressure, acting through the brake line, causes the brake pads to squeeze against the disc on both sides. Friction causes the disc and the attached wheel to slow down or stop. Brake pads must be replaced periodically because the pad surfaces wear away after repeated use.

Seat and Accessories:

Seats on motorcycles are designed to carry one or two passengers. They are located behind the gas tank and are easily removable from the frame. Some seats have small cargo compartments underneath or behind them. For more storage, saddlebags -- either hard plastic

boxes or leather pouches -- can be installed on either side of the rear wheel or over the rear fender. Large motorcycles can even tow a small trailer or pull a sidecar. The sidecar has its own wheel for support and may have an enclosed seating compartment to accommodate a passenger.

Shaft Drive System:

3.6 Motorcycles Drive System:

Most motorcycle is driven by rear wheel for better traction and more load on rear wheel. But engine of motorcycle mostly mounted on middle portion of chassis so there should be a power transmission arrangement need to provide which can transmit power from gearbox output shaft to rear wheel hub. So most motorcycle used chain drive to transmit power because chain drive is a positive drive mechanism with less maintenance required. But there also other types of drive system used such as:

1. Rear wheel chain drive motorcycle.
2. Rear wheel direct mounted transmission system motorcycle.
3. Front wheel drive electric scooter.
4. Hybrid motorcycles.
5. CVT drive type motorcycle.

3.6.1 Rear wheel chain drives motorcycle:

This types of drive mechanism mostly used in motorcycle due to position of engine mounting and gearbox. The output power shaft from gearbox connected to rear axle hub by means of chain drive having driver and driven sprocket as shown below. This type of drive mechanism most efficient compare to other types of mechanism due to better traction as main load on rear wheel of vehicle. And also center position of motorcycle utilized for mounting engine so cooling efficiency of the engine is increased.

3.6.2 Direct Mounted Engine And Transmission On Rear Wheel:

Old model scooters used this type of mechanism for transmitting power to rear wheel. In this drive system the gear box is an integral part of engine assembly and gear box output shaft directly connected with rear wheel. Due to side way mounting of engine assembly. The dead weight of engine tries to pull the scooter to one side so driving this type of scooter is difficult. Another drawback is the width of the rear section is wider. As shown below. Mainly two stroke engine used as power source so fuel consumption is higher.

3.6.3 Front Wheel Drive Electric Scooter:

Now a day due to scarcity of petroleum fuel and environment pollution concern electric scooters are widely gaining popularity. As weight is the main consideration for this type of vehicle so the electric motors are directly mounted on wheel hub so transmission system eliminated. Generally the motor is mounted on front wheel hub as shown below.

3.6.4 Hybrid Motorcycles:

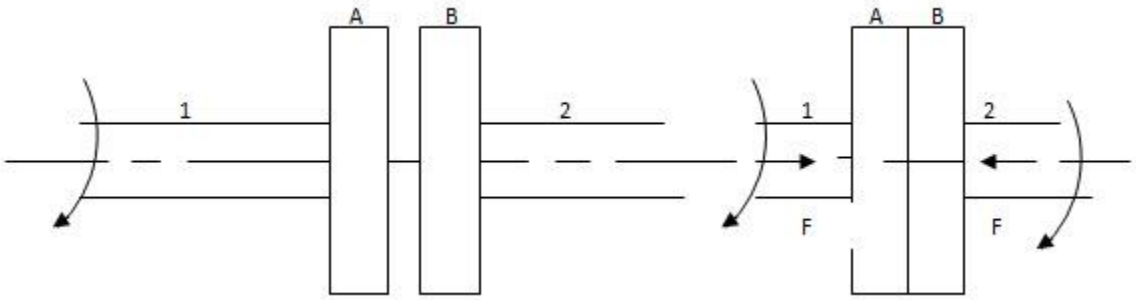
Sometimes motorcycles having conventional power source and another extra power source say electric to increase the fuel economy and decreasing pollution. So now researchers are developing such types of scooters the configuration might be rear engine drive and front electric motor drive or both drives are connected to rear wheel.

3.6.5 CVT Drive Type Motorcycle:

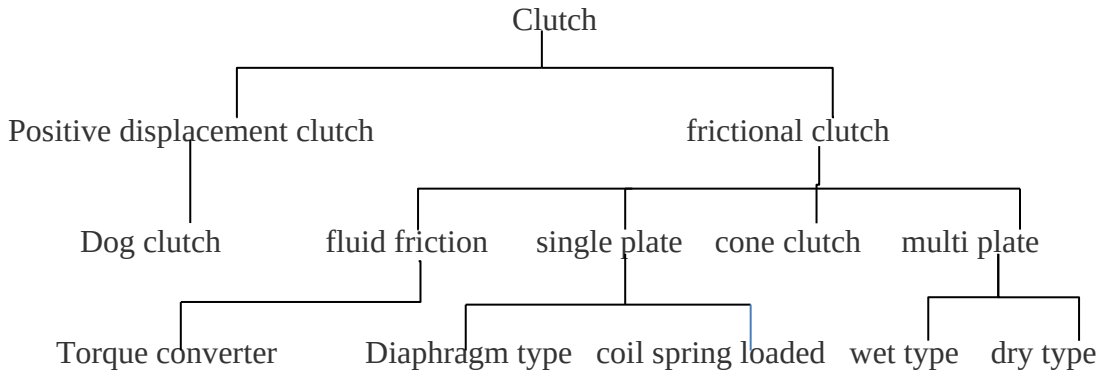
CVT drive system is now widely implemented in scooter transmission system. Because in this drive system no need to change the gear by driver. The speed and torque is automatically controlled by centrifugal clutch and cvt mechanism as shown above. The cvt mechanism directly connected from engine output shaft to rear wheel drive shaft through centrifugal clutch mechanism. After that speed further reduced by reduction gear box.

3.7 Clutches:

It is a mechanical device which transmits power and torque from driver shaft to driven shaft without stopping the system. It mainly works on principle of friction between two rotating components. When there is more frictional force more load transmitted and when the frictional force is less little power transmitted between two shafts. So high coefficient of friction material and spring load is the main consideration while designing the clutch mechanism. The main components of clutch are pressure plate, friction disc, springs; actuating mechanism etc. below fig shows a simple mechanism of clutch working principle.



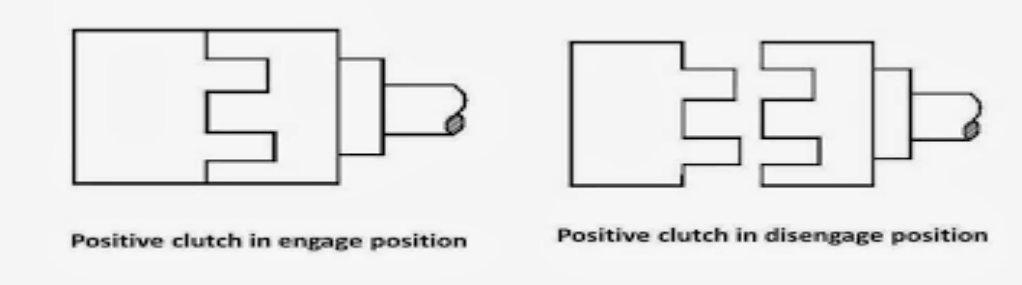
Many types of clutch used for different purposes these are described in below table in details



3.7.1 Positive Displacement Type Clutch:

In positive displacement type clutch system the power from the driver shaft to the driven shaft transmits without friction so the name suggests as positive displacement type clutch. In this clutch mechanism the driver and driven shaft have multiple slots when these are connected with each other transmits power and torque without slippage as shown below.

In engaged position both male and female slots are connected with each other so power transmitted from left to right side shaft. But in case of disengage position the loose pulley slides over spline shaft so the clutch disengages as shown right side of figure.



During engage and disengage of clutch slow speed should be maintained for reducing sound and jerk. Due to this disadvantages this type of clutch is mostly used for slow speed transmission system such as: - constant mesh gear box, lathe lead screw etc.

Advantages:

1. Low manufacturing cost.
2. Maintenance cost also less.
3. Less number of components.
4. No loss of power while in operation due to positive drive.

Disadvantages:

1. Clutch need to engage at slow speed.
2. Wear and tear of parts is more frequent.
3. Produces sound while engaging.

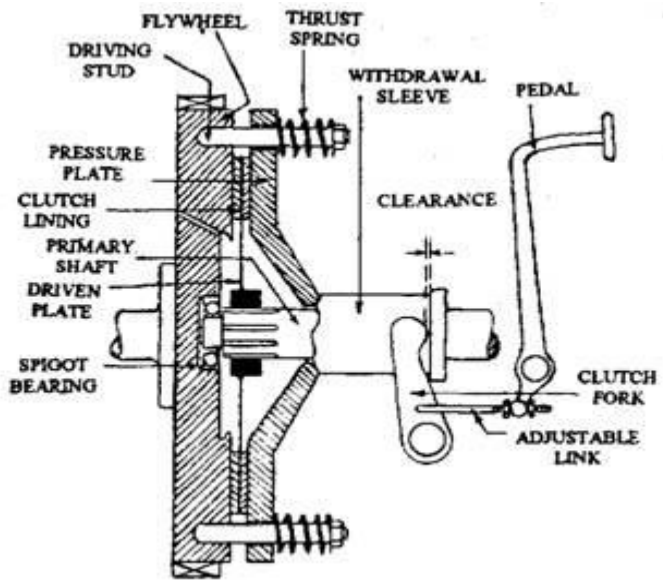
3.7.2 Frictional Clutch:

As the name suggests frictional clutch works on the principle of friction between two mating component. When the resistive force is more than frictional force at that time the driver shaft transmits power to the driven shaft. In automobile from engine to gear box power mostly transmitted by means of this type of clutch due to its smooth operation during engagement and disengagement.

3.8.2.1 Single Plate Clutch:

Construction:

This type of clutch mostly used in automobile transmission system for transmitting power smoothly from engine to gearbox without slippage. As more load applied on clutch plate by means of helical or diaphragm spring mostly heavy transport vehicle uses single plate clutch.



The clutch assembly consists of flywheel (which is connected with crank shaft of engine), clutch plate or friction disc, pressure plate, helical spring, lever mechanism, splined shaft and clutch housing.

Fly Wheel: Fly wheel is a circular disc type heavy mass connected to the crank shaft by means of bolted joint. Front surface of the fly wheel directly exposed to the clutch friction plate. At the center of fly wheel one circular hole is provided for mounting gearbox shaft. Flywheel generally made of mild steel or cast iron.

Clutch Disc or Friction Plate: The efficiency of single plate clutch depends on the type of friction plate used. It is a disc type plate having splined inner hub which is slides on shaft of pinion gear. The plate outer surface bonded with high coefficient of friction material such as asbestos, Ferrero etc. as shown below due to high coefficient of friction when the clutch disc connected with flywheel and pressure plate the power transmitted with minimum loss.

Some friction disc have cushion spring for minimizing the vibration during engagement and disengagement of clutch.

Pressure Plate: the main function of pressure plate is to apply equal pressure on clutch plate against flywheel by the help of helical or diaphragm spring and is made of mild steel. The inner diameter of pressure plate splined so that it can easily slide on pinion shaft. The pressure applied on pressure plate by means of thrust bearing.

Clutch Housing: all clutch components fitted inside clutch housing and the clutch housing directly connected to crankcase. So it should be rigid enough to carry all static and dynamic load of transmission system.

Lever Mechanism: It is a multiple joint linkage mechanism helps to engage and disengage the clutch according to driver will. When the clutch is in engaged position there

should be enough free play for avoiding chatter of clutch. The engagement or disengagement of clutch occurs either by mechanical linkage or hydraulic operated mechanism.

Springs: Mostly two types of spring used in single plate clutch such as diaphragm type and coil spring type. Generally the former used for small transport vehicle and the latter is used for heavy transport vehicle. The load on clutch disc decided by the tension on spring so proper spring should be selected for load transmission.

If the clutch uses diaphragm type spring as shown below so the uses of bell crank lever mechanism eliminated because the diaphragm spring have dual purpose it gives proper pressure force to clutch disc and also works as a lever so lever mechanism eliminated.

Working Principle:

During normal running condition of vehicle the clutch mechanism always connected with the flywheel so power transmitted with minimal loss from flywheel to gearbox shaft. But when driver need to change gear first of all the power from engine should be disconnected so that the gear changing operation performs smoothly. So to disengage power driver press clutch pedal either mechanical or hydraulic actuated type. So after pressing clutch pedal the actuation mechanism pushes the thrust bearing of clutch which freely moves above mounting shaft.

When the bearing moves towards pressure plate which is connected by means of bell crank lever mechanism. The lever pulls the pressure plate away from friction disc against spring pressure so that pressure plate disengages from flywheel and no power transmitted through clutch.

Advantages:

1. Used for high power transmission vehicle.
2. Construction is simple.
3. Only one friction disc required.
4. Actuation mechanism is simpler.
5. Initial cost is less.

Disadvantages:

1. More space required for installation of clutch.
2. The force required to disengage is higher.
3. If lubricating oil leaks into clutch system it may not work properly.

3.7.2.1 Multi plate dry clutch:

The main difference between single plate and multi plate clutch is that instead of single friction plate used unlike in single plate clutch it uses number of friction plate and pressure plate say odd number friction plate and even number of pressure plate. So that the name

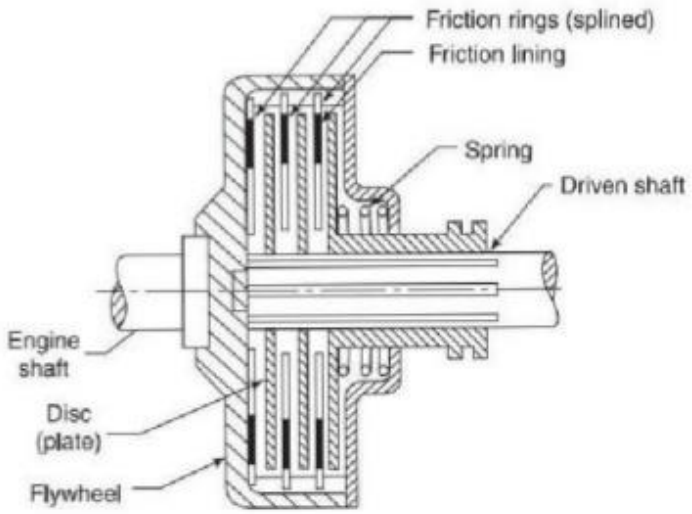
suggest as multi plate clutch. Generally two types of multi plate clutch widely used in automobile applications.

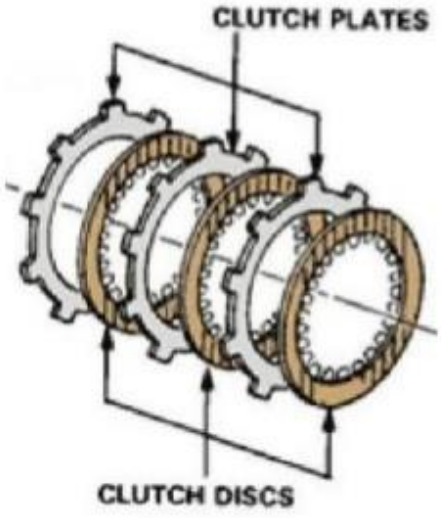
1. Dry type clutch.
2. Wet type clutch.

The dry type clutch used where the provision of lubricating clutch disc is not possible but the wet type clutch always dips inside lubricating oil so life of the wet type clutch is more than dry type clutch.

Construction:

As the multi plate clutch is compact in design so this type of clutch widely used in small transport vehicle like motorcycle, agricultural machinery etc. as shown below the clutch assembly having clutch plate, clutch disc, helical springs, splined housing and flywheel. The two sets of clutch plate one set having outer teeth to lock with housing which having internal splined and other set having inner teeth for locking with external splined shaft. The two sets of plates called as clutch plates and clutch disc. The housing is either directly connected with the flywheel or connected by means of gear drive in the case of motorcycle clutch. On outer portion of shaft thrust bearing is connected with clutch linkage to engage and disengage the clutch by a suitable mechanism.





Working Principle:

The working principle of multi plate clutch is similar to a single plate clutch. During normal operation clutch is in engaged position the power transmitted from flywheel to gearbox shaft through clutch casing, clutch plates and friction disc due to force created by compression of helical spring which is previously adjusted according to load condition. When the driver applied the clutch lever the thrust bearing compresses the spring further so the contact between the clutch plate and disc become loose so no power transmitted from clutch disc to friction disc.

Advantages:

1. Compact in construction so can be easily installed inside gearbox.
2. The efficiency of multi plate clutch is higher than single plate clutch.
3. The chance of slippage due to oily surface eliminated.

4. Easy to install and maintenance due to lower spring force.
5. The life of the clutch plate is long.
6. The area of frictional surface contact increased due to multiple clutch disc.

Disadvantages:

1. Initial and maintenance cost is higher due to more number of friction surface.
2. Sometimes due to weathering action the plates are joined with each other.
3. The power transmission is lower.

3.7.2.3 Multi Plate Wet Clutch:

The construction and working of multi plate wet clutch is similar to multi plate dry clutch except for increasing life of clutch system and easy of power transmission the multi plate dry clutch submerged in engine oil as we can observe in motorcycle. The gearbox and clutch assembly fitted near crank case of engine so all three components lubricated by same engine oil.

Advantages:

1. Longer life of friction disc due to cooling of clutch.
2. No separate lubricating chamber or oil required.
3. Silent In operation.

Disadvantages:

1. Due to lubrication of clutch the quality of lubricating oil quickly eroded.

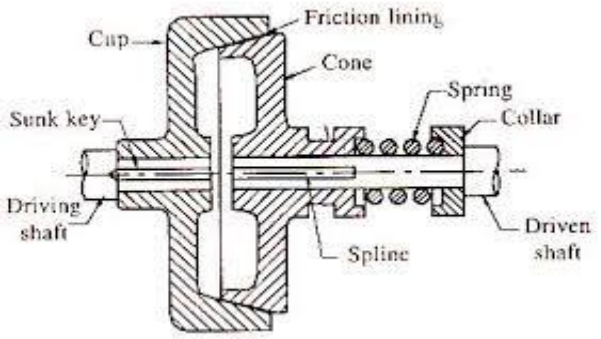
2. Slippage of clutch might occur if the friction discs are over worn out.
3. Power transmitted through multi plate wet clutch is lower than its peers.

3.8.2.4 Cone Clutch:

It is a simple type of clutch mechanism used in old machinery, synchromesh gearbox of automobile etc. in this two conical surface when connected with each other due to frictional resistance power transmitted from driver to driven shaft.

Construction:

As shown below cone clutch is the simplest form of clutch among all clutch system. The main components of cone clutch system are: - female cone (cup), male cone, friction lining, collar bearing, helical spring, drive and driven shaft.



The friction lining material bonded with both cone surface for increasing the efficiency of clutch system. The female cone is usually fixed with the flywheel and male cone moves on spline shaft by means of collar bearing as shown above.

Working Principle:

When the clutch is in engaged position the cone friction lining is perfectly connected with cup friction lining with proper force provided by helical spring. So power transmitted from driver to driven shaft. But when the driver applied the clutch pedal due to linkage mechanism the collar bearing moves outward. Due to outward movement the force on the cone decreases due to decreasing of force the male and female cone disconnected and no power transmitted from driver to driven shaft. Whenever the driver releases the clutch pedal again due to spring force both cone connected with each other.

Now a day cone clutch is widely used in synchromesh gearbox to changing gear smoothly without any chattering effect.

Advantages:

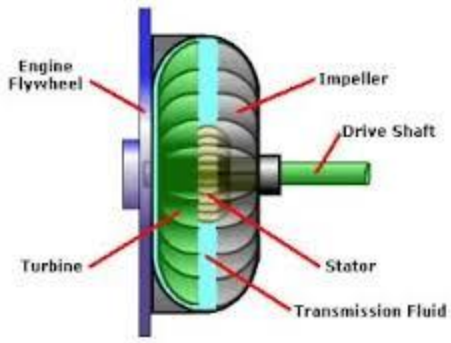
1. Less number of component so initial cost is lower.
2. Small to large size clutch can be constructed according to requirement.
3. Simple operating mechanism.

Disadvantages:

1. The transmitted power is lower due to less surface contact area.
2. More wear and tear between friction surfaces.

3.7.2.5 Fluid Friction Clutch:

This type of clutch is widely used in automatic transmission system vehicle such as sports vehicle. In this clutch system instead of mechanical clutch components fluid is used as working horse. So it named as fluid friction clutch. “Torque converter” is called as fluid friction clutch because the torque from flywheel transmitted to gearbox shaft due to motion of fluid inside a closed casing as shown below.



We can observe from figure that impeller of torque converter connected with fly wheel when fly wheel rotates the fluid moves from impeller to turbine through stator so that due to fluid friction the power from impeller transfers to turbine as turbine shaft connected with drive shaft of gearbox so power transmitted without loss.

3.8 Gearbox

The term gear box is derived from the number of gear presents in a box to perform some useful output. The main function of gearbox is to control the torque and speed of an automobile according to road and load condition without disturbing the power source. In automobile mainly reverted gearbox used for same axis power transmission and for compactness. So according to development gearbox mainly classified in automobile as:-

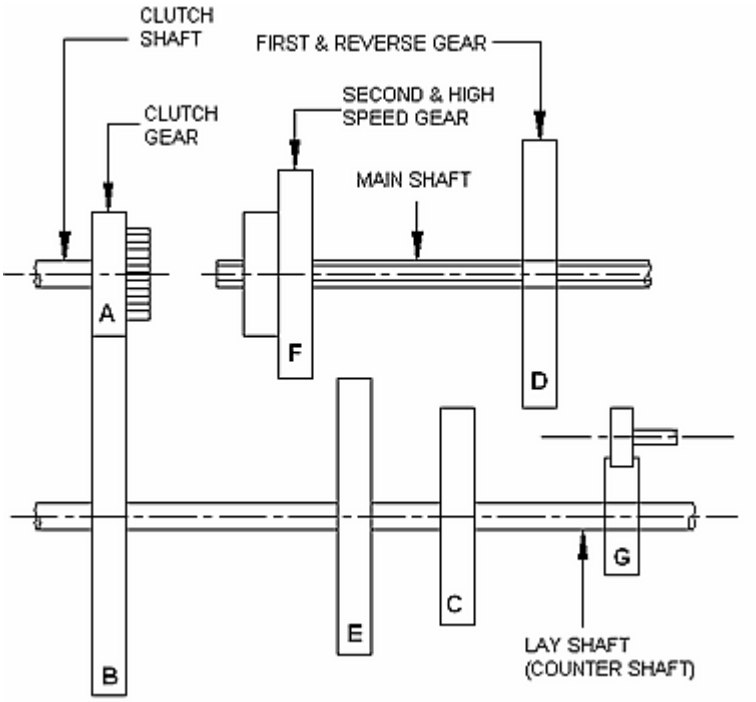
1. Sliding mesh gearbox.
2. Constant mesh gearbox.
3. Synchromesh gearbox.
4. Epicyclical gearbox.

3.8.1 Sliding Mesh Gearbox:

Construction:

This type of gearbox used in old model slow speed vehicle due to less advancement in gearbox design. The main components of this type of gearbox has input shaft, counter shaft or lay shaft, main shaft or output shaft, shifting levers, gearbox housing etc. as power transmitted axially so this gearbox also called as reverted type gearbox. The block diagram of sliding mesh gearbox shown below, from the block diagram you can observe that it has three forward speed gear pair and one idler gear for reversing the vehicle to backward direction. The input shaft pinion is always connected with lay shaft gear so when driver need to change the gear

directly shift the gear on main shaft which are free to slide on splined shaft. To a specific limit.



Working Principle:

The working principle of this type of gearbox is simpler as there is less number of components. From the above diagram shows that there is no power transmission from clutch shaft to main shaft as no gear pairs are connected only the lay shaft rotating with the input shaft.

During starting: the gear shifting lever situated near driver directly connected with gear F and D by means of shifting fork. During starting high torque with slow speed preferable for smooth stating of vehicle so driver need to connect larger gear of main shaft

with smaller gear of counter shaft this is possible by connecting gear D with gear C so vehicle smoothly started from rest.

Highway driving condition: After starting of the vehicle from rest the speed of the vehicle should be increase for better fuel economy and saving time so at that time as vehicle already in motion so driver changes the gear for higher speed. So the driver engages second gear F with counter shaft gear E as shown above.

For further increasing speed of the vehicle now the internal compound gear F of main shaft directly connected with external gear of input shaft. So vehicle can cover more distance with higher fuel economy at highway.

Reverse drive condition: Some time during riding on road driver need to move the vehicle to backward direction for changing the direction of travel and blockade of road so at that time reverse gear mechanism comes into effect which not only changes the direction of travel but also save time and resources. In this mechanism another extra idler gear connected between main shaft gear D and counter shaft gear G as shown above. When the idler gear connected the direction of rotation of main shaft changed because we know that in compound gear train if the number of gear connected is odd number so direction of rotation of driven gear is same as driver gear.

Advantages:

1. Simple mechanism.

2. Number of components are lesser so lower initial cost.
3. Simple gear shifting mechanism.

Disadvantages:

1. More wear and tear of gears.
2. Only spur gear used so more sound created while in operation.
3. Difficult to engage and disengage.
4. The gear reduction ratio is minimum.
5. Every time while changing gear the speed should be reduced to minimum.
6. Not suitable for automobile due to frequent changing of gears required.
7. More strain to the driver.

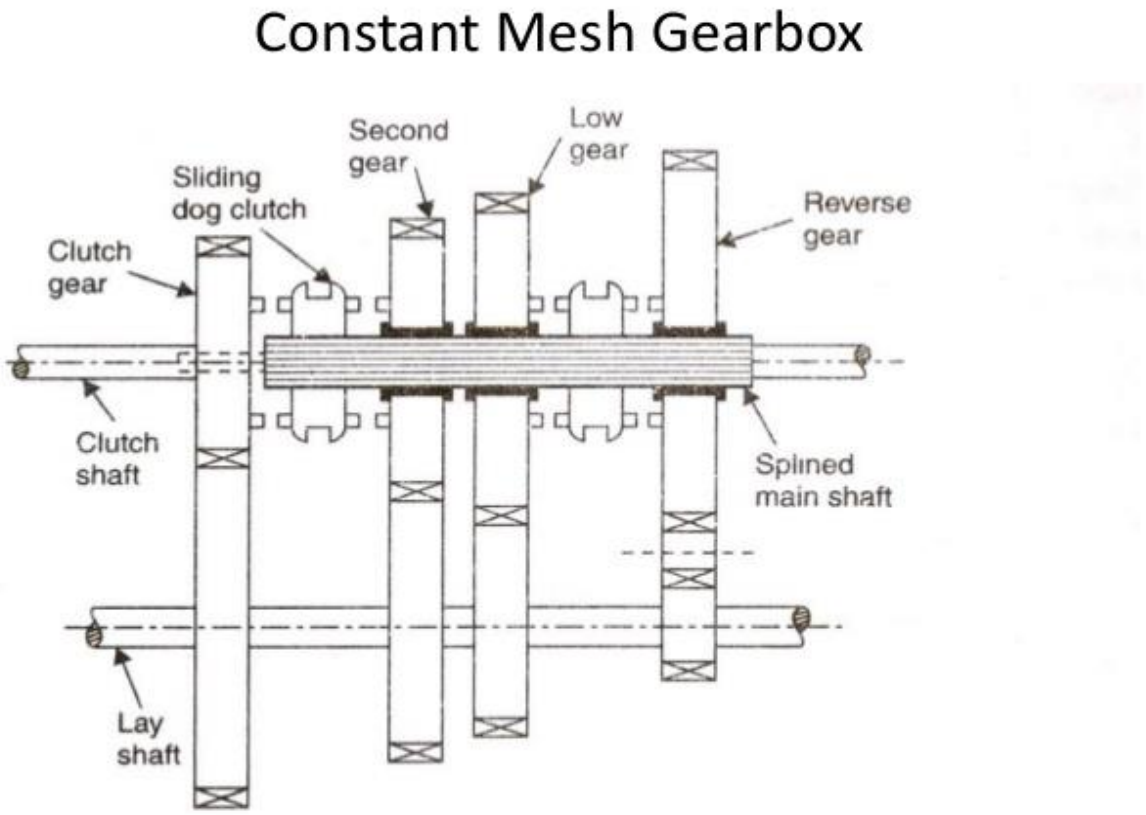
Due to all these many disadvantages now a day sliding mesh gear box become obsolete in automotive applications only used in lathe machines.

3.9.2 Constant mesh gearbox:

Due to many disadvantages in sliding mesh gear box inventors developed another type of gearbox which is superior than sliding mesh gearbox in term of smooth engagement and quitter running by connecting the gear pairs permanently with each other but free to rotates on driving shaft by means of bearing arrangement.

Construction:

As shown below we can observe that constant mesh gear box also have same number of forward and reverse gear as sliding mesh gearbox except the gear pairs are connected permanently with each other and the main shaft gears are free to rotate by means of ball bearing. The only difference is that it uses dog clutch which are free to slide on splined main shaft. As we studied about dog clutch in previous section it is a positive drive clutch that means it quickly engages and disengages the mating surface. The dog clutch is with gear changing lever so when the driver need to change the gear he changes the position of dog clutch.



Working principle:

While the vehicle is in standing position all dog clutches is in disengaged position so power from the input shaft goes to the lay shaft as lay shaft gears are connected with the main shaft gear so the gears on main shaft rotates with lay shaft. for engaging the first gear the driver apply the clutch so power from engine disconnected at the same time driver shifts the gear changing lever for first gear. After engagement of first gear the flow line of power is input shaft - smaller gear of lay shaft – larger gear of main shaft – dog clutch – main shaft. So that vehicle started from static position with high torque and less speed.

Medium and top speed operation:

As the speed increases slightly the driver “first press the clutch pedal to disengage the dog from first gear and releases the clutch pedal after that when speed of both the shaft become equal again pressed clutch pedal and changes to second gear. This phenomenon for applying clutch two times is called as **double declutching**”. Double declutching is only done when constant mesh gear box used by vehicle. After reaching a specified speed of vehicle if the driver want to go in higher speed in highway so he/she have to follow the above said process for engagement or disengagement of higher or lower gears.

Reverse gear:

Without reverse gear it is very difficult to drive the vehicle on road because there might be some road blockade, need to change the direction of travel at the end of the journey. So for

fulfilling these requirements reverse gearing mechanism is used in automobile unlike four wheeler two wheeler doesn't have reverse gearing mechanism .so no reverse gear required in two wheelers. During the engagement of reverse gear the power from input shaft travels to main shaft through counter shaft gear, idler gear, reverse gear on main shaft, dog clutch.

Advantages:

1. Wear and tear of gears reduced.
2. Higher velocity ratio possible.
3. Smooth changing of gears.
4. As helical gear used so sound while operation of gearbox reduced.
5. Maintenance cost of gearbox reduced.

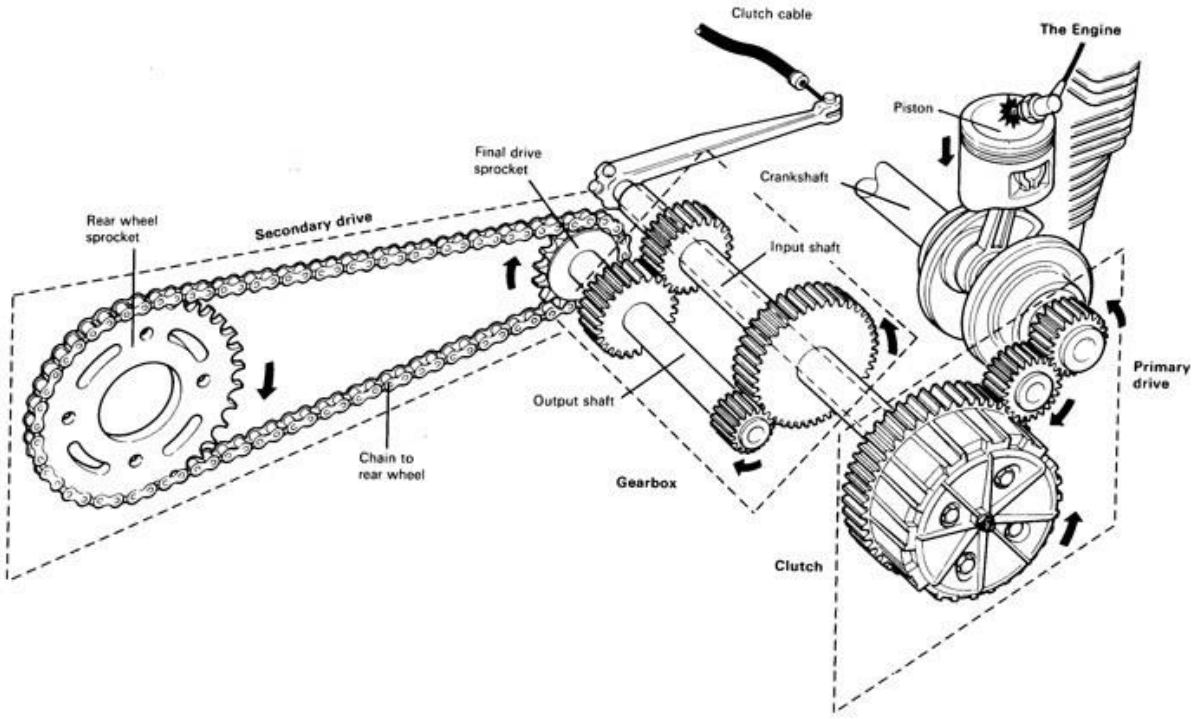
Disadvantages:

1. Due to double declutching operation driver applied more effort.
2. More wear and tear of clutch plate and dog clutch teeth.
3. Teeth of dog clutch should be strong enough to transmit torque.
4. Due to double declutching fuel economy of vehicle reduced

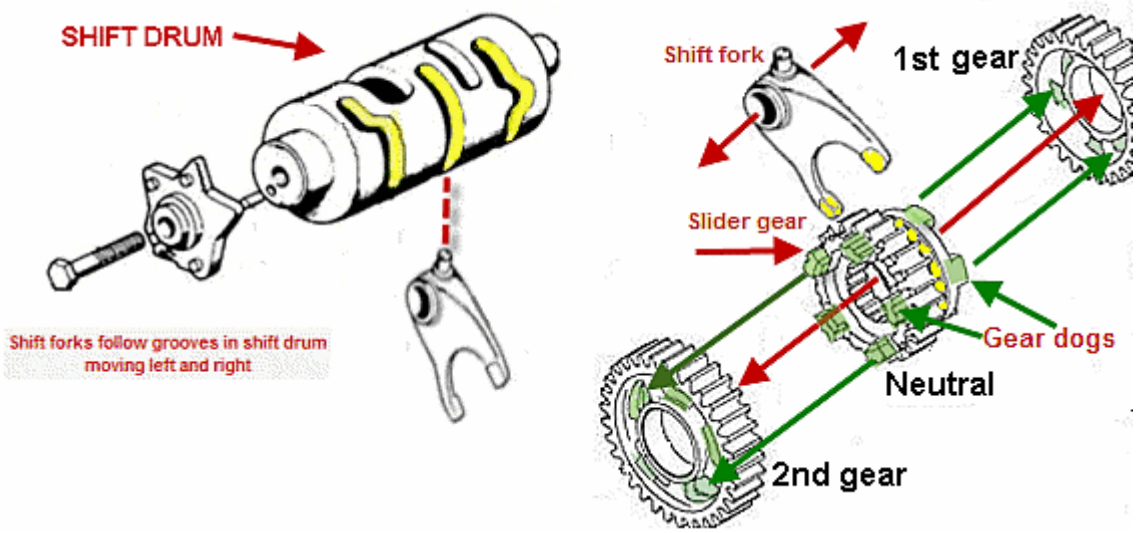
3.9.3 Gearbox of motorcycle:

Almost all motorcycle uses constant mesh gearbox for transmission of power from engine to sprocket drive. The constant mesh gearbox used in motorcycle is slightly different from heavy vehicle gearbox because the shifting lever mechanism, clutch are integral part of gearbox. And two types of drive system used primary drive and secondary drive system as shown below. The

primary drive consists of power from crank shaft to clutch assembly or input shaft. And sprocket drive is called as secondary drive.



In this gearbox the shifting lever mechanism is different from others because for sake of compactness drum cam used for changing the gear. Some motorcycle have only rearward direction gear shifting mechanism and some have first forward and remaining rearward direction gear shifting mechanism. The gear shifting mechanism of motorcycle shown below. The shift drum is a cylindrical drum having grooves to operate the shifting fork when driver pushes the shifting lever by foot. As the drum have spiral slots so according to slot the shift fork moves to left or right direction so when the fork moves it also slides the dog which connects appropriate gear as per requirement.

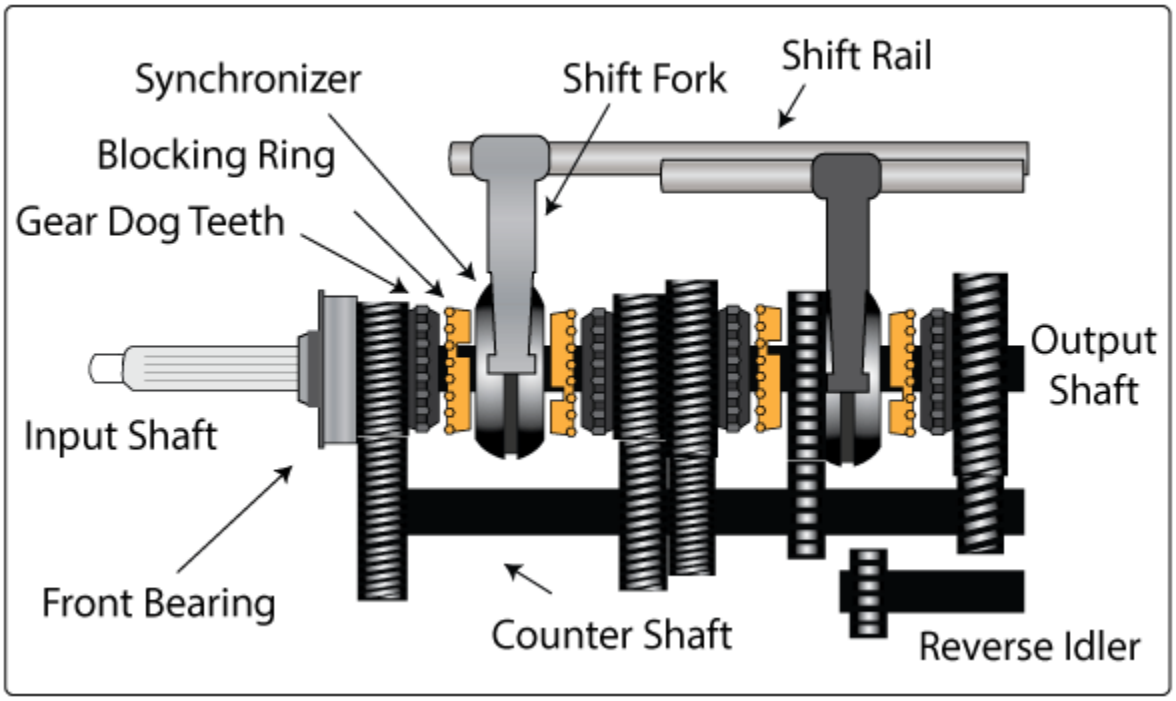


3.9.4 Synchromesh Gearbox:

Now a day almost all four wheeler vehicle uses synchromesh gearbox due to its many advantages. This gearbox is similar to constant mesh gearbox the only difference between this two gearboxes is the gear shifting mechanism.in case of constant mesh gearbox dog clutch is used for changing gear but in synchromesh gearbox cone clutch and synchronizer is used for swift changing of gear without any hassle.

Construction:

The main components of synchromesh gearbox have gear dog teeth which is fixed with main shaft gears, blocking ring, synchronizer and shift levers. The below fig shows four speed gearbox having one reverse gear. The synchronizer assembly slides on main shaft spline which is operated by gear shifting fork. The blocking ring which connects the synchronizer smoothly with main gear having cone clutch type construction so when the cone clutch pressed against the main gear the speed of the blocking ring matches with the main gear speed .



Working Principle of Synchronizer:

The synchronizer slides above splined shaft of synchromesh gear box when the driver need to change the gear first of all he shifts the synchronizer to desire gear dog teeth. As the speed of counter and main shaft is different so if gear engaged at this different speed the changing of gear was not smooth as experienced earlier in other type of gear box. So synchronizer first pushes the blocking ring which having female cone surface and made of brass for increasing coefficient of friction. The female cone pressed against male cone of gear dog teeth so both are rotated at same speed. As the blocking ring and gear dog teeth having conical teeth so the mismatching of synchronizer avoided.

Advantages:

1. Smooth engagement and disengagement of gears so were and tear of components minimised.
2. Salient in operation.
3. Due to higher power and torque transmission capability widely used almost all vehicle.
4. No sound produced while engagement.
5. Long life of clutch plate.
6. Compact in construction.
7. Less Maintenance cost.

Disadvantages:

1. Higher initial cost.
2. Skilled person require to repair the gearbox.

3.8.5 Epicyclical Gearbox:

Epicyclical gearbox is advanced model of gearbox recently started using in automotive industry. This gearbox mostly used in automatic transmission system vehicle because of its wider range of speed ratio and compact in design. As compact so it can be easily installed on front wheel drive vehicle. In this gearbox the power can be transmitted axially.

Advantages:

1. Compact in construction.
2. Wider range of speed reduction possible.
3. Most suitable for automatic transmission vehicle.
4. Widely used in sports vehicle.

Disadvantages:

1. Initial cost is higher.
2. Complicated mechanism.

3.9 Suspension System of Motorcycle:

3.9.1 Front suspension system:

Front suspension system is the main requirement for a motorcycle to maintain stability and comfort while riding of motorcycle. Without suspension system driver might not feel comfort because of direct shock load transmitted to hand of driver. Front Suspension systems are classified as:

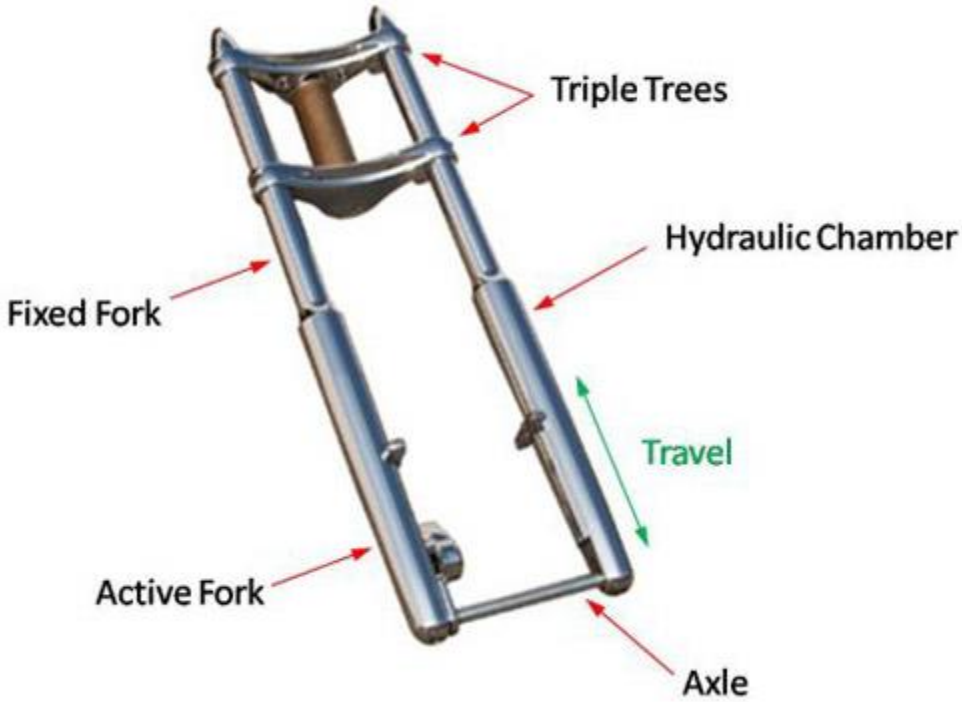
1. Telescopic front suspension system.
    a) Conventional type.
    b) Upside down type.
2. Spring and damper front suspension system.

3.9.1.1 Conventional Type Telescopic Front Suspension System:

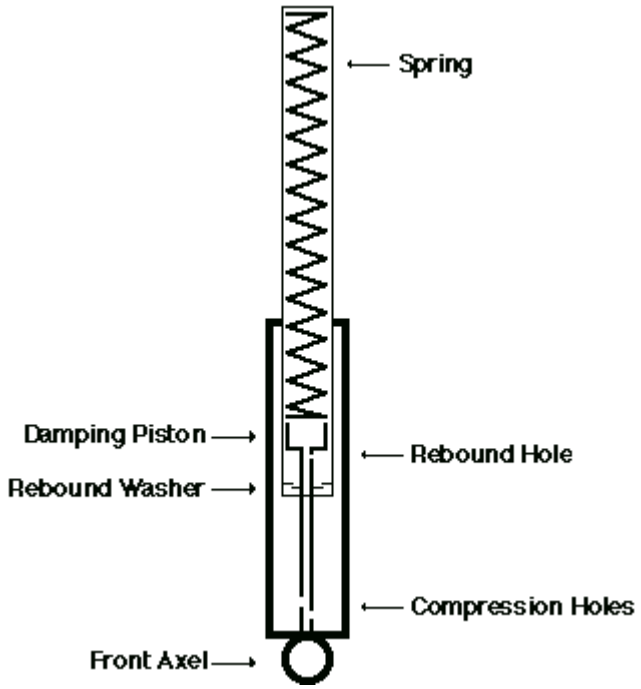
The conventional type telescopic front suspension system is very common in all motorcycle due to its simplicity in operation. As two fork are connected to center pipe of steering wheel .it looks like telescope, so it named as telescopic suspension system.

Construction:

This type front suspension system consists of fixed fork, movable fork, hydraulic chamber, triple trees etc. the fixed fork connected with the steering handle by the means of triple trees whose top portion connected with motorcycle handle. The fixed fork tube moves inside active fork by means of road condition and load.



The inside view of hydraulic chamber is shown below, in this the chamber is filled with suspension fork oil and coil spring which is mounted on piston rod. The piston has small holes which restricts the flow of oil in case of sudden movement of piston. So the damping action of telescopic fork suspension system achieved.

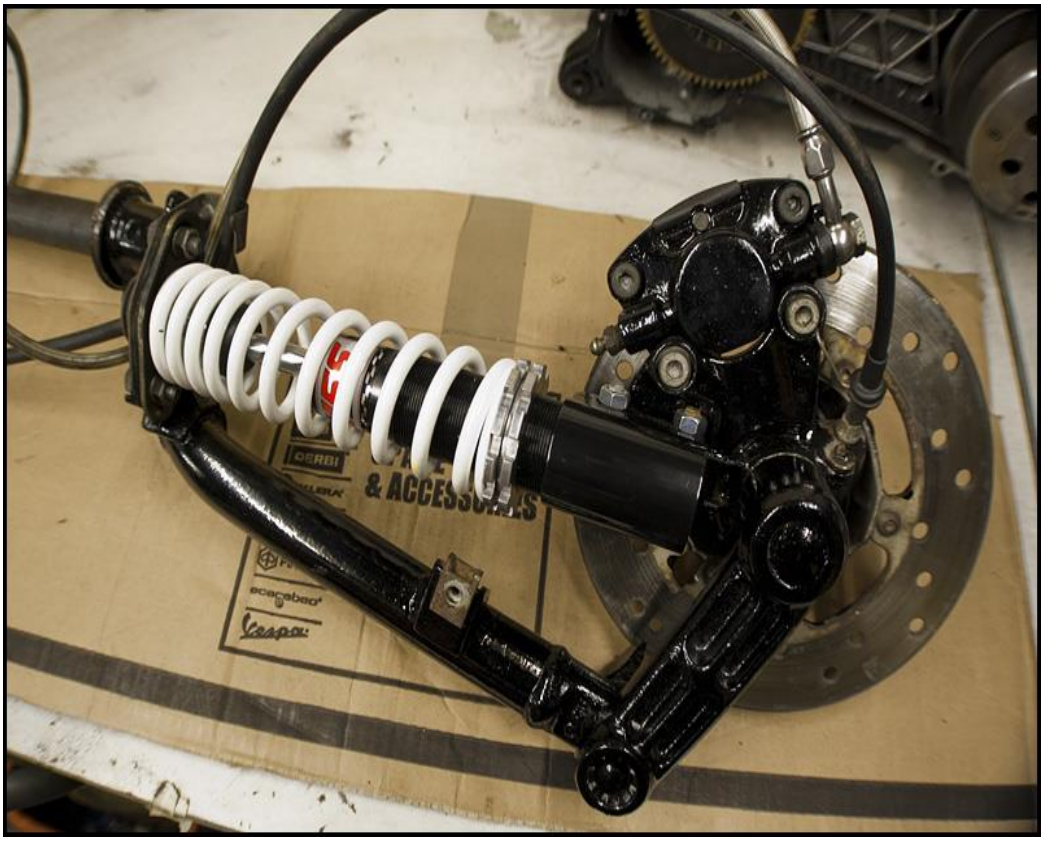


Working Principle:

When motorcycle running in normal road the pressure difference between both sides of damping piston is equal. When the road surface is uneven or front wheel ride on sudden bump at that time the coil spring inside tube absorb sudden shock impact. As the compression load increases on one side of piston due to pressure difference across piston the fluid tries to flow into low pressure region. As the fluid restricts sudden rebound of piston so smoothly suspension system comes to original position avoiding transfer of road shock to driver.

3.9.1.2 Spring and Damper Front Suspension System:

Unlike motorcycle front suspension system this type of front suspension system mostly used in scooters and three wheelers because this suspension system mounted on one side of wheel enabling quick assembly and dismantling of wheel from hub. As shown below this suspension system have also single spring and damper system connected wheel hub with steering column. Besides that another link also connects the steering column to front wheel hub by means of pin joint. Both the spring damper system and the link make a triangular shape. As the suspension system mounted on one side of wheel so it should be strong enough to withstand both compressive as well as shear load. Generally to minimize the risk of bending the length of suspension system kept smaller.



Working principle:

As the shape of suspension system is triangular form consisting spring damper system and revolute link so when front wheel ride on a sudden bump as the spring damper mounted axially on load direction it get compressed.as the length of one side decreases to accommodate the angle between the spring damper link and revolute link changes so smooth suspension effect of front wheel achieved.

3.9.2 Rear suspension system:

To give comfort to passenger of motorcycle and to carry maximum load rear suspension system should be strong and sturdy enough to fulfil the desired requirement. There are different types of rear suspension system used from early development of motorcycle to modern motorcycles these are:

1. Plunger suspension system.
2. Swing arms type
3. Twin shock absorber type.
4. Single shock absorber type.

3.9.2.1 Plunger suspension system:

The plunger type rear suspension system used mostly in old model motorcycle in which the vertical movement of wheel absorbed by plunger movement inside cylinder while running in uneven road. As shown below we can observe that the wheel hub is mounted centrally of the two opposite spring loaded plunger so the vertical up and down movement of wheel easily absorbed by the opposed plunger system.

Advantages:

1. Simpler design.

2. Slake length of chain drive doesn’t changes.

3. As the suspension system is at outermost portion so easy to assemble and disassemble.

Disadvantages:

1. The suspension system is rigid so less comfortable to rider.

2. More components required for suspension system.

3. As the suspension system directly mounted on hub of wheel so there is frequent loosening of nut due to rotational motion of suspension.

3.9.2.2 Swing Arms Type Suspension System:

Now a days this type of suspension system are widely used in high end motorcycle due to its simplicity, light weight and compactness. It connected directly with rear wheel or in conjunction with helical spring mounted between upper frame and swing arm as shown below. At the end of swing arm wheel hub directly mounted on slotted hole and other side of swing arm is connected with frame of motorcycle.

Review questions:

1. What are the types of frame used in motorcycle?
2. What are the difference between frame and chassis?
3. Classify clutch system used in automobile.
4. What are the difference between constant mesh and synchromesh gearbox?
5. What are the function of suspension system ?
6. Which type of gear selector mechanism used in motorcycle gearbox
7. Write advantages of CVT .
8. Why shock absorber is an integral part of suspension system in motorcycle?
9. What do you mean by transaxle power transmission?
10. What are the advantages of CV joint?
11. What are the components present on panel bar and handle bar?

IGNITION SYSTEM, BRAKES AND WHEELS

4.1 Fuel System:

Fuel system is the main energy carrying components of any automobile. It starts from fuel storage tank to fuel supply system into combustion chamber having many auxiliary components such as hose pipe, high and low pressure fuel pump, primary and secondary filter, and injection mechanism etc. the fuel system also interconnected with engine crank shaft for providing proper amount of fuel at proper time.

4.2 Classification of fuel system:

The fuel system classified according to type of engine used such as

1. S.I engine fuel supply system.
2. C.I engine fuel supply system.

4.2.1 S.I engine fuel supply system:

We know that In S.I engine gasoline fuel used for getting power output of engine so the fuel supply system some common components such as: fuel tank, fuel supply pipe, low pressure fuel pump in case of large capacity engine for pumping fuel from tank to carburetor (for small capacity engine generally fuel tank mounted above engine so no fuel pump required), primary and secondary filter and carburetor assembly etc. as shown in below figure.

Fuel tank:

It is a sealed hollow tank having opening for fuel filling and inlet and outlet pipe connection made from metal and hard plastic either welded or molded to store fuel when vehicle on move and constantly supply fuel to carburetor through hose pipe. The capacity of fuel tank depends upon the size of the engine and travelling distance. Inside fuel tank strainer connected with supply pipe and also provision for fuel level measuring device operated by electrical power source.

Fuel Supply Pipe:

For large vehicle we need some means to transport fuel from the tank to carburetor float chamber by using plastic or rubber hose pipe due to its flexibility nature and easy of assembly. In motorcycle as the fuel tank is mounted above the engine small pipe directly connected from tank outlet to fuel key (it has three position open, reserve and close) from the fuel key fuel directly enters into carburetor float chamber through small filter.

Low Pressure Pump:

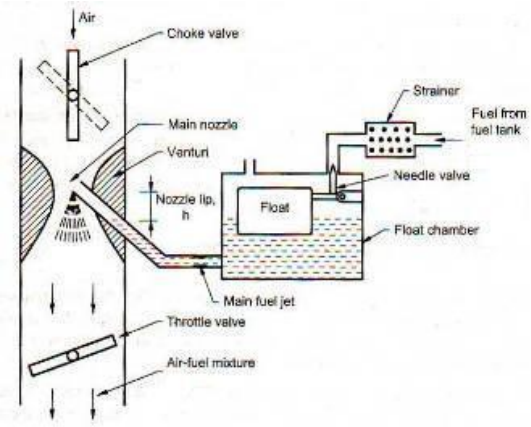
Low pressure pump generally used in S.I engine fuel system to pump fuel from tank to carburetor float chamber. It either battery operated or engine operated for most cases it's operated by electric pump. A small centrifugal pump used to pump fuel continuously to float chamber of carburetor.

Float chamber:

It is a chamber fitted below the carburetor to maintain level of fuel with nozzle position inside venture tube by using simple float mechanism. The float is connected with a needle valve which is used for opening and closing of fuel passage. Whenever the level of fuel reached to a specified level due to light weight of float it also moves upward which in turn closes the needle valve so it arrest extra fuel supply into float chamber. There is a fuel well dipped in float chamber to suck fuel into venturi tube due to pressure difference.

Carburetor:

It is the main heart of S.I engine because it mix proper amount of fuel with air when driver press the accelerator pedal by using pressure difference at both side of venturi tube. Below diagram shows a simple carburetor for better understanding of carburetor operation. As we know that gasoline fuel is highly volatile when it comes with contact to flowing air it get vaporized by absorbing latent heat of vaporization. That vaporized air fuel mixture supplied into inlet manifold of engine from where the mixture is supplied to appropriate combustion chamber during operation of multi cylinder engine.



Filters:

As fuel transported, handled and stored in metal container so due to environmental degradation rust formed inside these components if these rust are not removed from fuel this may block intricate fuel passage of carburetor. So fine dust particle should be removed from fuel before entering into carburetor for this purpose fuel filters play an important role to supply clean fuel into carburetor. Mainly two type of filter used in fuel supply system these are primary and secondary filter. In primary filter large dust particle removed by using wire mesh made of steel wire after that fuel goes to secondary filter which is made of either paper type or cloth type which are helpful to remove fine dust particle from fuel.

4.2.2 C.I Engine Fuel Supply System:

C.I engine fuel supply system is more or less similar to S.I engine fuel supply system in term of transportation of fuel from tank to fuel pump. We know that S.I engine uses carburetor to vaporize fuel and mixes with water but in C.I engine diesel fuel directly pumped into combustion

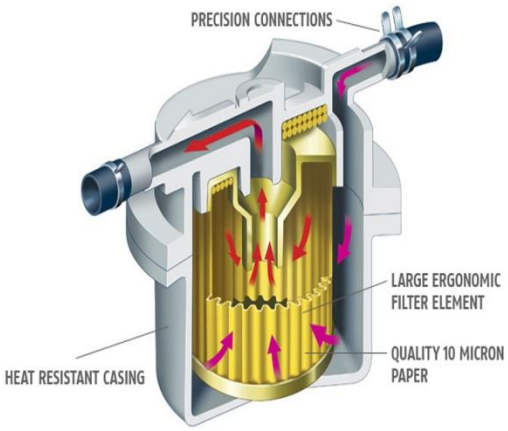
chamber at the end of compression stroke by using high pressure pump system. The main components of C.I engine fuel system are: diesel tank, steel and rubber hose pipe, fuel feed pump, primary filter, secondary filter, fuel injection pump, high pressure pipe, injector, and return line etc. In this section we only concentrate on the main components of C.I engine fuel system

Fuel Feed Pump:

The fuel feed pump used for the diesel engine is similar to that of a fuel lift pump for the petrol engine. It delivers the fuel from the tank to the injection pump continuously and at a reasonable pressure. It is necessary because there is possibility of formation of vapour bubbles and subsequently cavitation in the pump due to suction of the rapidly moving plungers of the injection pump. This would lead to uncontrolled variations in the rate of delivery of fuel to the cylinders, causing rough running and possibly even mechanical damage to the engine. Also cavitation could cause mechanical damage in the injection pump. Generally delivery pressures of between about 29 and 98 kPa adequate for preventing vapour formation on the suction side of in-line type injection pumps. This pressure also ensures adequate supply of fuel for filling the plunger elements at high speeds in a rotary or distribution pumps.

Primary and Secondary Filter:

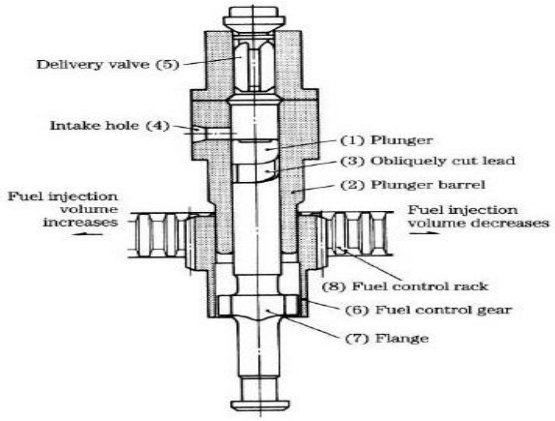
In most of the diesel engine two filters are used for cleaning fuel as we know that diesel fuel is more impure than petrol because water, wax of fuel and dust particle need to be removed first before entering into high pressure pump. If these are allowed to enter it might block the intricate passage of fuel flow. So first of all primary filter removes water present in fuel, wax content of fuel and large size dust particle by using paper and cloth type filter after that the partially cleaned fuel supplied to secondary filter which is fitted side by of primary filter. The secondary filter made of fine wire mesh or paper type which is helpful for cleaning remaining fine dust particle from fuel so that we get clean diesel fuel at pump inlet for smoother operation of engine for longer period. Generally primary filter clogged first due to maximum removal of dirt from diesel fuel.



Fuel Injection Pump:

An **Injection Pump** is the device that **pumps** diesel (as the **fuel**) into the cylinders of a diesel engine. Traditionally, the **injection pump** is driven directly from the crankshaft by gears,

chains or a toothed belt (often the timing belt) that also drives the camshaft. Below shows an injection pump for single cylinder engine.

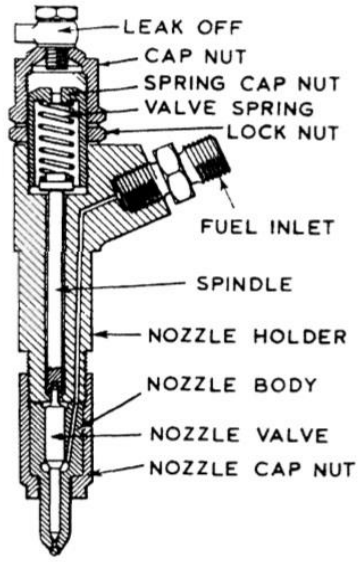


We know that in four stroke diesel engine in every two revolution of crank shaft there is one power stroke that means fuel injected once in every two revolution so as the driving shaft of fuel pump connected with the timing gear assembly it should rotate half the revolution of crank shaft. When the driving shaft of fuel pump rotated it reciprocates the plunger of fuel pump inside plunger barrel to supply enough fuel at proper pressure (around 100 bar) with proper timing to the injector through high pressure pipe.

Fuel Injector:

Fuel injection is the introduction of fuel in an internal combustion engine, most commonly automotive engines, by the means of an injector which is fitted on head of an engine. The injector tip has multiple intricate holes to atomize the high pressure diesel fuel coming from fuel pump. As the fuel atomized it get properly mixed with hot high pressure air inside combustion

chamber to get a highly combustible air fuel mixture. Below shows a cut section model of simple injector assembly.



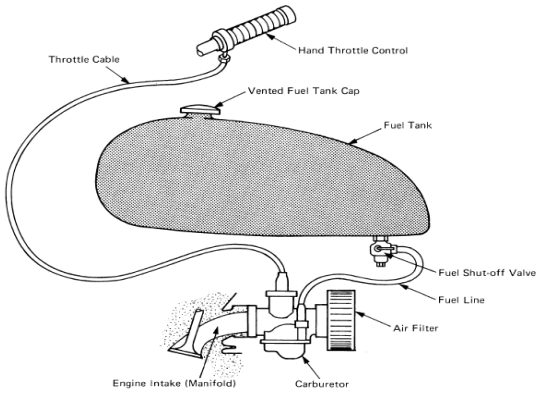
Fuel injector assembly

Besides all these main components some auxiliary components also used in fuel supply system such as return pipe line, governor assembly for controlling speed of engine are also necessary for proper functioning of engine.

4.2.3 Motorcycle Fuel Supply System:

As most motorcycle uses single cylinder 4-stroke S.I engine as power source to drive the vehicle so as already discussed earlier in S.I engine fuel supply system the fuel is gravity fed to carburetor as the fuel tank is mounted above engine and carburetor. Some modern day motorcycle now a day using port injection system instead of carburetion to supply fuel into combustion chamber like C.I engine for better fuel economy, higher power output and

compactness of engine. Below figure shows fuel supply system of motorcycle it consists of storage tank, carburetor, hand throttle control, fuel shut-off valve etc. which are common for almost all motorcycle.



LUBRICATION SYSTEM:

Introduction:

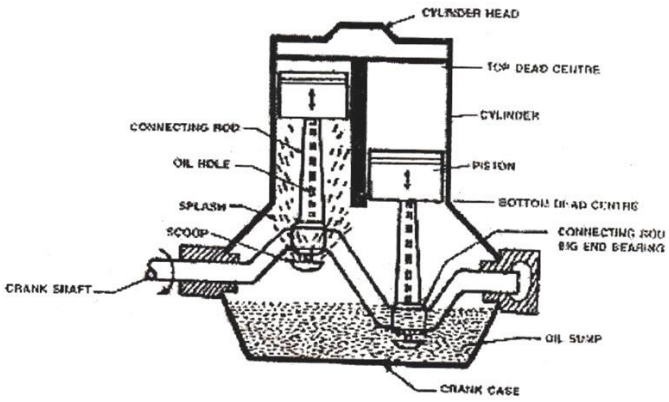
As we know that during operation of engine many components reciprocates, rotates so due to this friction comes into play between two rotating component due to friction heat also produced between these mating part. If the friction between two components is not reduced it may pose serious risk to engine components. To minimize this friction lubrication system is the most necessary for running the vehicle smoothly. The substances used to fulfill this purpose is called as lubricant this may be solid, semisolid or liquid but in our vehicle operation mostly liquid lubricants are used for lubricating engine components and sometime semisolid lubricants are also used for lubricating chassis components. Here we will discuss about former lubricants used for engine lubrication system. So lubrication system of engine mainly classified as follows

1. Wet sump lubrication system.
    a) Splash lubrication system.
    b) Splash and pressurised lubrication system.
    c) Pressurised lubrication system
2. Dry sump lubrication system.
3. Mist lubrication system

5.1 Splash Lubrication System:

This type of lubrication system was widely used in old model engines and slow speed running engine. As the crank shaft speed is low so whatever oil sprayed onto

lubricating components perfectly goes deep into friction surface. In this lubrication system a spoon type structure extended from main bearing cap of crank shaft when the spoon type extruded portion dipped in oil of oil sump it directly throw oil to cylinder liner situated above crank shaft due to inertial effect produced. Below figure shows a simple splash lubrication system of a dual cylinder engine.

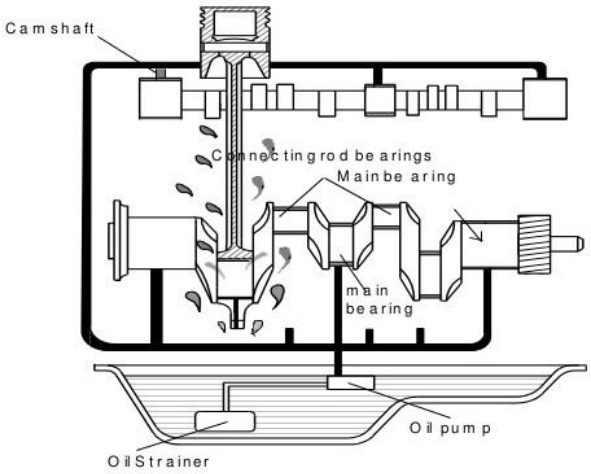


SPLASH LUBRICATION

Now a day splash lubrication system becomes absolute due to some disadvantages and availability of better lubrication system.

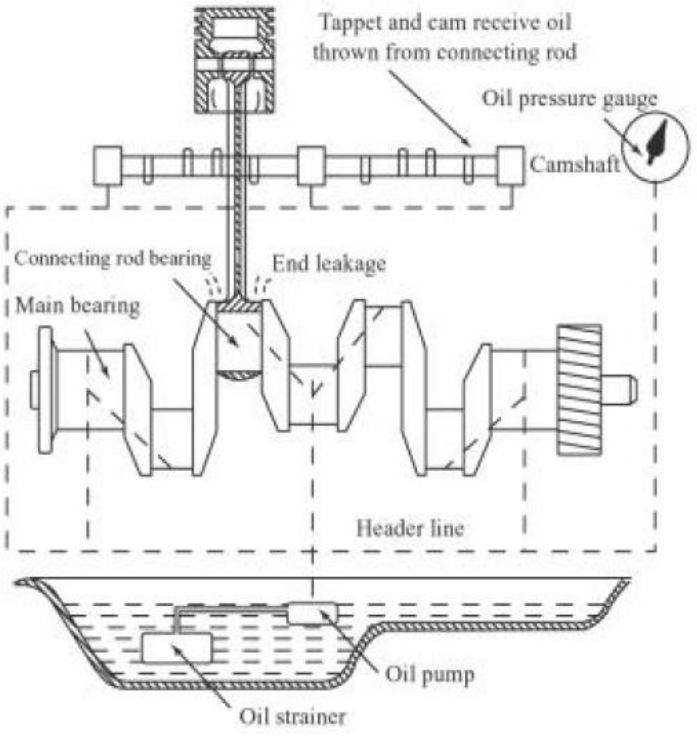
5.2 Splash and Pressurized Lubrication System:

In most small single cylinder 4-stroke engine used in motorcycle and low speed diesel engine this type of lubrication system implemented it consists of combination of both splash and pressurized lubrication system which efficiency is in between splash and pressurized lubrication system. Below figure shows this system which is more or less similar to pressurized lubrication system.



5.3 Pressurized Lubrication System:

Now a day pressurized lubrication system implemented almost in all engine used for various purpose due to its high speed, compact design and more challenging operating condition these earlier lubrication systems are not efficient so pressurized lubrication system implemented the main advantages of pressurized lubrication system is that it gets its power from engine crank shaft to drive positive displacement type pump to supply more amount of oil to main oil gallery of engine. The main components of pressurized lubrication system are: oil strainer, oil pump, filter, main oil gallery etc. below fig shows the block diagram of pressurized lubrication system.

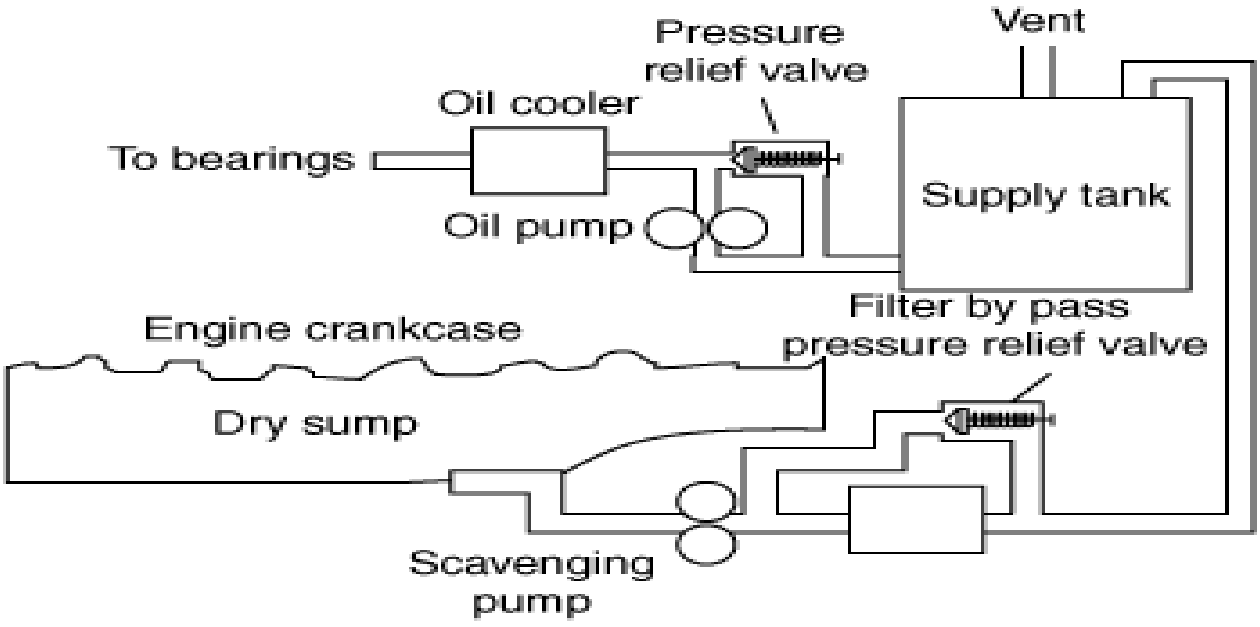


Operation:

In pressurized lubrication system, first of all strainer or primary filter dipped in oil present in sump of engine which is at bottom most portion of engine. The inlet pipe of oil pump connected with oil strainer, when engine started rotating as driving gear of oil pump directly connected with cam shaft by means of spiral gear so oil pumped into main oil gallery of engine, from main oil gallery high pressure oil supplied to all lubricating components of engine through internal passage drilled inside engine block. After lubricating the oil fall on oil sump due to gravitational action.

5.4 Dry Sump Lubrication System:

This system is a special type of lubrication system implemented mainly on aero plane engine as we know that aero plane always changes altitude and angle of assent and decent so if ordinary lubrication system used the oil pump might not get continuous supply of oil so in the



IGNITION SYSTEM:

Introduction:

Ignition system is the most important of component of s.i engine. At the end of compression stroke when sufficient pressure and temperature built up inside combustion chamber the air fuel mixture ignited by the means of spark generated at spark plug. The current supplied to spark plug by means of ignition system. The ignition system mainly classified as:

1. Magneto ignition system.

2. Battery ignition system.

3. Electronic ignition system.

   a. Transistor coil ignition system.

   b. Capacitor discharge ignition system.

6.1 Magneto Ignition System:

It is the simplest and oldest form of ignition system used in si engine. Where it works like a generator which gets its power from crank shaft to produce electricity for ignition process. The main components of magneto ignition system are:

Magneto:

It is the major part of this type of ignition system because it is source of energy. A magneto is a small electric generator which is rotate by the engine and is capable of produce a very high voltage and does not need battery as a source of external energy. The magneto contains both primary and secondary winding thus it does not require a separate coil to boost up the voltage required to operate the spark plug. There are two types of magneto. First one is known as armature rotating type and other one is known as magnet rotating type. In the first type, the armature rotates between the stationary magnets. On the other hand in second type armature is stationary and the magnates are rotating around armature.

Distributers:

Distributor is used in multi cylinder engine to regulate spark in each spark plug at correct sequence. It distribute ignition surge in individual spark plug in correct sequence. There are two types of distributor. One is known as carbon brush type and the other one is gap type. In carbon brush type carbon brush carried by the rotor arm sliding over the metallic segment embedded into the distributor cap or molded insulating material. This makes electric connection or secondary winding with spark plug. In gap type distributor electrode of rotor arm pass close to but does not make contact with the distributor cap. So there is no wear of electrode.

Spark plug:

A spark plug generally has two electrodes which are separated with each other. A high potential discharge flow through it which generate spark and ignite the combustion mixture in cylinder. It mainly consist two electrodes a steel shell and an insulator. The central electrode

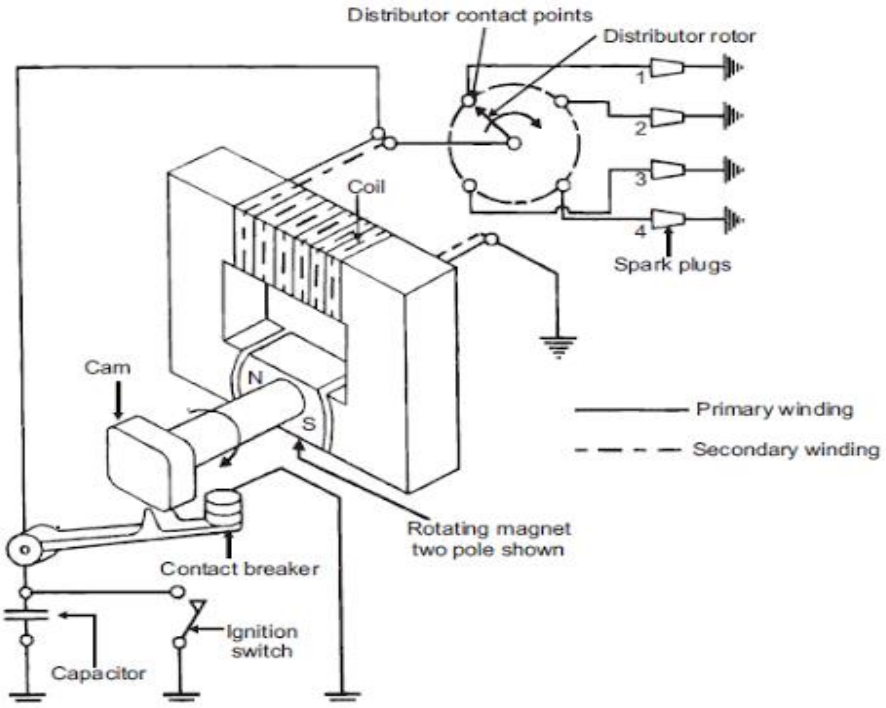
connected with the supply of ignition coil. It is well insulated with the outer steel shell which is grounded. There is a small air gap between steel shell and central electrode, between which spark is generated. The electrode usually made by high nickel alloy so it can withstand with high temperature and corrosion resistance.

Capacitor:

It is a simple electrical capacitor in which two metal plate are separated by an insulating material with a distance. Commonly air is used as insulating material but for particular technical requirement some high quality insulating material is used. The main function of capacitor in ignition system is to store and release energy when required.

Working of magneto ignition system:

Below figure shows a multi cylinder magneto ignition system and the working of magneto ignition systems explained, First when the engine starts or during cranking magneto rotate which generates a very high voltage in primary winding the output of primary winding is connected with the ignition capacitor in parallel with contact breaker. One end of magneto winding is also grounded through contact breaker.



The cam regulates the contact breaker. Wherever the breaker open, current flows into condenser, which charged the condenser. As the condenser become charger the primary current falls and the magnetic field collapses. This will induces a much higher voltage in condenser. Now this high voltage EMF produce spark at correct spark plug through distributor.

Advantages:

- Most efficient at high speed so used in racing car and aeroplane engine.
- Low maintenance cost.
- No external power source required.
- Mostly used in medium and high speed engine.

Disadvantages:

- Difficult to start due to current produced according to speed of engine.
- Higher initial cost compare to battery ignition system.
- Chance of misfire is more due to possibility of leakage because very high current passed through wiring.

6.2 Battery Ignition System:

Due to some disadvantages in magneto ignition system instead of magneto which produces electricity battery used as the source of electric power to initiate the spark. The working of battery ignition system is similar to magneto ignition system. The main components of battery ignition system are:

Battery:

A battery is used to provide energy for ignition. It is work as storage of energy and charged by dynamo, which is driven by engine. It converts chemical energy to electric energy. Two types of battery used in spark ignition system, lead acid battery and alkaline battery. The first one is used in light duty commercial vehicle and the other one is used in heavy duty commercial vehicle. It is housed in primary side of ignition coil.

Ignition Switch:

It is used to turn on and off the ignition system. Battery is connected to the primary winding of ignition coil by ignition switch and ballast resistor. Generally when driver rotates the key he/she turn on the ignition system.

Ballast Resistor:

It is connected in series with primary winding to regulate current in primary winding. It is used to prevent injury due to overheating of ignition coil. It controls the current passes through primary winding. It is made by iron. Iron has property of increase electrical resistance rapidly by increase in temperature at certain limit. This additional resistance resists flowing current which control the temperature of ignition coil.

Ignition Coil:

Ignition coil is the main body of battery ignition system. The purpose of ignition coil to step up the battery voltage (6 or 12) to a high voltage, which is sufficient to produce spark at spark plug. It consist a magnetic core or soft wire or sheet, and two electrical winding called primary winding and secondary winding. The primary winding has generally 200-300 turn and the end are connected to exterior terminal. The secondary has almost 21000 turns of copper wire which is insulated to withstand with high voltage. It is located inside the primary winding and its one end connected to secondary winding and other end is grounded either to primary winding or to the metal case. This entire unit is enclosed in a metal container which makes it a compact unit.

Contact breaker:

This is a mechanical device making and braking the primary circuit to ignition coil. When the points are closed current flow in ignition coil and when it open, flow of current stopped.

Capacitor:

It is a simple electrical capacitor in which two metal plate are separated by an insulating material with a distance. Commonly air is used as insulating material but for particular technical requirement some high quality insulating material is used.

Distributor:

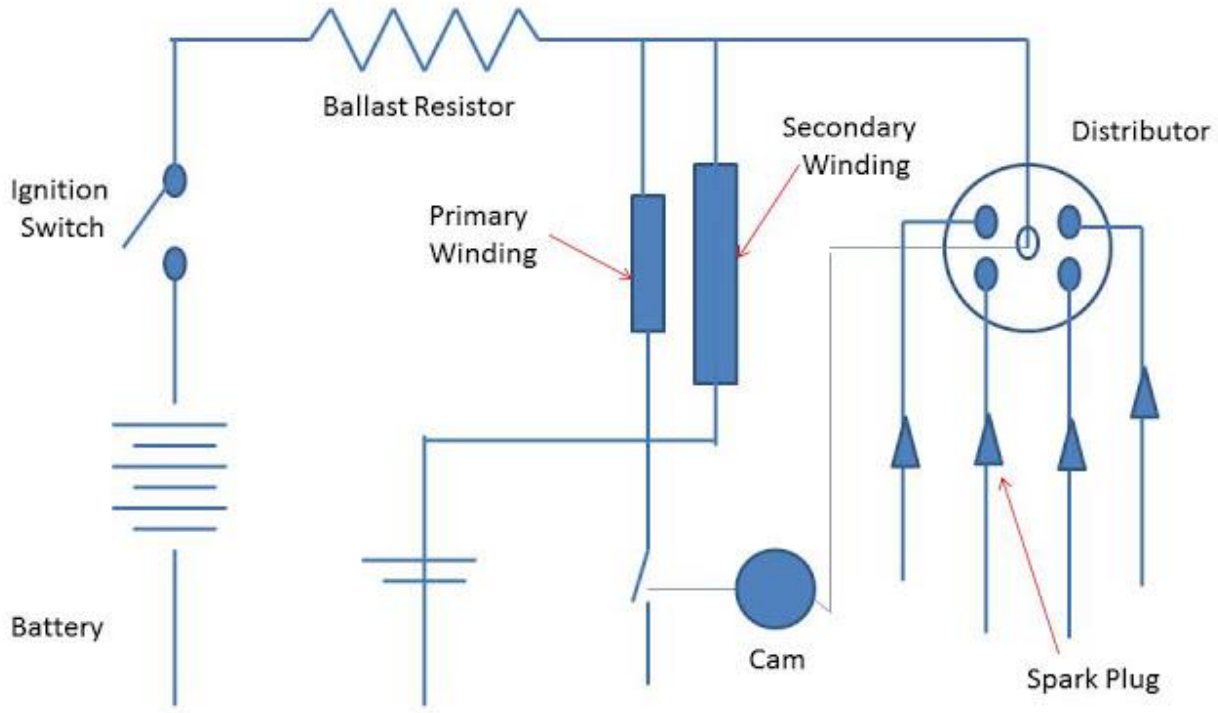
Distributor is used in multi cylinder engine to regulate spark in each spark plug at correct sequence. It distribute ignition surge in individual spark plug in correct sequence. There are two types of distributor. One is known as carbon brush type and the other one is gap type. In carbon brush type carbon brush carried by the rotor arm sliding over the metallic segment embedded into the distributor cap or moulded insulating material. This makes electric connection or secondary winding with spark plug. In gap type distributor electrode of rotor arm pass close to but does not make contact with the distributor cap. So there is no wear of electrode.

Spark Plug:

A spark plug generally has two electrodes which are separated with each other. A high potential discharge flow through it which generate spark and ignite the combustion mixture in cylinder. It mainly consist two electrodes a steel shell and an insulator. The central electrode connected with the supply of ignition coil. It is well insulated with the outer steel shell which is grounded. There is a small air gap between steel shell and central electrode, between which spark is generated. The electrode usually made by high nickel alloy so it can withstand with high temperature and corrosion resistance.

Working of Battery Ignition System:

In the battery ignition system ignition coil stores the energy in form of magnetic field and deliver it at the instant of ignition, in form of high voltage current with high tension wire to correct spark plug. The diagram of four cylinder battery ignition system is as follow.



Battery Ignition System for Four Cylinder SI Engine

1. First low voltage current flow form battery to the primary coil through ignition switch and ballast resistor.
2. Ballast resistor regulates the temperature of ignition coil by regulating current passing form it.
3. The ignition capacitor connected in parallel with contact breaker. One end of secondary winding is also grounded through contact breaker.
4. When the ignition switch is closed, the primary winding of the coil is connected to the positive terminal, and current flow through it known as primary current.

5. The current flows form primary coil produces a magnetic field which induces an EMF in secondary coil.
6. The cam regulate the contact breaker. Wherever the breaker open, current flows into condenser, which charged the condenser.
7. As the condenser become charger the primary current falls and the magnetic field collapses. This will induces a much higher voltage in condenser.
8. Now the condenser discharge into the battery which reverse the direction of both primary current and magnetic field. This will induce a very high EMF in secondary winding.
9. Now this high voltage EMF produce spark at correct spark plug through distributor.

Advantages:

1. At the time of starting or at low speed good spark is available.
2. The battery which is used to generate spark can be used to light other auxiliaries.
3. Initial expenditure is less and it has low maintenance cost.
4. Ignition system is not affected by adjusting spark timing in battery ignition system.

Disadvantages:

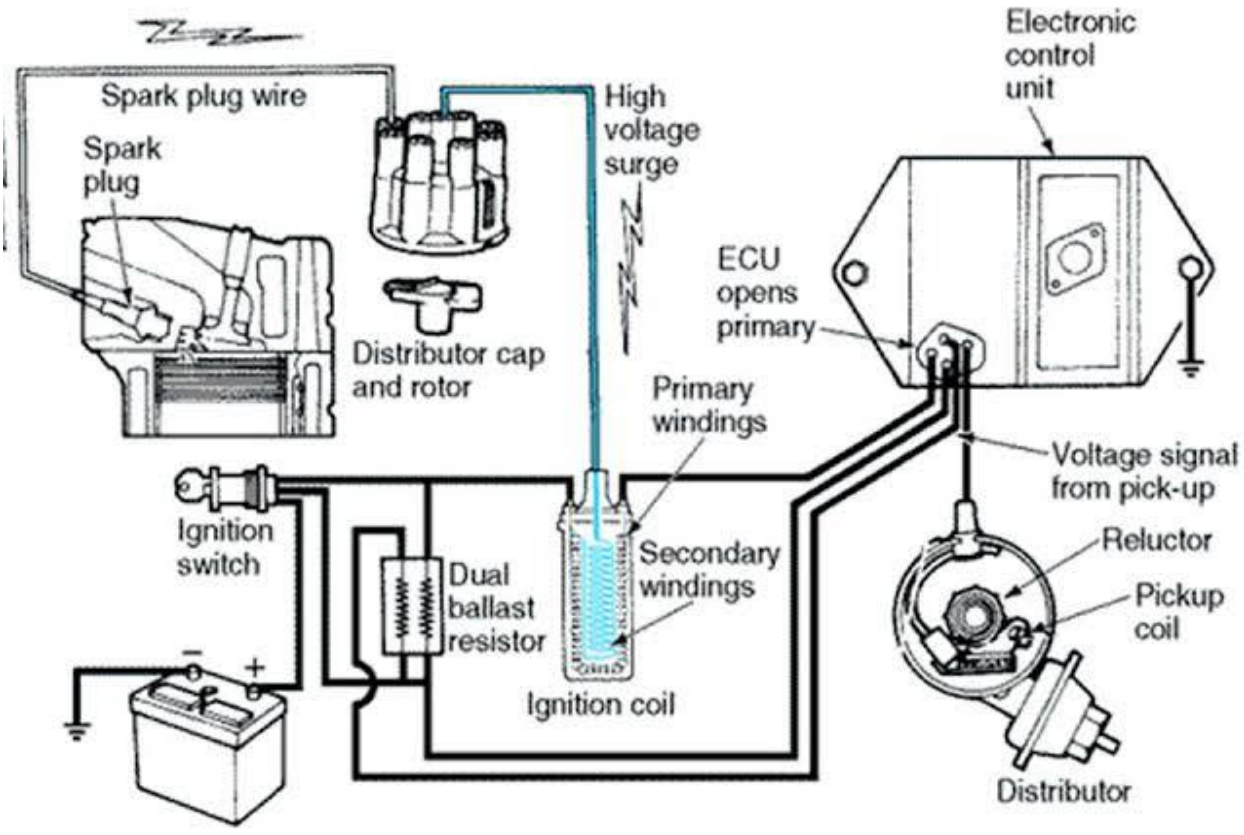
1. Time available of built up the current and stored energy is decrease as speed of engine increases.

2. Contact breaker subjected to both electrical and mechanical wear which results short maintenance interval.

3. The primary voltage decreases as the engine speed increase. So it is not fully reliable of high speed engine.

6.3 Electronic Ignition System:

Electronic ignition system is the type of ignition system that uses electronic circuit, usually by transistors controlled by sensors to generate electronic pulses which in turn generate. Better spark that can even burn the lean mixture and provide better economy & lower emission. The components of electronic ignition system is similar to battery ignition system e.g. battery, spark plug, distributor, ignition coil except electronic control module, sensors and pulse generator.



Types of electronic ignition system:

Capacitive discharge ignition system

Transistorized system

Piezo –electric ignition system.

Texaco ignition system.

Main components of electronic ignition system:

The components of an electronic ignition system regardless of the manufacturer all perform the same functions. Each manufacturer has its own preferred terminology and location of the components. The basic components of an electronic ignition system are as follows.

Trigger Wheel:

The trigger wheel, also known as a reluctor, pole piece, or armature, is connected to the upper end of the distributor shaft. The trigger wheel replaces the distributor cam. Like the distributor cam lobes, the teeth on the trigger wheel equal the number of engine cylinders.

Pickup Coil:

The pickup coil, also known as a sensor assembly, sensor coil, or magnetic pickup assembly, produces tiny voltage surges for the ignition systems electronic control unit. The pickup coil is a small set of windings forming a coil.

Electronic Control Unit Amplifier:

The ignition system electronic control unit amplifier or control module is an "electronic switch" that turns the ignition coil primary current ON and OFF. The ECU performs the same function as the contact points. The ignition ECU is a network of transistors, capacitors, resistors, and other electronic components sealed in a metal or plastic housing. The ECU can be located (1) in the engine compartment, (2) on the side of the distributor, (3) inside the distributor, or (4) under the vehicle dash. ECU dwell time (number of degrees the circuit conducts current to the ignition coil) is designed into the electronic circuit of the ECU and is NOT adjustable.

Working Of Electronic Ignition System:

To understand the working of the electronic ignition system let’s consider below fig in which all the components are connected in their working order.

When the driver switch ON the ignition switch in order to start a vehicle the current starts flowing from the battery through the ignition switch to the coil primary winding , which in turn starts the armature pick up coil to receive and send the voltages signals from the armature to the ignition module.

When the tooth of the rotating reluctor comes in front of the pickup coil, the voltage signal from pickup coil is sent to the electronics module which in turn senses the signals & steps the current to flow form. Primary coil.

When the tooth of the rotating reluctor goes away from the pickup coil, the change in voltage signal is sent by pickup coil to the ignition module & a timing circuit inside ignition module turns ON the current flow.

A magnetic field is generated in the ignition coil due to this continuous make & break of the circuit. Which induced an EME in secondary winding which increases the voltage up to 50,000 volts. The high voltage is them sent to the distributor, which has the rotating rotor & distributor points which is set according to the ignition timing. When the rotor comes in front of any of the distributor points the jumping of the voltage through the air gap from the rotor to the distributor point take place which is then sent to the adjacent spark plug through the high tension cable & a voltage difference is generated between the central electrode & ground electrode which is responsible for generating a spark at the tip of the spark plug & finally the combustion takes place.

Advantages of Electronic Ignition Systems over Conventional Ignition System:

1. No need to adjust spark advance and delay for avoiding knocking.
2. Mechanical distributor system eliminated in case of multi cylinder engine.
3. The quality of ignition improved.
4. No ignition problem arises if the engine speed varies.
5. Due to use of electronic ignition system in modern automobile fuel consumption decreased.

6.4 Starting System:

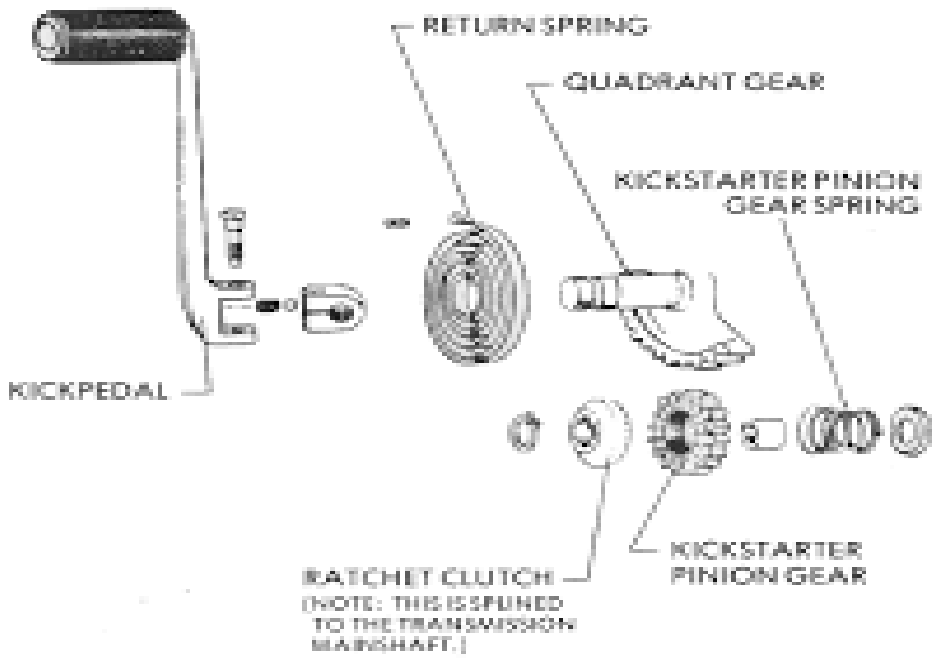
Starting system is necessary for cranking any engine from static position. Before starting of the engine driver need to switch on the ignition key. After closing of ignition circuit the driver goes for starting the engine. There are different methods implemented to start an engine. Earlier engines are started by rotating the crank shaft by means of rope directly wound around a pulley which is directly connected with crank shaft, and later on starting handles are used to start single cylinder engine and sometime small capacity multi cylinder engine. Due to difficulty during starting of multi cylinder engine later on electrical motor directly coupled with crank shaft through fly wheel and ring gear. So that due to easy of staring using electrical motor now a days almost all automobile engines are fitted with electrical starting systems. Starting system of two wheelers and three wheelers mainly classified as:-

1. Kick starter system.
2. Self-starter system.
3. Rope starting system.
4. Jerk starting system.

6.4.1 Kick starter system:

It is a method of starting an internal combustion engine (usually that of a motorcycle) by pushing a ratcheting lever with one's foot. Kick start mechanisms were almost universally a part of motorcycle engines before the mid-1970s, and were phased out of production over the next twenty years or so as electric starters became standard equipment. There are still some motorcycles produced that have both kick and electric starters.

Many mopeds and scooters also carry both a kick start and an electric start, the former being useful in case the latter fails, as scooter and moped batteries tend to be smaller and, as a result, run down much faster than other forms of automotive batteries. Also, it is usually not possible to push start a moped or scooter with automatic transmission



Above figure shows a simple kick starter mechanism of motorcycle having different components mentioned on it such as kick pedal, return spring, quadrant gear, ratchet clutch, pinion gear and pinion gear spring etc.

Operation:

The kick starter works on simple mechanism in this system the kick pedal is connected to quadrant gear shaft or sector gear by means of spline joint which is tightened by screw to avoid

slippage after regular use. In the sector gear shaft return spring mounted whose one end inserted with appropriate hole on shaft and another end fixed with casing. This helps to return the kick pedal to initial position after starting of engine.

Quadrant gear:

As the name implies this gear only operational for the quadrant portion of gear because when driver kicks the pedal around 120^0 rotation is enough for starting any engine. After starting of engine the teeth of quadrant/sector gear disconnected with the pinion gear so as the speed of the engine increases it doesn't affect the starting system. Due to tension on spring the pedal comes to its original position without engagement of sector gear and pinion gear.

Pinion gear assembly:

This unit is most important for kick starting system to avoid damage to rotating elements after starting of engine. It consists of ratchet clutch, kick starter pinion gear and spring. The ratchet clutch is directly connected with main shaft by means of gearing arrangement. And side of the ratchet clutch having teeth's for engage and disengagement of pinion gear with main shaft. Before starting of engine both ratchet clutch and pinion gear are engaged with each other due to spring tension. When engine started as the speed picked up the pinion gear automatically disengaged from ratchet clutch due to ratchet mechanism as shown.

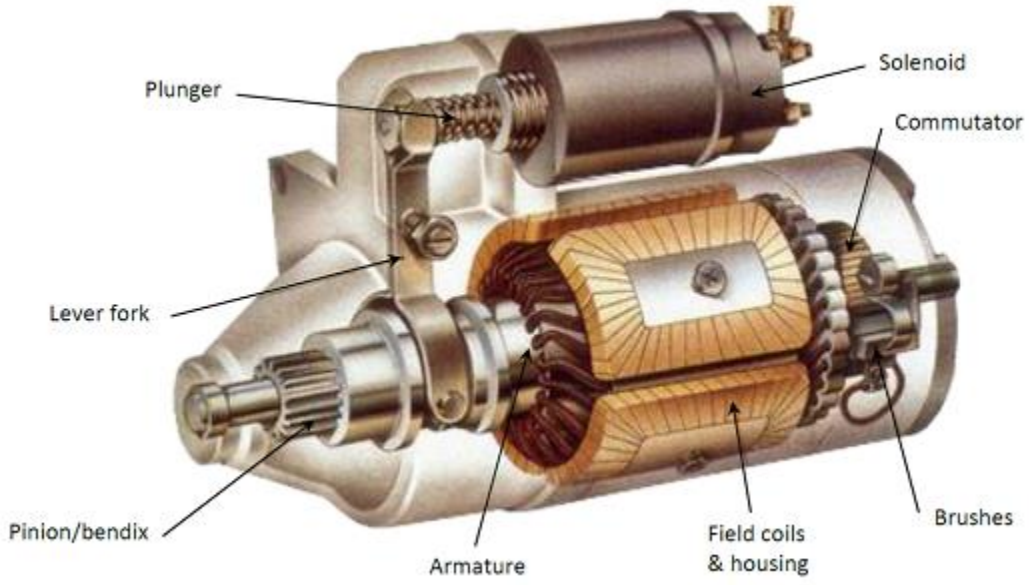
Self-Starting Mechanism:

When ignition switch of the bike is pressed, it allows a small current to flow through the solenoid present in the starter circuit. When current passes through coil of solenoid, it attracts an iron rod. The movement of the rod closes two electrical contacts, completing the circuit from the

battery to the starter. The powerful starter motor starts rotating. Its shaft carries a small pinion which engages with a large gear ring around the rim of the engine flywheel.

The ignition switch has a return spring, so that as soon as you release the key it springs back and turns the starter switch off. The rod also has a return spring -when the ignition switch stops feeding current to the solenoid, the contacts open and the motor stops. The return springs are needed because the starter motor must not turn more than it has to in order to start the engine. The reason is partly that the starter uses a lot of electricity, which quickly runs down the battery. Also, if the engine starts and the starter motor stays engaged, the engine will spin the starter so fast that it may be badly damaged. The starter motor itself has a device, called a Bendix drive, which engages its pinion with the gear ring on the flywheel only while the starter is turning the engine. It disengages as soon as the engine picks up speed.

So, ultimately, the starter system produces rotation of flywheel**,** and hence rotation of crankshaft, and thus the reciprocating motion of piston starts. After suction of charge, the first compression and first power stroke will occur due to starter and thereafter the flywheel will do its job to continue the rotation of the crankshaft.



There are different arrangements, sometimes the starter directly turns a gear attached to the crankshaft, often, and it spins a chain connected to a sprocket which then turns the crankshaft.

6.4.2 Rope starting mechanism:

Now a days in some small capacity stationary engine, off road vehicle engine(as shown below) and some three wheelers rope starting mechanism used due to its simplicity and less initial cost. In this system a rope usually made of cotton or some high co efficient material wound around a pulley having slots to accommodate three to four round of rope rotation to start the engine easily.

The rope drive pulley is connected with crank shaft by means of spring loaded ratchet mechanism so that the pulling force only starts the engine after starting of engine it automatically freed from crank shaft. Sometimes in three wheeler vehicle rope directly coiled on pulley on

crank shaft externally after pulling the rope automatically disconnected from pulley due to pulling force applied by driver.

6.5 Comparison between kick starting and self-starting mechanism:

Kick starting system	Self-starting system
• No need of battery and dc motor for starting of engine so lower initial cost.	• Battery and dc motor required so higher initial cost.
• If battery discharged by kicking the engine can be started	• If battery discharged to start the engine recharging needed.
• Physical handicapped person can't drive this	• Might drive if self-stating available.

type of vehicle	
• Almost all motorcycle comes with kick starting mechanism.	• Self-starting option provided to selective motorcycle.
• The weight of the vehicle less	• Weight of the vehicle increased due to addition of self-starting
• In heavy traffic situation kick starting is not a good option	• This system is good for heavy traffic situation
• Driver can't start the engine if gear engaged.	• If gear is in engaged position the engine can be started by applying clutch

BRAKING SYSTEM

Introduction

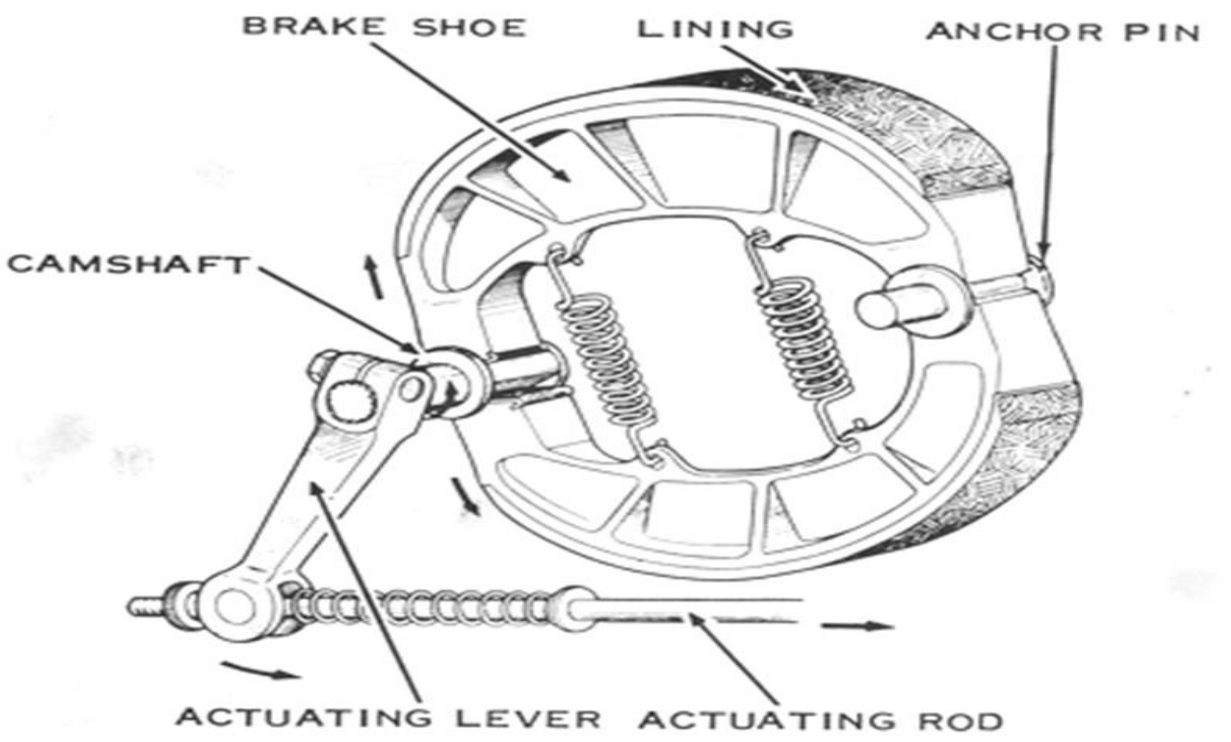
Braking system is the most important component of any vehicle playing on road without brake the vehicle might face accident due to traffic or other causes. So to run a vehicle on road it should have proper stopping system to stop the vehicle in case of emergency. The main function of braking system is to convert kinetic energy of moving vehicle into heat energy while the vehicle stops to static. Later on the heat produced by braking action dissipated to surrounding environment by moving air. The braking system of motorcycle mainly classified as:-

1. Mechanical linkage braking system.
    a) Drum braking system
2. Hydraulic braking system.
    a) Drum braking system
    b) Disc braking system
3. Pneumatic braking system
    a) Drum braking system
        - Internal expanding type.
        - External contracting type.

7.1 Mechanical Linkage Braking System:

7.1.1 Drum braking system

Before development of disc brake system drum brake system are widely used in all motorcycle and three wheelers due to its simplicity and ease of installation. This type of braking system comes under mechanical linkage braking system because the braking force applied on front and rear brake are provided by right hand lever and right foot of driver and from that position the force transmitted to brake drum by mechanical linkage i.e. the effort applied at right hand lever transmitted to front brake by means of steel wire, and the effort applied at right foot get transmitted to rear brake drum by means of mechanical linkage as shown below.



Two-wheelers such as scooters, commuter bikes, three-wheelers including auto-rickshaws widely use Drum Brake system for braking. This system is also known as the **'**Internal Expanding Shoe Type**'** brake system. This type of brake got its name from the drum structure of cylindrical-shape. Inside this drum, the parts of the conventional drum-brake system are housed. Hence, the name.

Components of drum brake:

1. A cylindrical drum itself made of cast iron or aluminium
2. A brake shoe actuating mechanism by a cam.
3. A pair of brake shoes (one each of Leading & Trailing)
4. Shoe adjuster

5. Return springs
6. Anchor Plate / pins etc.

Working principle:

In the mechanical system such as in two-wheeler & auto rickshaw, the brake shoes are actuated by a cam, which is attached to the brake linkage & pedal. When we press the brake pedal, the cam turns. Thus, it causes the brake shoes to expand outwards and rub against the drum. The friction between the brake linings and the drum causes the drum to stop rotating; thereby stopping the wheel. When we release the brake pedal, the retracting springs bring the brake shoes back to their original position. This results in a gap between them and the drum and to again spin it freely.

Advantages of Drum brake system:

1. Simple design.
2. Fewer parts.
3. Easy & cheaper to manufacture.
4. Low maintenance cost.
5. Comparatively longer life.

Disadvantages of Drum Brake system:

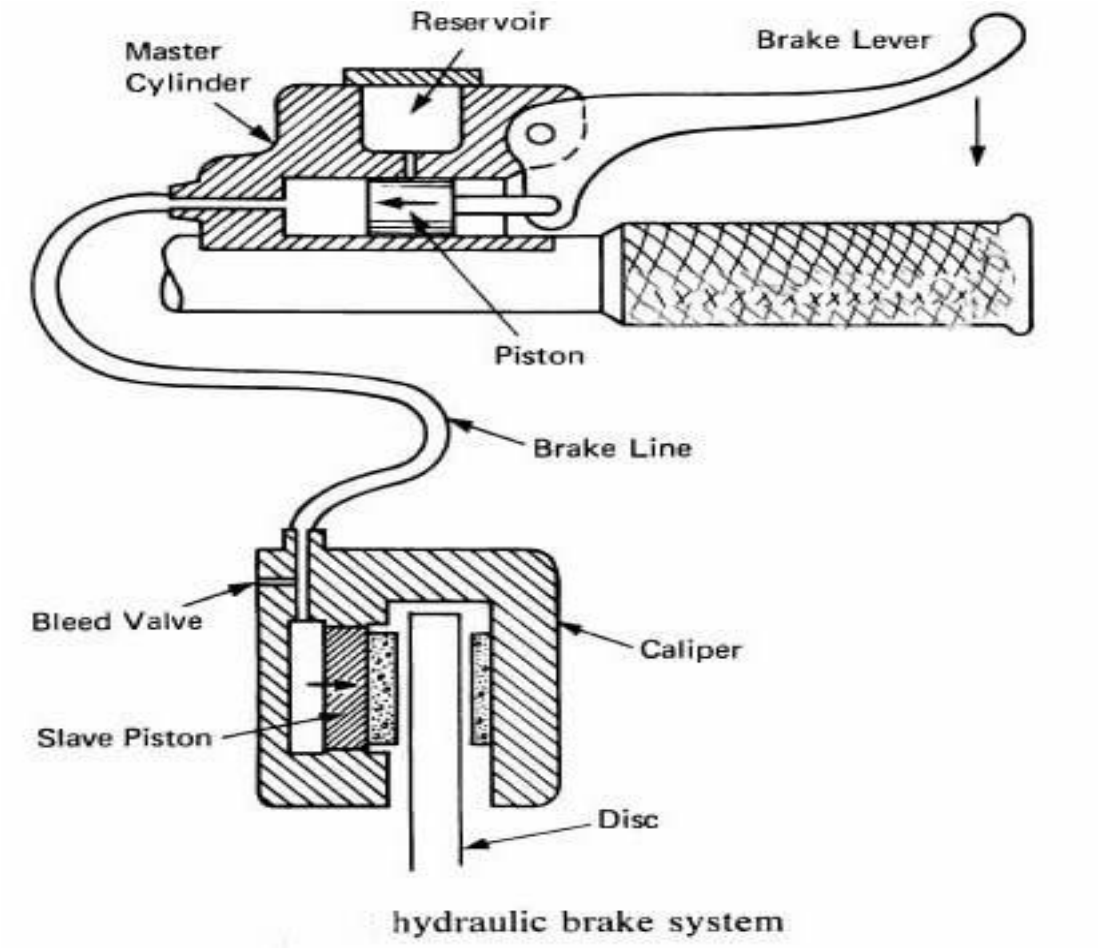
1. Low braking force compared to Discs.
2. Brakes 'fade' when the driver applies them for a prolonged time.

3. The brake shoe lining made of asbestos is harmful to humans.
4. When wet, the braking grip reduces considerably.
5. Non-asbestos linings catch moisture; causing the brakes to grab suddenly.

7.1.2 Disc braking system:

Disc brake system is widely used on front wheels in mid-range two-wheeler such as – commuter & sports bikes. Now a day's almost all motorcycle equipped with disc brake system for better driving experience of rider. Disc brake got its name from the circular-shaped plate or disc or rotor; onto which the disc brake parts are mounted. A conventional Disc Brake system consists of a brake disc, two friction pads, and brake caliper. In the Disc brake system; the friction pads apply grip on the external surface of the disc to perform braking. Modern vehicles come with ventilated discs. When you apply brakes, it converts the kinetic energy of the vehicle to heat due to the friction between the brake pads and the disc. Ventilated discs have passages or an air vent that helps pass air through the disc. Thus, it provides cooling & prevents brake fading. The disc brake consists of:

1. A circular disc made of - steel in two-wheeler.
2. A calliper assembly consisting of hydraulic pistons.
3. A pair of brake pads (one each on either side)
4. Bleed screw.



hydraulic brake system

Types of disc braking system:

Single piston:

In the single piston design such as in two-wheelers as shown above, the brake pads are actuated by a single piston, which is attached to the brake calliper. When you press the brake lever, the brake oil pushes the piston causing the brake pads to contract and rub against the disc. The friction between the brake pads and the disc causes the disc to stop rotating, thereby the wheel to stop. When you release the brake lever, the brake pads retract to their original position. This causes a gap between them and the disc and to again spin it freely.

Twin Piston:

The twin piston design such as in cars is almost identical to single piston one, except for the pistons which are two in numbers. In this system, the twin pistons push the brake pads to apply the brake. The brake pads fit on the calliper which holds the brakes system parts together. When the driver presses the brake pedal, the oil in the brake master cylinder multiplies the hydraulic force sent to the callipers; causing its piston to contract. The pistons, in turn, cause the brake pads to contract and rub against the disc. The friction between the brake pads and the disc causes it to stop rotating, thereby the wheel to stop.

Twin calliper:

The third type – Twin calliper system; actuated by two callipers which works on the same principle of that of single calliper brake system. In this design, there are two callipers instead of one. However, the high-speed luxury cars more commonly employ this type of system. This system provides more effective braking.

Advantages of Disc brake system:

1. No adjustment required. So, no maintenance.
2. Better stopping performance
3. Fade-free braking in all conditions. So, no fading of brakes.
4. Can check wear without dismantling the unit
5. Easy & quick to replacement of pads compared to Drum brakes

Disadvantages of Disc Brake system:

1. High braking force needed compared to Drum brake
2. Low life of brake pads compared to brake shoes
3. Need separate hand-brake mechanism when fitted to rear wheels.

7.2 Recent Technology Used In Two Wheeler Braking System:

7.2.1 Combined Braking System:

A combined braking system (CBS), also called linked braking system (LBS), is a system for linking front and rear brakes on a motorcycle or scooter. In this system, the rider's action of depressing one of the brake levers applies both front and rear brakes. The amount of each brake applied may be determined by a proportional control valve. This is distinct from integrated brakes, where applying pressure to brake pedal only includes application of some front brake

Operation:

The most efficient way of braking to apply front and rear brake simultaneously but in practice most riders are not experienced to apply both brake at same time. The combi brake system of Honda scooter enables to apply both front and rear brake by pressing a lever. The combi brake equaliser ensures the force distribution of both wheel at same time giving perfect balance to the rider.

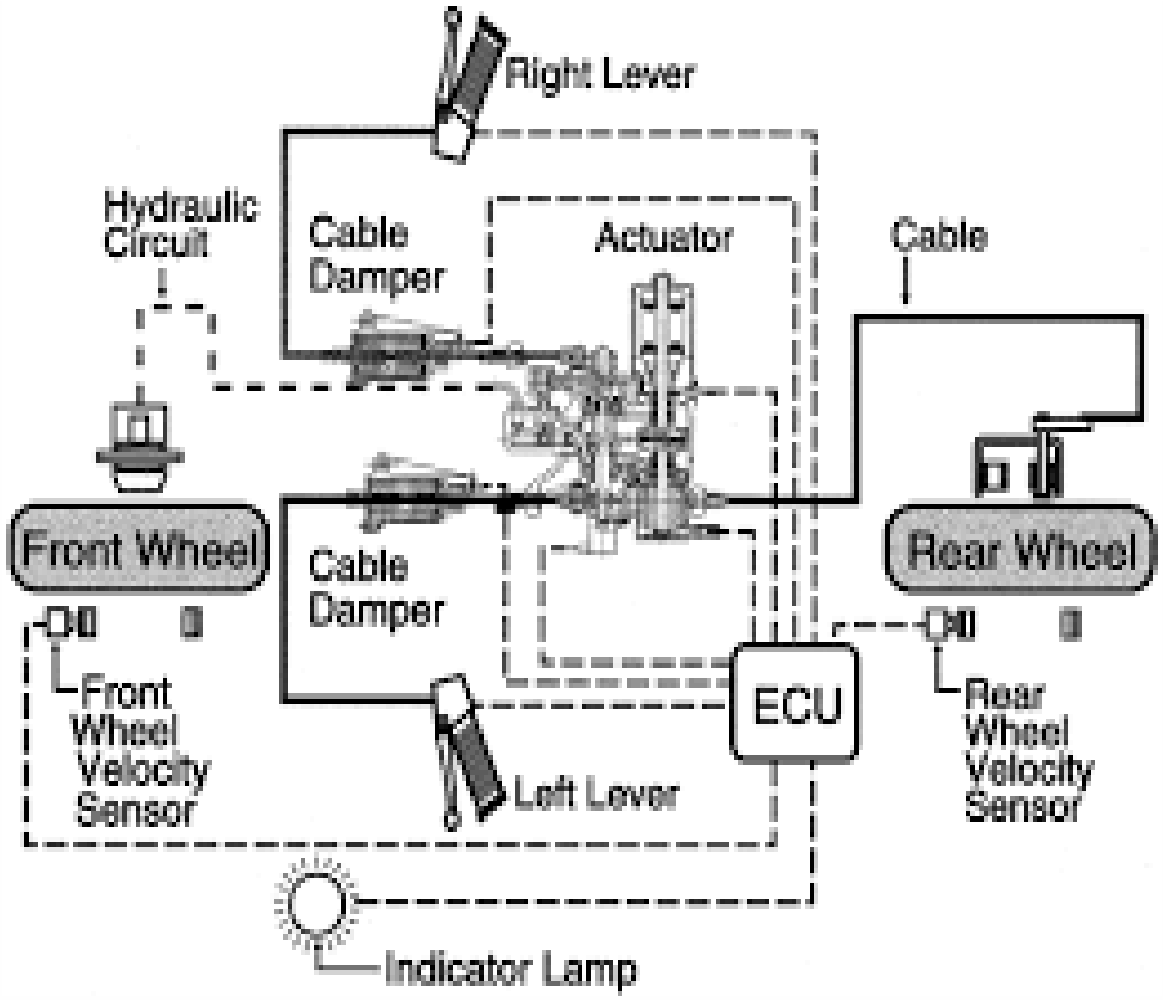
Advantages:

1. It reduces the braking distance and increases stability while braking.

2. It ensures the rider with low expertise is also confident of riding.
3. Simultaneous application of front and rear brake ensures most efficient braking.

7.2.2 Antilock Braking System:

Once considered an expensive, fancy technology meant only for premium cars, ABS, or Anti-Lock Braking System has become increasingly important to ensure road safety for not just cars, but two-wheelers as well. The efficacy of ABS systems in preventing locking of wheels and offering more control to the rider has been proven beyond doubt. A two-wheeler equipped with ABS will always be safer to operate, not just in slippery, treacherous road conditions, or in case of an emergency, but also in everyday riding scenarios. The importance of having an ABS system in ensuring rider safety has been acknowledged by the Indian government as well, and all newly sold two-wheelers above 125cc of cubic capacity will have to compulsorily come equipped with ABS by April 2019. TVS has been a pioneer in two-wheeler ABS technology for India, and was the first Indian bike maker to offer the feature on the Apache RTR 180.



Operation:

Wheel speed sensors mounted on front and rear wheel constantly measure the rotational speed of each wheel and deliver this information to an Electronic Control Unit (ECU). The ECU detects on the one hand if the deceleration of one wheel exceeds a fixed threshold and on the other hand whether the brake slip, calculated based on information of both wheels, rises above a certain percentage and enters an unstable zone. These are indicators for a high possibility of a locking wheel. To countermeasure these irregularities the ECU signals the hydraulic unit to hold

or to release pressure. After signals show the return to the stable zone, pressure is increased again. Past models used a piston for the control of the fluid pressure. Most recent models regulate the pressure by rapidly opening and closing solenoid valves. While the basic principle and architecture has been carried over from passenger car ABS, typical motorcycle characteristics have to be considered during the development and application processes. One characteristic is the change of the dynamic wheel load during braking. Compared to cars, the wheel load changes are more drastic, which can lead to a wheel lift up and a fall over. This can be intensified by a soft suspension. Some systems are equipped with a rear wheel lift off mitigation functionality. When the indicators of a possible rear lift off are detected, the system releases brake pressure on the front wheel to counter this behaviour. Another difference is that in case of the motorcycle the front wheel is much more important for stability than the rear wheel. If the front wheel locks up between 0.2-0.7s, it loses gyrostatic forces and the motorcycle starts to oscillate because the increased influence of side forces operating on the wheel contact line. The motorcycle becomes unstable and falls.

Advantages and disadvantages of ABS:

Advantages:

- Stops the car at a shorter distance than the conventional brakes.
- Prevents the wheels from locking up hence avoids uneven tyre wear.
- The vehicle is still in control under heavy or any braking conditions, unlike normal braking which is hard to steer when wheels lock up.
- Serves as a value added safety feature.

- Makes better use of the brake pads and brake disc.

Disadvantages:

- Increases the cost of the vehicle.
- Involves the use of an extra sensor and a controller which increases the complexity.
- The electronic devices like the sensor and the controller are delicate and expensive to repair and maintain.

WHEELS AND TYRES

Introduction:

Motorcycle wheels are made to cope with radial and axial forces. They also provide a way of mounting other critical components such as the brakes, final drive and suspension. Wheels, and anything directly connected to them, are considered to be unsprung mass. Traditionally motorcycles used wire-spooked wheels with inner tubes and pneumatic tyres. Spooked wheels are usually made using steel spokes with steel or aluminium rims. Cast wheels are predominantly made from an aluminium-alloy, but can also be made from more-exotic materials, such as magnesium content alloy or carbon fibre. So motorcycle wheels are mainly classified as:

1. Spooked wheel.
2. Alloy wheel.
3. Disc type wheel.

8.1 Spooked wheel:

Spooked wheels are wheels whose rims connect to their hubs by wire spokes. Although these wires are generally stiffer than a typical wire rope, they function mechanically the same as tensioned flexible wires, keeping the rim true while supporting applied loads.

Advantages and Disadvantages of Spooked Wheel:

Advantages:

1. Lower initial cost.
2. Easy to repair if damaged.
3. Sometime absorb road shock.

Disadvantages:

1. More weight
2. Tube less tyre can’t be used.
3. Old looking.
4. Chance of corrosion more.

8.2 Alloy wheel:

In the automotive industry, **alloy wheels** are wheels that are made from an alloy of aluminium or magnesium. Alloys are mixtures of a metal and other elements. They generally provide greater strength over pure metals, which are usually much softer and more ductile. Alloys of aluminium or magnesium are typically lighter for the same strength, provide better heat conduction, and often produce improved cosmetic appearance over steel wheels. Although steel, the most common material used in wheel production, is an alloy of iron and carbon, the term "alloy wheel" is usually reserved for wheels made from nonferrous alloys.

Advantages and disadvantages of alloy wheel:

Advantages:

1. Better looks.
2. Better heat dissipation and conduction.
3. Better fuel economy.
4. Better performance.
5. Better braking.

6. Good corrosion resistance.
7. Well suited for tubeless tyre.
8. Tyre life increases.

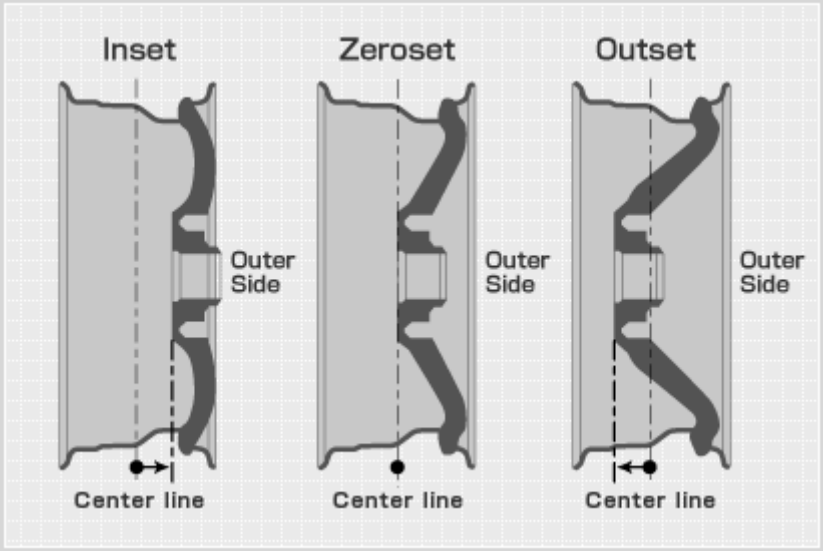
Disadvantages:

1. Higher initial cost.
2. Not strong compare to steel wheel.
3. If damaged impossible to repair.

8.3 Disc wheels:

In motorcycle disc wheels are rarely used in sports bike, but disc wheel are widely used in three wheeler because of its high strength and durability. The wheel looks like disc shape so it named as disc wheel. Mostly disc wheels are used in car, buses and heavy vehicle due to stronger in design. The disc wheel used in vehicle classified as follows:

1. Zero set wheel.
2. Inset wheel.
3. Outset wheel.



Zero set wheel:

A wheel may be inset, zero set or outset depending upon the position of the rim in relation to attachment face of the disc as shown above. In the inset wheel, the centre line of the rim is, located in board of the attachment face of the disc to the centre of the rim. A zero set wheel is the one in which the rim centre line coincides with the attachment face of the disc.

Inset wheel:

When the attachment face is outside of rim centreline the wheel called as inset wheel.

Outset wheel:

When the attachment face is inside to the rim centreline as shown above the disc type wheel called as outset wheel.

The disc type wheel are made of pressed steel having intricate hole to decrease weight of the wheel and to pass air for cooling of braking surface.

Advantages and Disadvantages of Disc Type Wheel:

Advantages:

1. More load carrying capacity.
2. Stronger in design.
3. Easy to mount tyre due to wider rim.
4. Tubeless tyre can be mounted easily.

Disadvantages:

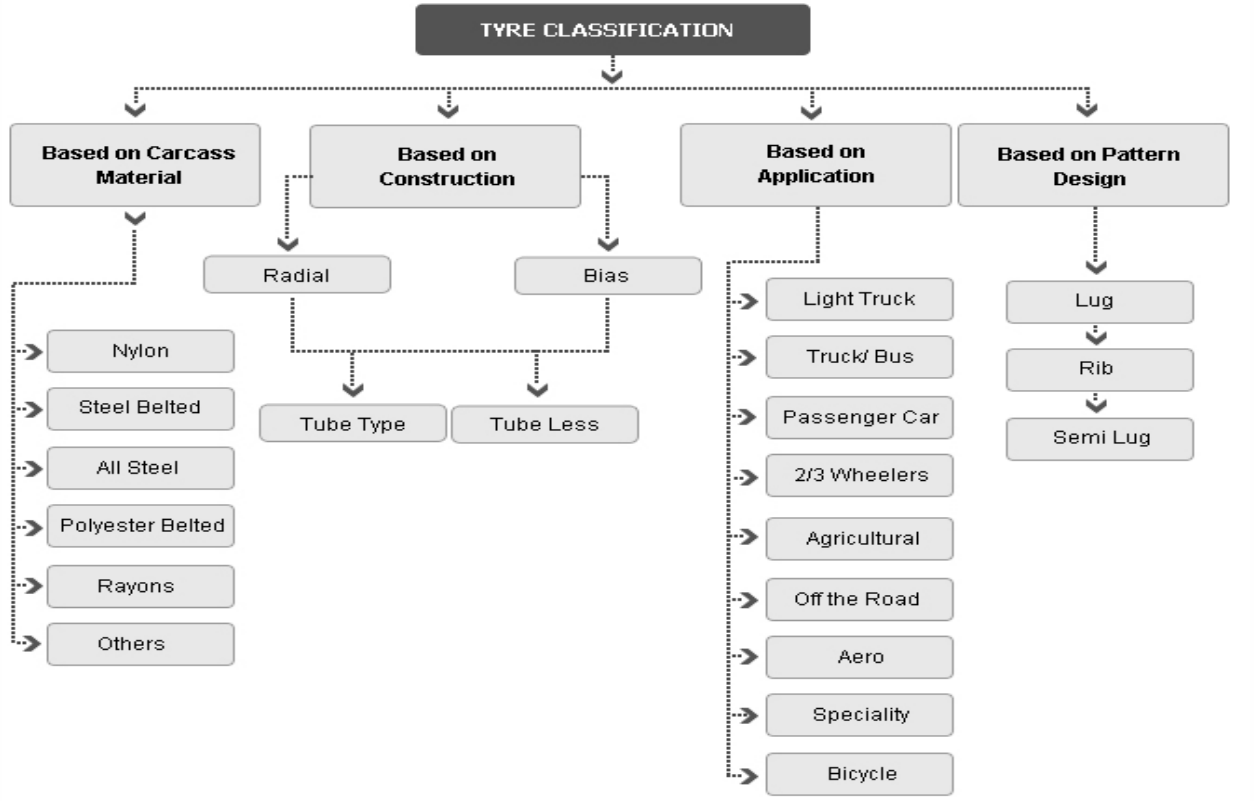
1. Higher manufacturing cost.
2. Heavier in weight.
3. Only suitable for heavy vehicle.
4. Higher initial cost.

8.4 Tyres and Tubes:

A **tyre** is a ring-shaped component that surrounds a wheel's rim to transfer a vehicle's load from the axle through the wheel to the ground and to provide traction on the surface travelled over. Most tyres, such as those for automobiles and bicycles, are pneumatically inflated structures, which also provide a flexible cushion that absorbs shock as the tyre rolls over rough

features on the surface. Tires provide a footprint that is designed to match the weight of the vehicle with the bearing strength of the surface that it rolls over by providing a bearing pressure that will not deform the surface excessively.

The materials of modern pneumatic tires are synthetic rubber, natural rubber, fabric and wire, along with carbon black and other chemical compounds. They consist of a tread and a body. The tread provides traction while the body provides containment for a quantity of compressed air. Before rubber was developed, the first versions of tires were simply bands of metal fitted around wooden wheels to prevent wear and tear. Early rubber tires were solid (not pneumatic). Pneumatic tires are used on many types of vehicles, including cars, bicycles, motorcycles, buses, trucks, heavy equipment, and aircraft. In automotive application tyre are mainly classified as:

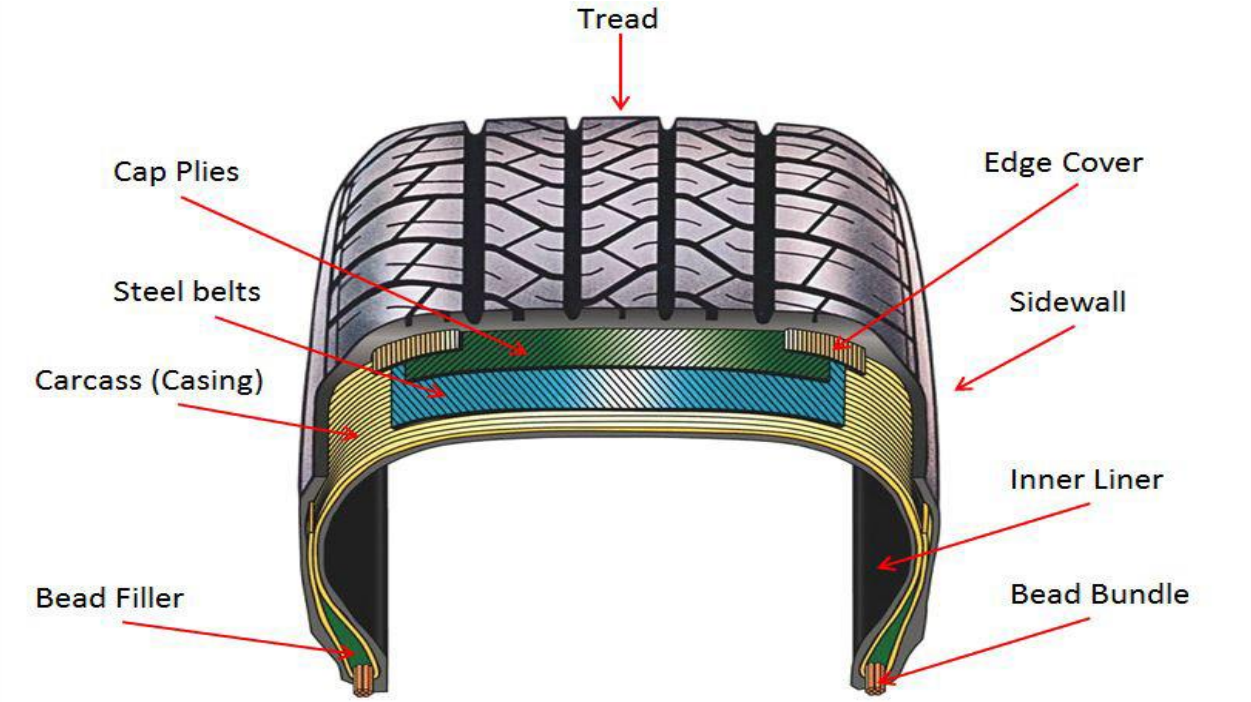


Construction of Tyres:

As shown below a simple looking tyre from outside is constructed critically from inside because it carries load of the vehicle and also absorb road shock while running on road so the terms used in tyres are: bead, tread, carcass, sidewall, steel belt, plies, filler material etc.

Beads:

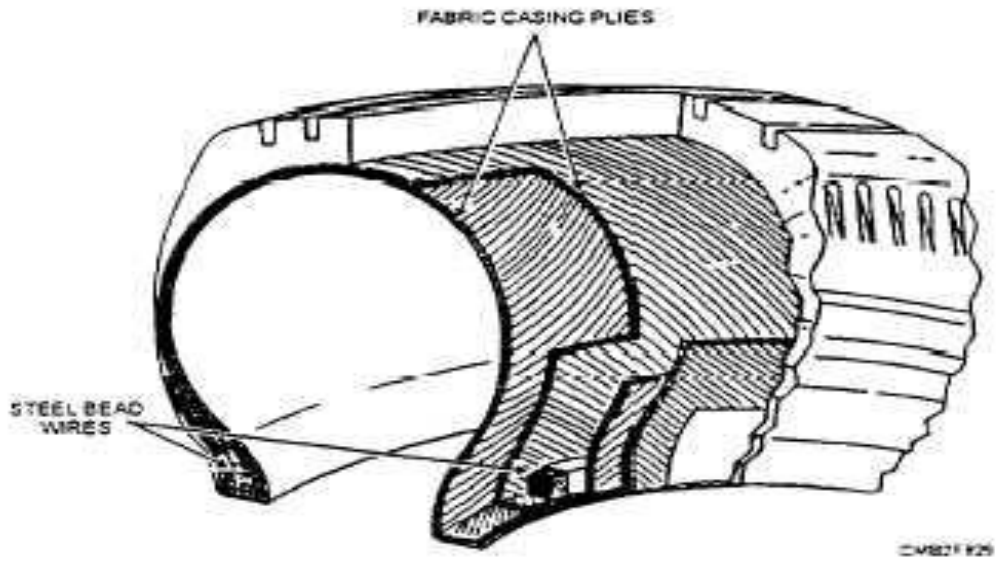
It act as skeleton of tyre situated at both end of tyre opening which consists of bundle of steel wire joined together to make a circular shape according to diameter of rim and give strength. Generally the bead bundle covered with rubber for easy of mounting and to provide leak proof construction.



As you seen tyres are classified into different category, in this chapter we only discuss tyres based on construction.

8.4.1 Bias- Ply Tyre:

A bias-ply tire is one of the oldest designs, and it does NOT use belts. The position of the cords in a bias-ply tire allows the body of the tire to flex easily. This design improves the cushioning action, which provides a smooth ride on rough roads. A bias-ply tire has the plies running at an angle from bead to bead as shown below. The cord angle is also reversed from ply to ply, forming a crisscross pattern. The tread is bonded directly to the top ply. A major disadvantage of a bias-ply tire is that the weakness of the plies and tread reduce traction at high speeds and increase rolling resistance.



Advantages:

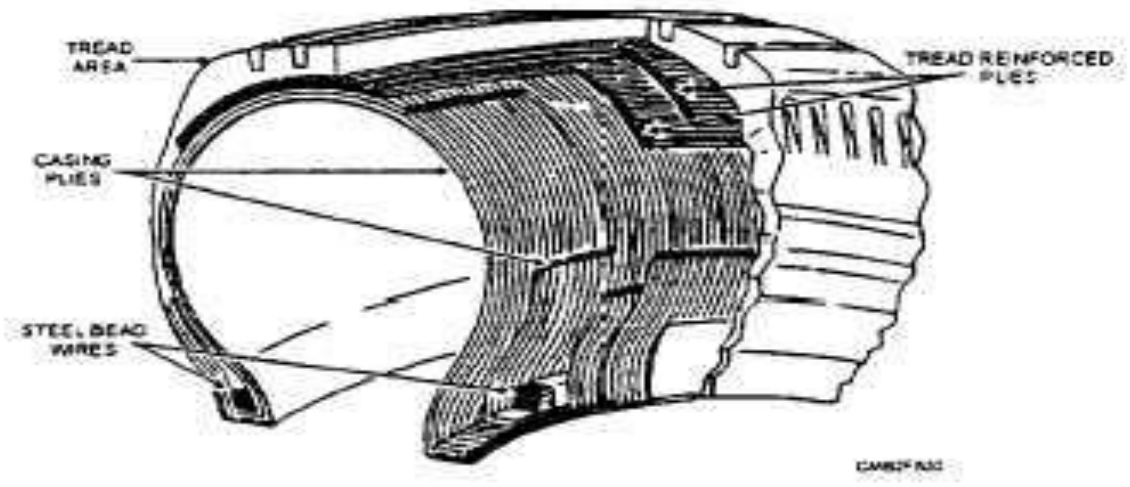
- Improved vehicle stability.
- Higher resistance against sidewall damages.
- Cheaper to produce.

Disadvantages:

- High rolling resistance, which causes tyres to quickly heat up
- Reduced comfort due to the tyre's rigidity
- Increased fuel consumption.

8.4.2 Radial Ply Tyre:

The radial ply tire (fig. 8-30) has very flexible sidewall, but a stiff tread. This design provides for a very stable footprint (shape and amount of tread touching the road surface) which improves safety, cornering, braking, and wear. The radial ply tire has plies running straight across from bead to bead with stabilizer belts directly beneath the tread. The belts can be made of steel, flex ten, fibre glass, or other materials. A major disadvantage of the radial ply tire is that it produces a harder ride at low speeds. The stiff tread does NOT give or flex as much on rough road surfaces.



Advantages:

- Good steering and better road contact
- Improved driving comfort thanks to flexible sidewalls
- Less heat generated in the tyre at high speeds
- Higher resistance against tread-related damage

- Lower fuel consumption through better transfer of energy from machine to road

Disadvantages:

- The soft sidewalls are vulnerable when, for example, vehicles collide with curb stones
- Minor bumps in road are dealt with less effectively because radial tyres feature a steel belt.

8.4.3 Belted-bias tyre:

A belted bias tire provides a smooth ride, good traction, and offers some reduction in rolling resistance over a bias-ply tire. The belted bias tire is a bias-ply tire with stabilizer belts added to increase tread stiffness. The belts and plies run at different angles. The belts do NOT run around to the sidewalls but lie only under the tread area. Two stabilizer belts and two or more plies are used to increase tire performance.

Main function of tyres:

1. To maintain contact between vehicle and ground by providing desired traction.
2. To support the load of vehicle.
3. Dealing with various forces acting on vehicle during its motion.
4. Providing cushion against shocks and damping them.

Tyre nomenclature:

There is a specific method of denoting size of tyres. Manufacturers often call it the 'tyre-nomenclature' or 'tyre-code' and mark it on the side wall of tyre. Every term of this specification has some meaning associated with it. Selecting a proper tyre for a vehicle would be impossible unless one understands these terms perfectly. A typical tyre nomenclature of a passenger car tyre is as below:

175/65 R 14

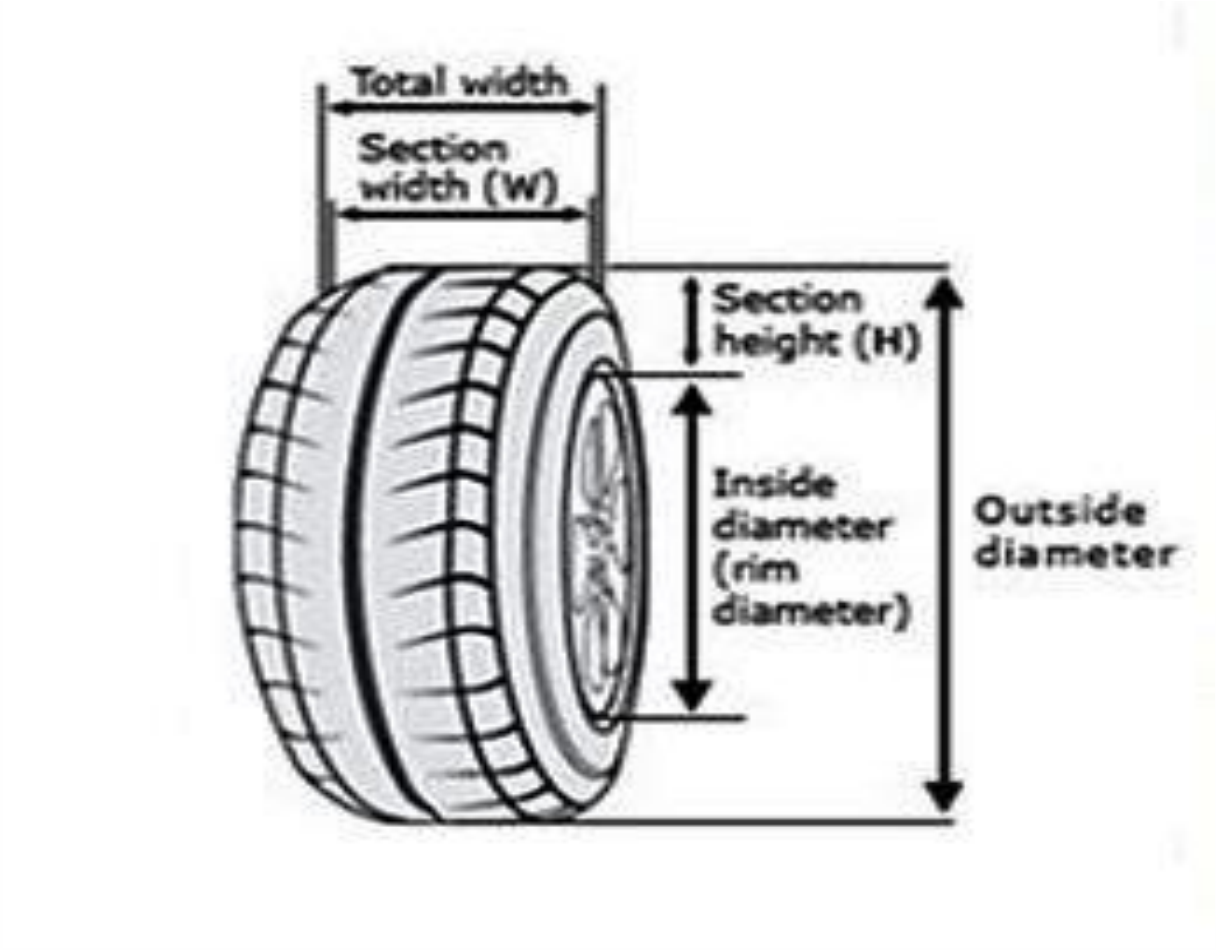
In the above mentioned specification,

175: Nominal section width in mm

65: Aspect ratio. This means section height of tire is that many percent of its section width i.e. 65 % of 175 =114 mm (Approx.)

R: Denotes the construction of tire which is Radial in this case

14: Rim code or rim diameter in inches



8.5 Comparison between radial ply and cross ply tyre:

Radial ply tyre	Cross ply tyre
• Now a days almost all vehicles are uses this type of tyre.	• Older vehicles used this type of tyre.
• Efficient at higher speed.	• Not efficient at higher speed
• Less heat produced due to less internal	• More heat produced due to internal

movement between ply.	movement between ply.
• Higher initial cost	• Lower initial cost.
• Used in all on road vehicle.	• Used in off road like agricultural vehicle.
• Higher ply rating.	• Lower ply rating.

8.6 Tubes:

To inflate a motorcycle tyre to carry total load of vehicle a hollow closed tube made of synthetic rubber used inside tyre. The tube has a unidirectional valve fitted along with rim of vehicle. After inflating the tyre by compressed air the valve automatically locked inside the tube. As the content of sulphur is more in tube material so it is softer and easily inflate.

Mostly tubes are used along with spooked type of wheel. Tubeless tyre doesn't uses any tube to inflate the tyre. As the tube less tyre uses alloy wheel and have stronger bead so that tyre directly arrest the compressed air.

Review questions

1. How two wheeler fuel system differs from three wheeler fuel system?
2. Classify brake system used in two wheelers.
3. What are the difference between magneto and battery ignition system?
4. What is electronic ignition system?
5. What are the starting system used by two and three wheelers?
6. What are the types of wheel used in automobile?
7. What is mist lubrication system?
8. Explain types of lubrication systems.
9. Classify tyre used in automobile.
10. What is the function of capacitor in ignition system?
11. What is the importance of bleeding in hydraulic braking system?
12. Mention importance of lubrication.

STABILITY AND CONTROL

Stability:

It is the tendency of a vehicle to return to its original direction in relation to the oncoming medium (water, air, road surface, etc.) when disturbed (rotated) away from that original direction.

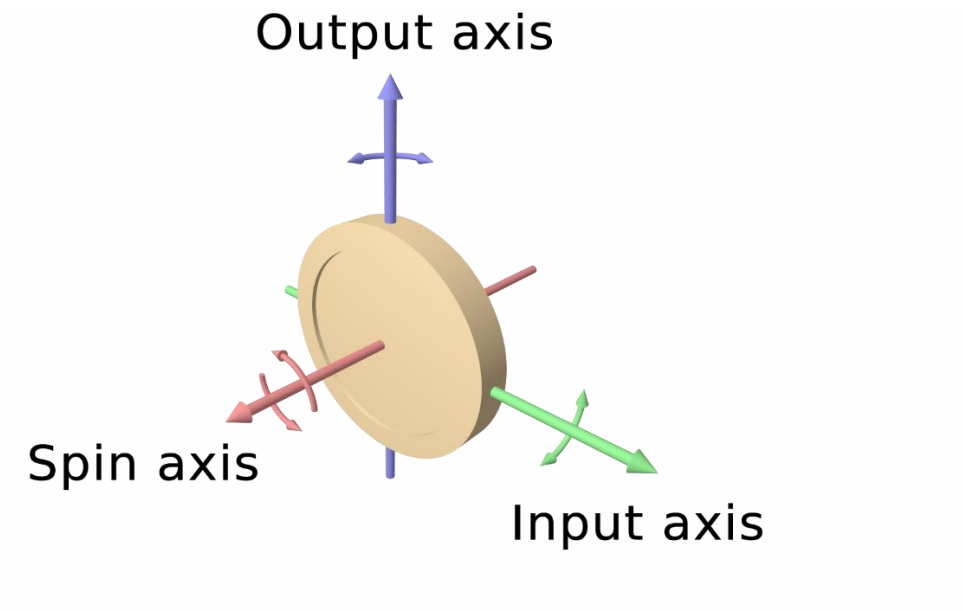
When the vehicle moves on a curved road due to gyroscopic effect(it is the ability of the rotating body to maintain a steady direction of its axis of rotation) the vehicle is automatically tends to bend towards curve direction so the stability of vehicle controlled respect to load and angle of curve.

9.1 Gyroscopic effect:

Gyroscopic effect is ability (tendency) of the rotating body to maintain a steady direction of its axis of rotation. The gyroscopes are rotating with respect to the axis of symmetry at high speed.

9.1.1 Gyroscopic effect on motorcycle:

As shown below gyroscopic effect on front wheel of a bike. Applying torque(in green) about the lean axis results in a reaction torque(in blue) about the steer axis.



The role of the gyroscopic effect in most bike designs is to help steer the front wheel into the direction of a lean. This phenomenon is called precision and the rate at which an object precesses is inversely proportional to its rate of spin. The slower a front wheel spins, the faster it will precess when the bike leans, and vice versa. The rear wheel is prevented from precessing as the front wheel does by friction of the tires on the ground, and so continues to lean as though it were not spinning at all. Hence gyroscopic forces do not provide any resistance to tipping.

At low forward speeds, the precession of the front wheel is too quick, contributing to an uncontrolled bike's tendency to oversteer, start to lean the other way and eventually oscillate and fall over. At high forward speeds, the precession is usually too slow, contributing to an uncontrolled bike's tendency to understeer and eventually fall over without ever having reached the upright position. This instability is very slow, on the order of seconds, and is easy for most riders to counteract. Thus a fast bike may feel stable even though it is actually not self-stable and would fall over if it were uncontrolled.

During turn:

In order for a bike to turn, that is, change its direction of forward travel, the front wheel must aim approximately in the desired direction, as with any front-wheel steered vehicle. Friction between the wheels and the ground then generates centripetal action necessary to alter the course from straight ahead as a combination of cornering force and camber thrust. The radius of the turn of an upright (not leaning) bike can be roughly approximated, for small steering angle.

$$r = \omega/\delta\cos(\emptyset)$$

where r is the approximate radius, ω is the wheelbase, δ is the steer angle, and $\emptyset$ is the caster angle of the steering axis.

During leaning:

unlike other wheeled vehicles, bikes must also lean during a turn to balance the relevant forces: gravitational, inertial, frictional, and ground support. The angle of lean, θ, can easily be calculated using the laws of circular motion.

$$\theta = \arctan(v^2/gr)$$

where v is the forward speed, r is the radius of the turn and g is the acceleration of gravity This is in the idealized case. A slight increase in the lean angle may be required on motorcycles to compensate for the width of modern tires at the same forward speed and turn radius.

For example, a bike in a 10 m (33 ft) radius steady-state turn at 10 m/s (36 km/h, 22 mph) must be at an angle of 45.6°. A rider can lean with respect to the bike in order to keep either the torso or the bike more or less upright if desired. The angle that matters is the one between the

horizontal plane and the plane defined by the tire contacts and the location of the center of mass of bike and rider.

9.1.2 Steps should followed by driver to control stability:

1. Reduce the speed of motorcycle before a sharp turn.
2. Shouldn’t apply brake while cornering.
3. The driver should lean towards the turn for positioning the C.G of vehicle at proper axis.
4. Should not over steer or under steer.
5. Should maintain proper tyre inflation pressure and having good tread condition.
6. Vehicle fitted with narrow width tyre should be more cautious during a turn.
7. For self-balancing motorcycle gyroscopic flywheel fitted on vehicle to maintain the vehicle in vertical position.

9.2 Stability Of Three Wheeler:

When three wheeler moving on road its more Stabler than two wheeler due to three wheel present on a three wheeler but as one wheel present on front side of vehicle so some time due to road turn the front left corner of the three wheeler tries to pull the vehicle left side or right side if the driver doesn’t have experience the vehicle might over turn. So stability of three wheeler mainly depends upon driving skill and sometime road condition.

As the steering of three wheeler similar to motor cycle handle so if the vehicle is over loaded the propensity of vehicle tries to pull one side. It directly impact the driver and increases the stress on driver hand.

9.2.1 Steps for stability control in three wheeler:

1. The three wheeler should not be over loaded.
2. Skilled driver should hold steering handle.
3. As the load of the vehicle shifted to left or right while turning so driver should maintain proper speed while sharp turning.
4. While vehicle goes uphill as engine situated at rear side of vehicle so proper load distribution necessary, vice versa for downhill riding.

Review questions:

1. What is mean by gyroscopic couple?
2. Why gyroscopic effect important for two wheelers?
3. What happened while vehicle takes a turn?
4. How stability of three wheeler maintained?
5. Why load shifting happens during uphill and downhill condition?
6. What are the necessary steps should taken for maintaining stability of motor cycle?

MANUFACTURING PROCESS OF AUTOMOTIVES

Although now a days there are many motorcycle companies having presence in Indian subcontinent i.e. hero motocorp ltd, HMIL, bajaj motors, Yamaha etc. but there manufacturing process are more or less similar to each other. The OEM are just manufacture the power house of vehicle and remaining sub-assemblies are out sourced to other allied industries and suppliers all around the world due to globalization. The auxiliary components such as vehicle frames, tyre, suspension system, tyre, wheels and many more small components are made somewhere else and supplied to main OEM for assembling. After assembling of complete vehicle the manufacturer release the full-fledged product to market for consumer.

9.3 Steps Involved For Manufacturing:

Before lunching any new products to market the R&D team of OEM goes through rigorous steps for market survey, viability of new product, mind storming by group of engineers, finalising the design, prototype manufacturing, testing and aftermarket services etc.

Market Survey:

The market survey is carried out by group of sales people directly observing the market scenario, need of the people, what are the available products, rules and regulation for environment protection, cost effectiveness of different products and safety features available of different products. The market survey is helpful to design team to reach on a conclusion to reach a final model.

Product Viability:

After market survey the type of products going to manufacture are analysed for viability by group of management people for cost effectiveness, profitability, break even analysis of the said product and finally the penetration capability of the product to targeted customers.

Mind Storming And Design Steps:

After getting green signal from management team of any new product lunch the design team get activated for conceptualising the said product by sketching, selection of final sketch model, type of manufacturing process involved, division of all components to sub groups for easy of manufacturing, design of different components by different team, assembly of different components to make a complete vehicle finally the complete vehicle tested using software's. after successful testing the component level design are digitally stored for future references.

Tendering For Subassembly Manufacturing:

After completion of design process by engineering team at company R&D centre the sub-assemblies are call for global tender for manufacturing and suppling the required components with specified standard set by R&D team. After selection of successful bidder the term and condition agreement signed by both party, the time for supply of subassembly and required quantity finalised.

Assembly Line And Testing:

The assembly line of OEM is having huge built up area having all facility for easy and quick assembly of all components. Generally for automobile company line type plant layout is mostly preferred for assembling. The sub-assemblies received by different manufacturer and supplier first tested for any flaws at plant site then send for assembling to make the vehicle complete at different location by technician manually or by using robot for quick assembly.

The first five to ten assembled vehicle supplied to own testing centre or outsourced to other agency for analysing different driving parameters such as fuel consumption, crash testing, speed of vehicle, load carrying capacity, power available at road wheel, emission level etc. if the output result is par with designed output result green signal given to assembly line for continuous production. Finally the complete assembled vehicle released to the market for customer use.

CASE STUDY, TROUBLE SHOOTING AND MAINTAINANCE

Introduction:

In this chapter we will study the construction, working, advance technology, trouble shooting and maintenance of different Indian model motorcycle and three wheelers such as hero moto corp, Honda motors, tvs motors, Suzuki motors, royal Enfield and three wheelers such as piaggio, tata ace, Bajaj auto etc.

10.1 Yamaha rx-100:

This is the most popular motorcycle back in 90's among young stars due to its high pick up , exhaust sound and higher fuel efficiency. The specification of this motorcycle is shown in below table.

Manufacturer	Yamaha Motor Company
Also called	RX
Parent company	Escorts
Production	1985–1996
Predecessor	Rajdoot 350
Class	Classic
Engine	98 cc two-stroke, reed valve, air-cooled, single-cylinder, gasoline seven-

	port torque induction
Top speed	110+ kmph (fully conditioned)
Power	11 HP (8.206 kW) @ 8500 RPM
Torque	10.39 Nm (1.06 kgf-m or 7.66 ft.lbs) @ 6500 RPM
Transmission	four-speed constant mesh, multiplate clutch
Suspension	Telescopic fork front(KYB IN JAPANESE) , swing arm rear telescopic with spring
Brakes	Expanding Drum (both front and rear)
Tires	Wire spoked, 2.50-inch × 18-inch (4-ply rating) front tyre, 2.75-inch × 18-inch (6-ply rating) rear tyre
Wheelbase	1240 mm
Dimensions	L:2040mm W:740mm H: 1060 mm
Seat height	765 mm
Weight	95 kg (dry) 103 kg (wet)
Fuel capacity	10.5 L (2.3 imp gal; 2.8 US gal)
Oil capacity	0.650 L (0.687 US qt)
Fuel	40-45 km/L

consumption	
Turning radius	2100 mm

Advantages:

1. Engine Performance Is Very High Compare To Other Two Wheeler.
2. Highly Popular.
3. Most Desired 2nd Hand Bike.
4. Most Reliable Bike.

Disadvantages:

1. Pollution Occur Due To Use Of Two Stroke Engine Used.
2. Maintenance Cost Is High.
3. Undesirable Noise Is Created.

10.2 KTM India:

The name KTM is a abbreviation in German of " *Kraftfahrzeug Trunkenpolz Mattighofen*", which was the name of the workshop where the company was founded. KTM is a global motorcycle and sports car manufacturer owned by KTM Industries AG and Indian manufacturer BAJA Auto. KTM is well known around the globe for manufacturing compact, light weight, fast and agile motorcycles.

KTM launched its first motorcycle “DUKE 200” in 2012 to great sales and response. The vehicle was regarded revolutionary for taking a step away from the conventional mileage centered motorcycles of other brands. It vastly appealed the new generation of emerging bike riders in India. The motorcycle was designed to be sporty, coming with 200cc liquid cooled power plant.

Description:

- Mileage: 41.3 Kmpl
- Overall Riding Range: 413 km
- Transmission
- Gears: 6 Speed
- Engine: 124.7 cc
- Max Power: 14.3 bhp @ 9250 rpm
- Max Torque: 12 Nm @ 8000 rpm
- Valves Per Cylinder: 2
- Kerb Weight: 135 kg
- Length: 1978 mm
- Width: 688 mm
- Height: 834 mm
- Wheelbase: 1340 mm

10.3 Royal Enfield:

The Royal Enfield Classic 350 is the brand's most popular and best selling bike in India. It has a retro design and comes in a variety of colours and editions to make it appealing to the younger audience. Given its retro positioning, the Classic 350 does not get as many features as a similar capacity street naked. It gets a single-pod analogue instrument console that includes a speedometer, odometer and low fuel warning lamp. This is a heavy bike weighing at 192kg (kerb) and given its touring nature, fuel tank capacity is a disappointing 13.5-litres. However, the upright riding position and a comfortable spring-loaded single seat is comfy for touring on the highways.

Specification of classic 350:

Fuel Type:	Petrol
Battery Type:	DC
Engine Displacement (CC):	346 cc
Power (PS@rpm):	20.07 PS @ 5250 rpm
Mileage (ARAI) kmpl:	37 Kmpl to 40 Kmpl
No Of Gears:	5 Speed
Fuel System:	Carburetor
ABS:	Dual Channel
Head Lamp:	Halogen
Wheels Type (Pressed Steel/ Alloy):	Spoke
Tyre Type:	Tube
Transmission:	Manual

10.4 Hero Moto corps limited:

Hero India offers a total of 29 bikes. These consist of 2 Hero upcoming bikes and 27 new Hero bikes in India.. The list of Hero bike models in the country comprises 16 commuter bikes, 3 sports bikes, 6 scooter , 2 off road bikes. Some of the popular Hero bikes in India include Hero Splendor Plus, Hero HF Deluxe i3s, Hero Super Splendor, Hero XPulse 200, Hero Xtreme 200S, Hero HF Deluxe, Hero Passion Pro 110, Hero XPulse 200T, Hero Passion Pro i3S, Hero Glamour, Hero Glamour 125, Hero Splendor iSMART 110, Hero Maestro Edge, Hero Passion Xpro, Hero Glamour Programmed FI, Hero Pleasure, Hero Xtreme Sports, Hero Splendor Pro, Hero Destini 125, Hero Pleasure Plus 110, Hero Xtreme 200R, Hero Karizma ZMR, Hero Duet, Hero Achiever, Hero Splendor iSmart, Hero HF Deluxe Eco, Hero Maestro Edge 125, Hero HF Dawn.

Specifications of hero splendour plus:

Mileage (ARAI) kmpl:	80 Kmpl
Fuel Type:	Petrol
Battery Type:	Maintenance Free
Engine Displacement (CC):	97.2 cc
Brakes Front:	Drum
Power (PS@rpm):	8.36 PS @8000 rpm
Kerb Weight:	113 kg
Starting:	Kick and Self Start
Wheels Type (Pressed Steel/ Alloy):	Alloy
Tyre Type:	Tubeless
Digital Fuel Indicator:	No
Transmission:	Manual

10.5 Honda motorcycle limited:

Honda Motorcycle and Scooter India (HMSI) is an Indian two-wheeler arm of the Japanese auto major Honda. The brand entered the country back in 1999 and is well-known for its popular Activa scooter range. Apart from its bread-and-butter models like the CB Shine and CB Unicorn 150, the company also sells premium products from its international portfolio. This includes the Goldwing, Africa Twin, CB300R and the likes. Going forward, expect the Japanese bike-maker to bring even more enthusiast-oriented products, apart from bringing in the sixth generation of the Activa.

Specification of Honda shine:

Mileage (ARAI)	65 kmpl
Engine Type	Air Cooled, 4 Stroke, SI Engine
Displacement	124.73 cc
No. of Cylinders	1
Max Power	10.30 PS @ 7500 rpm
Max Torque	10.30 Nm @ 5500 rpm
Front Brake	Disc
Rear Brake	Drum

Fuel Capacity	10.5 L
Body Type	Commuter Bikes

11.6 Piaggio ape:

Piaggio Ape is referred to as India's leading three-wheeler LCV (Light Commercial Vehicles). The vehicle is based on a Vespa scooter and is highly recommended by small business owners for its superb performance. The Ape was first launched way back in 1948 at the end of World War II to fulfil the transport needs. It comes in many configurations and is used for different purposes, be it for light cargo movement or goods carriage. The small truck has scooter-styled handlebars for its three-wheeler body and was originally designed for one person, though it can accommodate a passenger in the cab now. This affordable vehicle is easy to be operated and is offered in seven body colour options, such as orange, green, blue, white, yellow, and red. Recently Piaggio launched a new range of the Ape in Gujarat with a water-cooled engine, including the Ape Xtra LDX and Ape.

Specifications:

Engine	Single cylinder,Water Cooled,DI
Emission Norms	BS-IV
Engine Cylinders	1
Displacement (cc)	395

Max Power	8.04 bhp @ 3400 rpm
Max Torque	22.2 Nm @ 2000 rpm
Transmission	Manual
Clutch	Multi Disc Wet Type
Gearbox	4-Speed
Fuel Tank (Litres)	18.13
Gradeability (%)	18
Mileage (kmpl)	36
Brakes	Disc Brakes
Front Axle	Rigid Axle
Front Suspension	Helical spring with hydarullic telescopic shock absorber
Rear Axle	Rigid Axle
Rear Suspension	Rubber Compression with hydarullic telescopic shock absorber

11.7 Bajaj RE Three Wheeler:

In India Bajaj three wheeler is the largest selling brand in India having different variants such as compact, large and comes with different fuel variant such as diesel, petrol, LNG and LPG etc. in all two tier and three tier city this type of passenger three wheeler widely used because of good millage, low maintenance cost.

Specification compact 4 stroke:

Power	7.6KW at 5000rpm
Torque	17Nm at 3500 rpm.
Cubic capacity	198.88 cc
Transmission	4 forward + 1 reverse gear.
Clutch	wet multidisc type.
Engine type	4 stroke.

10.8 Problems and Remedies in Two Wheelers:

Problems	Reasons	Remedies
1. Engine not starting	1. Spark plug burn out. 2. Carburettor blocked by foreign particles. 3. Battery low. 4. Combustion chamber flooding. 5. Cold weather. 6. Mechanical components failure 7. Clutch worn out. 8. Ignition system not functioning properly	1. Open spark plug from engine head, clean carbon black by emery paper then check the spark plug gap to 0.5 to 0.8 mm using filler gauge. 2. Wash the carburettor then refit. 3. Recharge battery. 4. If combustion chamber flooded just close the fuel line then kick for multiple time. 5. If combustion chamber flooding carburettor need service.
1. More fuel	1. Piston ring worn-out. 2. Higher idler speed.	1. Re bore engine cylinder. 2. Change piston rings.

consumption	3. Low tyre pressure 4. Cylinder worn out. 5. Less lubricating oil in engine. 6. Clutch problem. 7.	3. Maintain tyre pressure. 4. Adjust idler speed. 5. Refill engine oil. 6. Adjust clutch free play.
1. Black smoke coming through exhaust.	1. Piston ring and cylinder worn out. 2. Engine oil burning. 3. Carbon deposited in combustion chamber.	1. Change piston ring and re bore cylinder. 2. Change to high grade engine oil. 3. Clean combustion chamber from carbon deposit.
1. White smoke coming out through exhaust.	1. Air fuel mixture not burning properly. 2. Piston ring damaged. 3. Low speed driving. 4. In traffic with engine running	1. Adjust timing of valves. 2. Change piston rings. 3. Whenever standing in traffic stop the engine. 4. Always drive the vehicle in economy speed.
1. Difficulty during kick starting.	1. Clutch plates worn out. 2. Sector gear of kick starter damaged. 3. No free play of clutch lever.	1. Check the free play of clutch lever. 2. If necessary change clutch

		plates. 3. Check the mechanical connection of kick starter mechanism.
1. Hard steering while cornering.	1. Less front wheel pressure. 2. Telescopic suspension arm over tightened. 3. Handle bend.	1. Check front wheel air pressure. 2. Slightly loose handle connecting screw. 3. Straight the handle.
1. While vehicle running total body of vehicle vibrating.	1. Wheel bend. 2. Engine mounting bolt loosened. 3. Over loaded. 4. Stub axle bearing damaged.	1. True both wheel for removing bend by proper tools. 2. Always go with recommended load. 3. If bearing damaged change it.
1. Hard and free suspension	1. Check for suspension oil leakage. 2. Oil seal damaged 3. Spring might be broken. 4. Mechanical component failure.	1. If oil seal damaged change it with proper cleaning. 2. Check the spring tension if required change it. 3. Fill new shock absorber oil after washing housing

		properly.
1. Sound coming from chain guard.	1. Chain loosened. 2. Sprocket damaged. 3. Vehicle vibrating.	1. Adjust chain free play by loosening rear hub nut and tightening adjustable screw. 2. Check the driven sprocket if damaged change it. 3. Correct wheel alignment.

10.9 Problems and Remedies in Three Wheelers:

1. Black smoke coming through exhaust.	1. Piston ring and cylinder worn out. 2. Engine oil burning. 3. Carbon deposited in combustion chamber.	1. Change piston ring and re bore cylinder. 2. Change to high grade engine oil. 3. Clean combustion chamber from carbon deposit.
1. White smoke coming out through exhaust.	1. Air fuel mixture not burning properly. 2. Piston ring damaged. 3. Low speed driving. 4. In traffic with engine running	1. Adjust timing of valves. 2. Change piston rings. 3. Whenever standing in traffic stop the engine. 4. Always drive the vehicle in economy speed.
1. Hard steering while cornering.	1. Less wheel air pressure. 2. Front Telescopic suspension arm over tightened. 3. Handle bend.	1. Check front wheel air pressure. 2. Slightly loose handle connecting screw.

	4. Over loaded.	3. Straight the handle.
1. More fuel consumption	1. Piston ring worn-out. 2. Higher idler speed. 3. Low tyre pressure 4. Cylinder worn out. 5. Less lubricating oil in engine. 6. Clutch problem. 7. Vehicle standing in idler speed	1. Re bore engine cylinder. 2. Change piston rings. 3. Maintain tyre pressure. 4. Adjust idler speed. 5. Refill engine oil. 6. Adjust clutch free play.
1. Engine not starting	1. Spark plug burn out. 2. Carburettor blocked by foreign particles. 3. Battery low. 4. Combustion chamber flooding. 5. Cold weather. 6. Mechanical components failure 7. Clutch worn out. 8. Ignition system not functioning properly. 9. Starting motor problem	1. Open spark plug from engine head, clean carbon black by emery paper then check the spark plug gap to 0.5 to 0.8 mm using filler gauge. 2. Wash the carburettor then refit. 3. Recharge battery. 4. If combustion chamber flooded just close the fuel line then kick for multiple time. 5. If combustion chamber flooding carburettor need

		service.
1. While vehicle running total body of vehicle vibrating.	1. Wheel bend. 2. Engine mounting bolt loosened. 3. Over loaded. 4. Half axle CV joint damaged.	1. True both wheel for removing bend by proper tools. 2. Always go with recommended load. 3. If bearing damaged change it. 4. Change the rubber coupling of half axle.
1. While vehicle running total body of vehicle vibrating.	1. Wheel bend. 2. Engine mounting bolt loosened. 3. Over loaded. 4. Stub axle bearing damaged.	1. True both wheel for removing bend by proper tools. 2. Always go with recommended load. 3. If bearing damaged change it.

Review questions

1. What is the importance of case study for automobile manufacturer?
2. What are the new technology recently introduced by Indian motorcycle manufacturer?
3. What are the importance's of three wheeler for south Asian market?
4. Mention main problems and its remedies for two wheelers.
5. What are the difference between electric mobility and conventional mobility?
6. What are the rules and regulation should followed by drivers for two wheelers?
7. What are the main problems of three wheelers and its remedies?
8. Compare Indian made motorcycle with foreign made.
9. what are the new products introduced by major two wheeler manufacturer in india
10. what are the main requirements of a prospective buyer for motorcycle?