UNIT 1

Clutch

Structure

1.0 Introduction
1.1 Necessity of clutch in automobile
1.2 Different types of clutches are as follows

Learning Objectives
On completion of this unit, a learner will be able

• To know the function of clutch
• To know the construction and working of various types of clutches
• To Draw the different types of clutches
• To Overhaul different types of clutches

1.0 Introduction

The torque developed by the engine at starting speed is very low. Therefore it is not possible to start the engine under load. This requires that the transmission system should provide a means of connecting and disconnecting the engine from rest of the transmission system. Such operation must be smooth and without shock to the occupants of the vehicle. Hence the device which is used to engage and disengaged the engine from the transmission system is called clutch. The clutch permits gradual taking of load when properly operated, thereby it prevents jerky motion of the vehicle and this avoids undue strain on the parts of vehicle as well as passengers.
1.1 Necessity of clutch in automobile

The clutch is a device which is necessary to transmit the power from the engine to the wheels of the vehicle by engaging the engine to the transmission system gradually without giving the jerks to the body of vehicle.

Types of clutches: The clutches used in motor vehicle are almost similar in construction and operation. There are certain differences in the details of their linkages as well as in the pressure plate assemblies.

1.2 Different types of clutches are as follows

1. Friction clutch
   (a) Single plate
   (b) Multi plate clutch
   (i) Wet clutch (ii) Dry clutch
   (c) Cone clutch
      (i) Internal (ii) External

2. Centrifugal clutch

3. Semi centrifugal clutch

4. Conical spring clutch

5. Positive clutch
   (a) Dog and spline clutch

6. Hydraulic clutch

Single plate clutch: It is the most common type of clutch used in motor vehicles. The clutch essentially consists of two members, one mounted on the driving shaft and the other on the driven shaft. These two shafts are parallel and concentric with each other, one shaft is fixed to its housing while the other is splined so that it can be moved axially. The driving torque can be increased by increasing the effective radius of contact.

Construction

A single plate clutch assembly for transmission of power consist of a flywheel, a clutch plate, pressure plate, clutch covers, release levers, withdrawal fork and bearings, primary or clutch shaft.
(a) Fly wheel

Fly Wheel is an integral part of engine which is also used as a part of clutch. It is a driving member and connected to the pressure plate of the clutch shaft is housed with bearings in fly wheel.

(b) Clutch plate or Disc

It is the driven member of the single plate clutch and is lined with friction material on its both surfaces. It has a central hub with internal splines to limit the axial travel along the splined gear box driving shaft.

(c) Pressure plate

It is also driving member. It presses the clutch plate on to the flywheel between the pressure plate and the clutch cover assembly. The pressure springs are fitted on the pressure plates will be withdrawn from the flywheel whenever the released levers are depressed by the clutch lever.

(d) Clutch cover

It is the driving member of the clutch assembly bolted to flywheel. Generally the clutch plate revolves with the flywheel but when the clutch is disengaged the flywheel as well as the pressure plates are free to rotate.

(e) Release levers

These are pivoted on pins to the clutch covers, their outer ends are located and positioned on pressure plate lugs and the inner ends are projecting towards the clutch shaft.

(f) Withdrawal fork and bearing

This fork carrying the withdrawal bearings and pivoted on a balls, mounted in the clutch outer casing.

(g) Clutch shaft

Actually it is a component of the gearbox. Since it is splined shaft to the hub of the clutch plate which is sliding on it. It has its one end supported in a spigot bush in the centre of the flywheel while the outer end carries one of the constant mesh gear.

1. Working of single plate clutch

This clutch always in engaged position. To disengaged, the clutch pedal is pressed, the pressure plate moves back against the force of the spring, then the clutch plate becomes free between the flywheel and the pressure plate. Thus the flywheel remains rotating as load as the engine is running and clutch shafts speed reduces slowly and finally it stops rotating.
When the clutch is engaged the clutch plate is gripped between the flywheel and pressure plate. Since it is having the friction lining on its both surfaces, due to friction between the flywheel, clutch plate and pressure plate, the clutch revolves with the flywheel. As such the clutch plate revolves, the clutch also revolves which is connected to the transmission (gear box) also revolves. Thus the engine power is transmitted from crank shaft to clutch shaft.

Fig 1.1 (a) Single Plate Clutch

Fig 1.1 (b) Exploded view of single plate clutch
2. Multi plate clutch

A clutch having more than three disc is called a multi plate clutch. This multi plate clutch is used where the space is limited, consist of a number of clutch plates, instead of only one clutch plate, as in the case of single plate clutch. The increased number of the clutch plates obviously increases the capacity of the clutch to transmit more torque. Due to this, these clutch plates are used in heavy duty commercial vehicles, racing cars, special purpose military vehicles etc. These may be dry or wet. When the clutch of this type is operated in oil bath, is called a wet clutch. The oil acts as a cushion to provide a smooth engagement. The energy released as heat is also carried away by the oil. This reduces the operating temperature and prolongs life. The dry clutch is used without oil having driving plates lined on each side with a frictional material. The function of dry clutch is similar to wet clutch.

In multi plate clutch as inner drum which is coupled to the gearbox shaft has a number of plates splined as its outer periphery. Another drum is bolted to the flywheel and carries a number of plates splined at its inner circumference.

The plates revolve with the drum but can slide axially. A spring keeps the outer and inner plates are pressed together so that the driving number transmits the power to driven number. The clutch is disengaged by pulling the inner drum against the pressure spring.
3. Centrifugal clutch

Several systems have been designed to make clutch operation automatic and this avoids the incorporation of a clutch pedal. A centrifugal clutch which automatically disengages itself when the speed falls below and again engages when the speed rises above a pre-set value is one such device. This clutch uses the centrifugal force instead of spring force for keeping it in engaged position.

The centrifugal clutch operates with the engine speed. As the speed increases the centrifugal weights fly off. These centrifugal weights pressurises the pressure plate and moves towards the flywheel. In between the pressure plate and flywheel, the clutch plate is positioned. When the pressure plate pressed towards flywheel, the clutch plate is sandwiched between flywheel and pressure plate, and the power flows towards the gear box. The main disadvantage of this clutch is that it will not engage at speeds.

4. Semi centrifugal clutch

These clutches are similar to the centrifugal clutches only difference is that these clutches uses centrifugal force as well as spring force for keeping it in engaged position. The springs are designed to transmit the torque at normal speeds, while the centrifugal force assist the torque transmitting at higher speed.
It consists of three lines and weighted levers and three clutch springs alternatively arranged at equal spaces on the pressure plate. At normal speeds when the power transmission is low the springs keeps the clutch engaged on the pressure plate. At high speed, when the power transmission is high, the weights fly off and the levers also extend pressure on the plate, thus keeping the clutch firmly engaged.

**Fig 1.4 Semi Centrifugal Clutch**

**Summary**

1. Clutch is a device to engage and disengage the engine with transmission system.

2. Different types of clutches are
   
   (i) Single plate
   
   (ii) Multi plate
   
   (iii) Centrifugal
   
   (iv) Semi centrifugal
3. Single plate clutch is used in motor vehicles for producing a quick engagement.

4. Multi plate clutch having more than 3 clutch plates having increased transmission torques used for heavy commercial vehicles.

5. Centrifugal clutch allows automatic engagement of clutch using centrifugal force instead of spring.

6. Semi centrifugal clutch uses both centrifugal force as well as spring force in keeping the clutch in engaged position.

**Activity**

1. A learner should observe carefully the section models of different types of clutches.

**Short Answer Type Questions**

1. What is the function of clutch?

2. Name different types of clutches.

3. What is the purpose of clutch?

4. What is meant by wet clutch?

5. Why is multi plate clutch sometimes used in heavy vehicles?

**Long Answer Type Questions**

1. Explain about construction working of single plate or multi plate clutch with neat sketch.

2. Explain about construction and working of centrifugal or semi centrifugal clutch with a neat sketch.

**O.J.T Questions**

1. Dismantle, inspect and assemble the single plate, multi plate, centrifugal and semi centrifugal clutches.
2.0 Introduction

High torque is required to start the vehicle from rest, accelerating, hill climbing, pulling load and facing other resistances. But the I.C. engine operates over a limited effective speed range which produces a comparatively low torque. In such case the engine is liable to stall and vehicle comes to rest if the speed falls below the limit. The torque developed by the engine is increasing with increase of engine speed and reaches maximum value at some predominant speed. If the engine is directly coupled to driving axle, the engine speed might be very low.
Due to the variable nature of the vehicle resistance resulted by load and gradient changes, it is required that the engine power should be available over a wide range of road speeds. Hence for this purpose the engine speed is maintained by using a reduction gear resulting the road wheels to rotate at a proper speed suiting the operating conditions of the vehicle.

Therefore, a single torque multiplication should be interposed in the rear axle and a variable multiplying factor in the gear box is provided for this purpose.

2.1 Necessity of Gear Box

In order to maintain engine speed on all conditions of load and vehicle speed, the gear box uses a system of leverages of keeping the speed of the engine up, while sacrificing same road speed.

In order to enable the engine to run faster in relation to the road wheels as well as to multiply the torque, a gear box is necessary.

2.2 Types of Gear Box

There are three main types of gear boxes are used. They are

1. Sliding mesh gear box.
2. Constant mesh gear box.
3. Synchromesh gear box.

1. Sliding mesh gear box

It derives its name from the fact that the meshing of the gears takes place by sliding of gears on each other. It is oldest and simplest form of gear box. The sliding mesh type gear box consist of clutch shaft, lay shaft, main shaft or splined shaft, dog clutch, selector rod, gear change levers, gears and an idler gear. The main shaft gears are moved axially along the splined shaft to mesh with the corresponding gears on the lay shaft, but this requires considerable skill to change the gear without damaging the gear teeth.

A three speed sliding mesh gear box shown in diagram and splines are provided on the main shaft. For meshing the pinion with the mating gears on the lay haft, the pinions are slided along the spline. When the main shaft is driven from the lay shaft, the gear reduction is provided by the first pair of gears which always in mesh. For changing the gear the clutch is depressed and the gear lever is moved till the selector pinion on main shaft engages with its mating gear on lay haft. To obtain three forward speeds, reverse and nutral, the relative positions are given under.
First Gear

Largest gear on the main shaft is driven by the smallest gear or pinion on the lay shaft with corresponding increasing the torque, the speed reduction is quite high. This gear is used when climbing hills and moving on steep hills.

Second Gear

In second gear, the second (smaller) gear on the splined shaft is in mesh with the next larger gear on the lay shaft. This provides a gear reduction smaller than that in the first gear.

Third Gear

In third gear, which also the top gear for this gear box, the main shaft is directly driven by the splined shaft with the help of a dog clutch. The main shaft revolving at the same speed at which the primary shaft is rotating.

The following position of gears shows when vehicle is in neutral and reverse gears. When in neutral, the primary shaft is in connection with the lay shaft but the shaft is not connected to the main shaft. Thus there is no power transmission to the wheels. An idler gear is used for reversing the direction of rotation of the splined main shaft.

Fig 2.1 Sliding mesh gear box
2. Constant Mesh Gear Box

In constant mesh type gear box, all the gears are all the time in constant mesh with the corresponding gears. It has three shafts namely primary shaft, main shaft and the lay shaft. The primary shaft carries the clutch is splined and carries a gear that mesh with the first gear on the lay shaft. The main shaft has a number of gears (in descending sizes) that meshes with the gears on the lay shaft. However, these gears on bushes or balls or roller bearings are free to move on the main shaft but do not transmit torque in this situation. The large layshaft gear is engaged with the primary shaft gear and other lay shaft gears are engaged with main shaft gears. A dog clutch is splined to the main shaft provides means of locking the freely rotating main shaft gears to the main shaft to allow a gear change. Sliding dog teeth enables smooth and silent gear change to take place if the numbers to be engaged are rotating at the same speed.

3. Sychromesh Gear Box

Sychromesh gear box uses synchroniser instead of sliding dog clutches to effect the ratio change. The synchronesh gear box is similar to the constant mesh gear box, but the synchronesh gear box is provided with a synchroniser device by which two gear to be engaged first brought into frictional contact which equalizes their speed, after wards they are engaged smoothly.
To engage, when the gear lever is moved the synchroniser cone meets with a similar cone on the pinion. Due to friction the rotating pinion is made to rotate at the same speed as the synchromesh unit. To give a positive drive further, movement of the gear lever enables the coupling to over ride several spring load balls and the coupling engages with the dogs on the side of the pinion. Since both pinions and synchromesh units are moving at the same speed, this engagement is done without noise or damage to the dogs.

A slight delay is necessary before engaging the dog teeth, so that the cones have a chance to bring the synchroniser and pinion to the same speed.

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**Summary**

1. In order to maintain engine speed on all conditions of load and vehicle speed, the gear box use a system of leverags of keeping the speed of the engine up.

2. There are three main types of gear boxes. They are
   (i) Sliding mesh gear box
   (ii) Constant mesh gear box
   (iii) Synchromesh gear box

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![Fig 2.3 Synchromesh gear box]
3. In sliding mesh gear box, the meshing of gears are taken placed by sliding of gear on each others.

4. In constant mesh gear box, all gears are all the time in constant mesh with their corresponding lay shaft gears and main shaft gears respectively.

5. The synchromesh gear box is first to bring into frictional contact that the member which is ultimately engaged positively and their friction and speed are equalized to take positive contact.

**Activity**

1. A learner should be able to observe the section model of all the three types of gear boxes for its constructions and working, to differentiate them.

**Short Answer Type Questions**

1. Why is the gear box is necessary in an automobile.

2. What is the function of gear box?

3. What are the different types of gear boxes used in automobile?

4. What is meant be constant mesh of gear box?

5. Why sliding mesh gear box in not preferred.

**Long Answer Type Questions**

1. Explain the construction and working of sliding mesh gear box with sketch.

2. Write the construction and working of constant mesh gear box.

3. Write the construction and working of synchromesh gear box.

**O.J.T Questions**

1. Overhaul the given sliding mesh gear box

2. Overhaul the given constant mesh gear box.

3. Overhaul the given synchromesh gear box.
3.0 Introduction

A medium or device is needed to transmit power from the engine driven gear box to the driving axles is called Propeller shaft. It connects the gear box.
to the final drive unit and transmits power in angular direction. It is made of strong steel tube because it has to withstand torsional stresses of the transmitting torque as well as it has to be high and well balanced. Also in order to make a flexible connection between two rigid shaft at an angle with each other varying constantly, universal joints are used.

In automobile, a gear box is rigidly mounted in relation to the engine and chassis. But due to action of the road springs, the position of the rear axle is varied and allowances should be made in it when the gear box is coupled to the rear axle by a propeller shaft. Therefore for connecting two shafts inclined to one another at an angles as well as for transmitting the rotary motion from the engine to road wheels throughout the variations in position a universal joint is used.

### 3.1 Necessity of universal joint

Universal joint is necessary to connect two shaft inclined to one another at an angle as well as transmitting the rotary motion from the engine to the road wheels.

(a) Necessity of propeller shaft

Propeller shaft is necessary to cope with and maintain the distance between gear box and differential and also to adjust with the varied length and angle.

### 3.2 Types of universal joints

1. Cross type or spider and two yokes type or Hookes Joints
2. Ball and trunnion type
3. Constant velocity type universal joint

1. Cross type or spider and two yokes types or Hookes Joints

This joint consists of cross piece or spider and two yokes and because of these parts it is known as cross type or spider and two yoke type universal joint. There are four needle bearings one for each trunnion of the spider, the bearings are held in place by rings heat drop in to under cuts in the yoke bearings holes. One commercial design of the cross type universal joint incorporates a slip joint. One yoke is integral with the hub that holds the female end of the slip joint. When the joint is used between the propeller shaft and rear axle gear shaft, the slip joint is omitted so that direct connection is made between two joints. Other design of cross type universal joint are ring trunnion type are used in torque tube drive and cross ball type used in hutch-kiss drive.
2. Ball and trunnion type universal joint

The ball and trunnion type universal joint consists of ball head fastened to the end of the propeller shaft through which a pin is pressed. Two steel balls fit over well the ends of the pin. So that when the assembly (ballhead, pin & balls) is fitted in to the body. The balls retain the roller bearings between them and U-shaped channels in the body. The centering button and the button spring help to keep the pinion properly centered. The universal joint and propeller shaft assembly is bolted to a companion flange with the gasket and grease cover between them. The rotary motion is carried out through the pin and balls, the balls can move back and forth in the channel of the body to compensate for varying angle of drive at the same time, they act as a slip joint by slipping in and out of the channels.
3. Constant velocity type universal joint

It consists of two individual universal joints linked by a ball and socket. The ball and socket splits the end of the two propeller shafts between two universal joints. This type of joint permits uniform because the two joints are operating at the same angle, the acceleration resulting at any instant from the action of one universal joint is cancelled out by deceleration of the other and vice versa.

Fig 3.3 Constant velocity type universal joint

3.3 Types of propeller shafts

1. Enclosing type
2. Hollow type

1. Enclosing type

It is a solid cross-section and is enclosed in a tubular rigidly connected to the gear box casing by a ball joint for resisting torque reaction. This type of propeller shaft is supported by roller bearings inside torque tube both at the front and rear and the diameter of this propeller shaft is quite small. To prevent longitudinal movements the splined sleeve is secured by rivets to both the shafts. A transverse semi-elliptic spring type rear suspension mounted on the rear cross-members of the chassis frame is used with this type of propeller shaft.
2. Hollow type

It is tubular in instruction and is not enclosed. It is provided with two universal joints one to each end. One of the U.J is attached to the gear box main shaft and other to driving axle pinion shaft. The propeller shaft which is comparatively longer is made up of two portions. It is connected with an additional universal joint supported to chassis cross members. The whip which is liable to be developed in the propeller shaft is removed by this centre support.

3.4 Slip Joint

The function of slip joint is to allow variations in the length of the propeller shaft. This need arises because of the differential motion between the frame mounted gear box and spring suspended rear axles. The slip joint is provided in the form of outside splines on one shaft and corresponding inside splines on other shaft. These splines permit change in length of the rotating propeller shaft.

![Fig 3.4 Slip Joint](image)

Hutch Kiss Drive

Hotchkiss drive consists of propeller shaft, universal joint and a slip joint. The propeller shaft is not enclosed in a tube as in the torque tube drive. The spring is rigidly fixed in the middle to the rear axle. The front end of the spring is rigidly fixed on the frame, while the rear end is supported on the shackle. The rear end torque is absorbed by the rear end springs. When the car is moving forward, the rear end torque causes the front halves of the spring to be compressed as the rear halves of the springs are expanded. Two universal joints, one at each end of propeller shaft are required in hotchkiss drive.
When the spring deflects, the pinion shaft also changes its position. If there is only one universal joint at the front end of the propeller shaft, it will bend under this condition. Therefore another universal joint at the rear end of the propeller shaft is used. The slip joint compensates for differences in the length of the propeller shaft caused by changes in its angularity as the axles move up and down with the spring.

**Fig 3.5 Hotchkiss Drive**

Torque tube drive

**Fig 3.6 Torque tube drive**
The propeller shaft is enclosed in a hallow tube. The tube is rigidly bolted to the differential housing at one end is fastened at the other end to the transmission through a some what flexible joint. The tube incorporates bearing which supports the propeller shafts. Only one universal joint is necessary in this type of drive. It is usually placed between the transmission and the propeller shaft. No slip joint is needed in the propeller shaft. On many cars, a pair of truss rods are attached between rear axle housing and the transmission end of the torque tube. The torque tube and the truss rods brace the differential housing to prevent excessive differential housing movement. In other words, the rear end torque is absorbed by these members.

**Summary**

1. A medium or device is needed to transmit power from the engine driven gear box to the driving axles is called propeller shaft.

2. These are two types
   1. Enclosing type and
   2. Hallow type

3. Universal joint is necessary to connect two shafts inclined to one another at an angle as well as transmitting the rotary motion from the engine to the road wheels.

4. There are three types of universal joints. They are
   (i) Cross type or spider and yoke type
   (ii) Ball and trunnion type and
   (iii) Constant velocity type

5. The cross or spider and two yoke type is capable of transmitting power upto 20° angle without causing vibration or strain.

6. In ball trunnion type universal joint the rotary motions carried out through the pin and balls and the ball can move back and forth in the channel of the body to compensate for varying angle of drive.

7. The constant velocity joints are used when the angle is more than 30° and upto 40°.

8. The enclosed type propeller shaft is in solid construction and enclosed in tubular structure called torque tube, rigidly connected to the gear box casing by a ball joint for resisting the torque reaction.
9. It is provided with two universal joints one at each end. One of the U.J. is attached to the gear box main shaft and other to driving axle pinion shaft.

10. Slip joints serves to adjust the length of the propeller shaft when demanded by the rear axle movements.

11. Hotch Kiss Drive: It converts of rear axle supported by semi-elliptical leaf spring with a swinging shackles at the rear spring and an open types of propeller shaft with a universal joint at each end.

12. Torque end drive will absorb rear end torque.

**Activity**

1. A learner should be able to observe the working of propeller shaft.
2. A learner should be above to observe the working of universal joint.

**Short Answer Type Questions**

1. What is Universal Joints?
2. Name the types of Universal Joints.
3. What is the necessary of propeller shaft?
4. What is Slip Joint?

**Long Answer Type Questions**

1. Explain about Hotch Kiss Drive.
2. Explain about Ball and trunnion type universal joint.
3. Explain about torque tube drive.
4. Explain about Hollow type propeller shaft.

**O.J.T Questions**

1. Know the construction of universal joint.
2. To know the working of propeller shaft.
3. To know the working Hotch Kiss and torque tube drive.
4.0 Introduction

The differential allows the each rear wheel to rotate at different speeds during cornering but at the same time, it transmit equal torque to each wheel when the both wheels have equal traction. The differential consist of system of gears arranged in such a way that it connects the propeller shaft with rear axle. In one word the purpose of differential is to provide the relative movement to the rear wheels.
4.1 Necessity of Differential

Differential is necessary to keep both the rear wheels at the same speed in straight travel and to make the outer rear wheel to rotate faster than the inner one during a turn.

Construction and working of differential unit

4.2 Construction of the differential

The two sun and two planetary are arranged in a cage as a unit like solar system. The cage unit is fixed to the ring gear of the final drive. The two sun gears are connected to the two haft axles.

Working of the differential

When the propeller shaft rotates the pinion drives the ring gear and hence, the differential cage. When the differential cage rotates, the differential planet gear also rotates because they are meshed with the drive pinion. The rotational speeds of the two planet gears are equal and hence the wheels rotate at the same speed. This happens when the vehicle is going straight path and hence there is no relative motion between differential pinion gears and the planet gears.
When the vehicle takes turn the inner rear wheel must turn slower than the outer rear wheel. Since the drive pinion is driving the differential cage, the differential pinion gears rotates on their shafts. This results in one planet gear axle shaft and wheel to rotate faster than the other. These pinion gears, thus accelerates one axle shaft and retard the other axle shaft by the same amount.

### 4.3 Differential Lock

The rear wheels receive equal torque when they are rotating at different speeds, due to this reason if one wheel is on a slippery surface, mud, loose dirt or sand, the wheel on the solid ground will not be driven while the other spins around idle due to the differential action. One wheel suffers less resistance and turns faster causing a loss of friction.

Therefore there must be some arrangement by which more torque can be transmitted to one wheel which is gripping the road than the other wheel which is slipping on the road. This is done by introduction of friction intensionally in the differential. Another method of avoiding the slipping wheel problem is to provide a differential lock. When the lock is applied, the differential action is stopped and the whole torque is then applied to the wheel which is gripping the road.

**Self locking differential**

It has two clutches, one on each side to lock the side gears, and axles to the differential cage when action is not desired. The differential clutch has gear ring and two clutch discs splined to the axle shafts, and three clutch plates connected to the differential housing by lugs. The plate far from the side gear ring is meshed to form a bell value spring. A mechanism to apply the clutch is also provided in the differential. The differential pinion gear mounted on two cross shafts at right angles to each other.

When the differential cage is driven by the rear axle gears, the turning resistance causes the cross shaft to move up the ramp and push the shaft a part. This action forces the pinion on each shaft to bear against the side gears in order to apply the clutch. The clutch locks both axle shafts to the cage and forces them to turn at the same speed. Thus no differential action. When vehicle take a turn the clutch release automatically and the differential acts again in its normal manner.
Summary

1. Differential allows each rear wheel to rotate at different speeds, during cornering but at the same time, it transmits equal torque to each wheel when the vehicle is moving in a straight path.

2. When the differential lock is applied, the differential action is stopped and the whole torque is then applied to the wheel which is gripping on the road.

3. When the differential cage is driven by the rear axle gears, the turning resistance causes the cross shaft to move up the ramps, which pushes the shaft apart. This action forces the pinions on each shaft to bear against the side gear rings to apply the clutch. The clutch locks both axle shafts to the cage and forces them to turn at the same speed, thus no differential action.

Activity

1. Learn should know about the construction and working principle of differential.

2. Learner should observe locking and self-locking differential.
Short Answer Type Questions

1. What is meant by differential?
2. What will happen if differential is not used?
3. Name the different parts of differential.
4. What is the necessity of differential?

Long Answer Type Questions

1. Explain the construction and working differential

O.J.T Question

1. Complete overhauling of differential unit.
Structure

5.0 Introduction
5.1 Necessity of front axle
5.2 Classification of axles
5.3 Types of stub axles
5.4 Rear axle

Learning Objectives

On completion of this unit a learner will able to

- Understand about front and rear axles
- Define functions of different types of front and rear axles
- State and explain front live axle and front dead axle

5.0 Introduction

An axle is a central shaft for rotating wheel or gear. An wheeled vehicle, the axle may be fixed to the wheels, rotating with them or fixed to its surroundings with the wheel rotating around the axle. In the former case, bearings or bushes are provided at the mounting points where the axle is supported. For cars and trucks, the shaft itself rotates with the wheels, being bolted or splined in fixed relation to it, and is called an axle or axle shaft. However it is truely the surrounding housing is called an axle (or axle housing).
Front axle beam

The front axle is used to carry the weight of the front part of the vehicle as well as to facilitate steering and absorb shocks due to road surface variations. It is made of I-Section in the centre position while the ends are made either circular or elliptical with the construction it takes bending loads and also torques due to braking of the wheel. To keep the low chassis heights its centre portion is given a down step sweep. Some times it also transmit torque from differential to the drive wheels.

![Front axle beam diagram](image)

**Fig 5.1 Front axle beam**

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**5.1 Necessity of front axle**

Front axles are necessary to carry and to support a part of vehicle weight and facilitates steering and absorb road shocks as well as torque applied to due to braking of vehicle. And some times it transmit torque from differential to the drive wheels.

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**5.2 Classification of axles**

1. According to their location
   
   (a) Front axle
   
   (b) Rear axle

2. According to their function
   
   (a) Live axle
   
   (b) Dead axle
Live front axle

The live axle receives power from the gear box and transmit it to the road wheels. It is the axle containing the differential mechanism through which the engine power flows to the front the wheels. For steering the front wheel, constant velocity joint are contained in the half shaft, these joints helps in turning the stub axle around the king pin.

Front dead axle

It is just a dummy axle having no connection with engine. These axles do not rotate with engine when compared to live axles. The Dead front axle has sufficient rigidity and strength to transmit the weight of the vehicle form the springs to the front wheels. The ends of the axle beam are shaped suitably to assemble the stub axle. In order to accommodate a swivel pin connecting the sub axle portion of the assembly, the ends of portion the beams are usually shaped either as a yoke or plain surface with drilled hole.

Sub Axle

A stub axle is a sub assembly of a front axle beam upon which the road wheel is mounted. Stub axle is connected to the front axle by means of king pin. These stub axles turns about the king pin which is light drive fit in the axle beam eye, located and locked by the taper cotter pin.
5.3 Types of stub axles

1. Elliot type stub axle
2. Reversed Elliot type stub axle
3. Lamoine type stub axle
4. Reversed Lamoine type stub axle

1. Elliot type stub axle
This type of stub axle is attached to the front axle by placing it in the yoke end with a king pin and a cotter to join the two together. The swivel pin is usually fixed in the stub axle forging with its ends turning in the forced end of the axle beam. Axle beam forms as yoke and receives stub axle. The thrust washer is placed at top portion of the stub axle.

2. Reverse Elliot type stub axle

The reverse Elliot type stub axle forms the fork end to receive the front axle beam. The front axle end forms eye and the thrust washer is placed at the bottom of the front axle beam that is at the contact face with the stub axle. The cotter pin in the joint, that locks the movement of the king pin in the front axle, the king pin is free to move in the phosphor bronze bushes placed in the eye of the fork end. The thrust washer takes vertical load in the joint and its use to increase the life of both the stub axle and front axle. Stub axle forms as yoke and receives front axle. Thrust washer placed at bottom.

3. Lamoine type stub axle

The front axle beam end forms eye to take support on the stub axle. The stub axle and king pin are integrated to form reverse L shape assembly receive the front axle. The thrust washer is placed between stub axle and front axle beam. Here the cotter pin in the joint is used to lock the front axle in position. The king pin is free to move in the bushes placed in the eye of the front axle. The thrust washer takes the vertical load in the joint.
4. Reverse Lamoine type stub axle

The front axle beam ends forms eye to take support the stub axle. The stub axle and king pin are integrated to form inverted L shape assembly to receive the front axle.
The thrust washer is placed at the bottom as shown in the figure. The cotter pin in the joint is used to lock the front axle in position. The king pin is free to move in the bushes placed in the eye of the axle. The thrust washer take vertical load and its increases the life of both the stub axle and front axle.

5.4 Rear axle

To transmit power from differential to driving wheels in a rear wheel drive automobiles rear axles are fitted. To transmit power to both rear wheels, the axle used is in two halves. Each half shafts inner end is splined in the differential and under ends are fitted to driving wheels.

Types of rear axles

(a) Dead rear axle

(b) Live rear axle

(i) Semi floating rear axles

(ii) Three quarter floating rear axle

(iii) Fully floating rear axles

(a) Dead Rear Axles: These axles do not rotate with wheels but rear wheels rotate an it. There are called stationary axles. They are used for supporting the rear weight of the vehicle. In case of front wheel drive vehicles, rear axles are dead axles.

(b) Live Rear axles: Live rear axles are used to transmit power from differential to rear wheels. They rotate along with the wheels. In this axles, the inner end of the axleshafts inner end is splined in the differential and bearing is on the axle shaft supported by axle housing.

Types of live rear axles

Depending on load carrying capacity, they are classified into three types. These are

(a) Semi floating

(b) Three quarter floating

(c) Fully floating

(a) Semi floating: A semi floating axle has a bearing located in the axle and inside the casing. The inner end of the axle is supported by differential side gear. Thus it relieved of the job of supporting the weight of vehicle by axle housing. The outer end of the axle has to support the weight of the vehicle and
take end thrust. The inner end of the axle is splined to the differential side gear the outer end is flanged so that wheel can be bolted directly to it.

(b) Three quarter floating axle
A three quarter floating axle has a bearing located between the hub and the axle casing. Thus the weight of the vehicle is transferred to the axle casing and only the side thrust and driving torque are taken by the axle. The axle is keyed rigidly to the hub, thus providing the driving connection and maintaining the alignment of the wheel.

(c) Fully Floating Axle

A full floating axle has two deep groove balls or taper roller bearings located between the axle casing and wheel hub. The outer of the axle is made flanged to which the wheel hub is bolted. The axle is not supported by bearings at either end, and its position is maintained by the way that it is supported at both ends. Thus axle is relieved of all strain caused by the weight of vehicle on end thrust. It transmits only the driving torque. The axle may be removed from the housing without disturbing the wheel by removing the nuts. This type axle is more expensive and heavier than other axles.

Fig 5.10 Full floating axle
Summary

1. Front axle is the major component of motor vehicle designed to transmit the weight of the automobile from the springs to the front wheels, turning right or left as required.

2. Dead axle is a dummy axle having no connection with the engine.

3. Live axle containing the differential mechanism through which the engine power flows towards the front wheels.

4. **Stub axle**: Stub axles are mounted to the axle beam by means of king pin. These are four types
   (a) Elliot type
   (b) Reverse Elliot type
   (c) Lamoine type
   (d) Reverse lamoine type

5. Rear axle is used to transmit power from differential to rear wheel to drive them and also to support the weight of the vehicle.

6. Live rear axles are three types
   (i) Semi floating
   (ii) Three quarter floating
   (iii) Full floating

7. In semi floating rear axle it carries 50% load and thrust by axle shaft and remaining percentage load by axle housing.

8. Three quarter floating rear axle, the weight of the vehicle is transferred to axle casing and only side thrust and driving thrust are taken by axle shaft.

9. In full floating rear axle the entire weight of the vehicle is carried by the axle housing only and hence is called full floating.

Short Answer Type Questions

1. What is Dead axle?
2. What is Live Axle?
3. What is stub axle?
4. Name different types of live front axle
5. What is the purpose of rear axle?
6. What are types of rear axles?
7. Name different types of live rear axles.

**Long Answer Type Questions**

1. Explain with neat sketch of any one type of stub axle.
2. Explain about any one type of live rear axle with a neat sketch.

**O.J.T Questions**

1. Observe the working of different types of stub axles.
2. Observe the working of different types of rear live axles.
# UNIT 6

## Structure

6.0 Introduction  
6.1 Functions of wheels and tyres  
6.2 Construction and working of Disc wheel  
6.3 Types of Rims  
6.4 Construction and properties of tyres  
6.5 Different tyre pattern  
6.6 Specification of tyre  
6.7 Tyre Rotation  
6.8 Tyre Vulcanizing and retreading  
6.9 Wheel Balancing

## Learning Objectives

On completion of this unit a learner will be able to

- Explain wheel assembly  
- State the functions of wheels and list out wheel types  
- State the importance of wheel balancing
• Identify tyre tread pattern
• Describe the process of Vulcanizing and retreading.

6.0 Introduction

The automobile is made to move on the road easily with less force of friction by air bag in a cover. This arrangements causes the vehicle of float on air cushion. The wheels does not only support the weight of the vehicle, but also protect it from road shocks. Wheel can absorb some of road shocks, depending upon the nature of tyre.

Where as rear wheels move the vehicle, the front wheels steer it addition to provide better comfort under various road and driving conditions. The modern tyres provides better adhesion between road and wheels for satisfactory grip for steering and braking. The wheels must be well dynamically and statically balanced when they are running at high speeds. Unbalanced wheels, causes vibrations and tyre rear.

6.1 Functions of wheels and tyres

1. The wheels should be able to take twice the load of vehicle.
2. Wheels should give cushioning effect and cope with steering control.
3. They should be lightest possible so that the un spring weight is less.
4. They should absorb the retarding force when the breaks are applied.
5. They should be balanced both statically as well as dynamically.
6. Their material should not deteriorate with weathering and age.

6.2 Construction and working of disc wheel

Disc wheel consist of steel rim and steel disc. The rim is rolled section some times invented but usually welded to the flange of the disc of steel rim, which generally well based to receive the tyre and pressed steel disc.

The rim and disc may be integral, permanently attached. When the bead of the tyre is resting in the well, it is possible to pass the tyre over the opposite edge of the rim. It is commonly used in heavy vehicles, cars, buses, trucks, etc. This type of wheel is simple, cheap and robust in construction.
Construction and working of spoke wheel

Spoke wheel

The spoke has a separate hub, which is attached to the rim through a number of wire spokes. The spokes carry the weight, transmit the driving and braking torques and to withstand side forces while cornering in tension. Spokes are long thin wires and as such these cannot take any compressive or bending stresses. All types of loads are sustained by the spokes in tension. The spokes are mounted in a complicated criss-cross fashion.

The side forces on cornering are taken up by the spokes forming triangular arrangement. The initial tension of the spokes can be adjusted by means of screw nipples which also serve to secure the spokes to the rim. The hub is provided with internal splines to correspond to the splines provided on the axle.
shaft. A wing nut and screws the hub on the axle shaft. The advantage of this type of wheel are light weight and high strength and above all it provides much better cooling of the brake drum. It is also very easy to change the wheel when required, because only one nut has to be opened. However, wire wheels are expensive due to their intricate construction.

### 6.3 Types of Rims

The outer circular portion of the wheel on which the tyre and tube are fitted is called the rim. These are generally two types:

1. Drop-Centre rim
2. Flat base rim

![Fig 6.3 (a) Drop Center Rim](image1)

![Fig 6.3 (b) Flat Based Rim](image2)
The flat base rim has its centre portion flat. One side of the rim is removable so that the tyre can be installed or removed without stretching the bead. This is known as continuous base type rim. A continuous rim side ring with a split-locking ring or a single side ring holds the tyre in the mounted position. In the demountable split ring type of flat base rim, the rim can be collapsed to a smaller diameter for mounting or dismounting the tyre. The flat base rims are used almost in all trucks and other heavy-duty vehicles.

When the centre portion of the rim is rolled to a smaller diameter to form a well, it is known as drop-centre rim. This type of rim allows the removal or mounting of the tyre by squeezing the beads of the tyre together on one side and dropping them into the well, while the opposite side is pulled over the flange. The rim is designed so that the well allows the bead of the tyre to pass over the edge of the opposite of the rim. The rim is tapered from the edge of the well to the rim.

The rims for commercial vehicles are one more complicated in design than those for motor cars. A wide base rim in two or three prices gives great stability to the tyre and ensure a true tight fit between tyre and rim where as semi-drop centre rims are essential if tyre beads are too rigid for fitment on the full well base type.

### 6.4 Construction and properties of tyres

#### Construction of tyre

A tyre may have conventional cross-ply construction or a radial ply construction. The strength of the tyre is based upon the construction of the casing because its fracture causes the tube blow out or bursting of the tyre. Casing of tyre is made up of four or six layers of fabric. In each layer, a sheet of series of rubberized cords is formed by laying them side by side. By placing each sheet at a given angle to the adjacent layer strong casing produced. Previously cotton was used as the main material. But now a days rayon or nylon having stronger fibre card offering greater resistance to the heat set up by the flexing of the tyres are employed. In order to retain the tyre on the rim, a bead having a number of hoops of steel wires are used. Around the bead wire the casing is wrapped and moulded into shape.

The tread bends with the soft rubber enclosing the casing. It is made of natural or synthetic rubber compounded with chemicals like carbon black for producing a hard, abrasion resisting substance. The teeth are formed by the zigzag circumferential groove biting into surface. By transversely slotting the tyre to form bold tread bars, an excellent grip preferable on soft surface can be obtained. But this type tread is quite noisy when used on a hard roads.
Properties of tyre

1. **No skidding**: The tyre should not skid on the road surface. It should have good grip.

2. **Uniform wear**: The tyre must get wear uniformly over its outer circumference.

3. **Load carrying**: The tyre should be able to carry the vehicle load, and also alternate stresses during each revolution.

4. **Cushioning**: The tyre should be able to absorb vibrations set-up by the road surfaces thus providing cushioning effect.

5. **Power consumption**: While rolling on the road, the tyre should consume least power developed by the engine.

6. **Noise**: The tyre should create minimum noise while running on the road.

7. **Balancing**: The tyre should be balanced dynamically as well as statically.
6.5 Different tyre pattern

Fig 6.5 Different tyre pattern
Different type of tread pattern

Good midways adhesion, Good grip

A

Good fore and aft grip

B

Rapid, irregular wear and noisy running

Types of Tread Patterns

Good sideways, fore and aft grip
Irregular wear on hard roads, noisy running

C

Good wear resistance and steering characteristic

D

Fig 6.6 Tread pattern
(a) **Pattern**: Good midways adhesion good grip.

(b) **Pattern**: Little ride ways adhesion but good fore and aft grip rapid irregular wear and noisy running.

(c) **Pattern**: Good side ways, fire up grip irregular wear on hard roads noising running.

(d) **Pattern**: Good wear resistance and steering characteristics used as tricks and farm implements.

(e) **Pattern**: Used a rough and loose surface giving maximum grip and side way stability.

### 6.6 Specification of Tyre

The tyre are specified and designated by the nominal size of their sectional width and the rim diameter.

**E.g**: $125J \times 225$ means a tyre having 125 mm as rim width with wheel diameter as 225 mm.

For radial ply tyre, a letter ‘R’ standing for redial ply construction is used along with marking as 154 R 14 where 14 is nominal diameter in inch code and 145 mm code and.

8.25x20 x10 PR

The width or thickness of tyre from shoulder to shoulder is 8.25 inch.

Diameter of the bead circle, which fit on the rim is 20 (inch)

PR means ply rating 10 PR means the tyre consist of 10 plies.

Scooter tyre consist of 1-4 plies, car tyre consist of 4-6 plies. The light truck back tyres has 6-10 plies etc.

### 6.7 Tyre Rotation

The equalize and distribute the tyre wear as well as to obtain maximum tyre life, the tyre should be rotated from one wheel to another wheel after every 4,800 kms further to compensate for any difference is the working tread pattern wear or uneven wear due to different working positions as well as to obtain a large over all tread pattern life. Rotation is also advisable even before the recommended or normal intervals if irregular tread wear begins to develop. Always determine the cause of uneven wear and correct any misalignment, tyre unbalance and other mechanical faults.
6.8 Tyre Vulcanizing and Retarding

1. Vulcanizing: This is the required work for puncture when the holes are bigger in size. In this process, the vulcanizing rubber is cured by heating at a temperature between 100°C and 150°C. The vulcanizing heat is either by electricity or gasoline. The vulcanizing tube is thoroughly cleaned and roughened around the hole. Dust is removed, and the tube is heated with gasoline. Then the vulcanising cement is applied to the edge of the hole. After about 15 minutes, the second coating of vulcanizing cement is applied and allowed to dry. Then a small piece of rubber is placed over the hole to be required. Afterwards, a wax paper is placed over the hole. Then the above arrangement is placed in the wax machine and pressed for 15 minutes at a temperature of 120°C.

2. Tyre Retreading: Retreading is a special process which involves in applying a new tread material to the old casing and vulcanizing it into plies and only casing that are in good condition should be recapped. Recapping requires special equipment. The tyre is cleaned and the tread area is roughed by rasping or buffing it with a wire wheel. Then strip of new rubber tread is called camel black is to be bed into the recapping machine. The machine is clamped shut, and heat is applied for the specified time. This vulcanizes the new tread into the old casing.
Wheel balancing is the placement of wheel weights around a tyre and wheel assembly to counteract the centrifugal forces acting upon heavy area. A properly balanced wheel will roll smoothly at varying speeds without hoop by unbalance. For good steering, the front wheels and tyres should be perfectly balanced. Due to uneven tread wear with probable patches on the inner tube and gaiters on the tyre, a certain amount of unbalance always exists. This balancing of wheel is very essential to prevent front wheel wobbling, otherwise this may result in hard steering.

**Static Balance**

This is the simplest way of checking to inspect and rectify. If any one of the front wheels is Jacked up and rotated slowly it will come to rest with the heaviest portion at the lowest point. Having ascertained the location of the heaviest portion, it must be marked with the chalk. But incase of wire wheel short length of lead wire can be wrapped around one or more spokes at a point opposite to chalk mark. The length of the wire will be sufficient to obtain satisfactory balance.

**Dynamic Balance**

A wheel may be in perfect static balance but dynamically unbalanced. The dynamic unbalance due to fact that when the wheel is rotated, the centrifugal forces acting in different heavy spots are unbalanced because the forces are not acting through the same line.
This would result in rotation of the two wheel axis around the king pin in different directions. This effect is known as wheel shimmy causing the wheel to flap around the king pin. For dynamic balancing the centre of gravity of wheel must coincide with the axis of wheel rotation. This is only possible if the masses of the wheel and tyre are properly distributed.

To adjust the dynamic unbalance suitable weight is attached to the inner and outer side of the wheel rim, thereby correcting the dynamic unbalance with disturbing the static balancing.

Summary

1. Tyre is band of iron, steel tread, rubber etc., placed round the rim of wheel, to carry the load to cushion the vibration caused by rod shocks.

2. A tyre may be either cross ply or radial ply construction.

3. Rim is well type of structure in which the tyre is contained. Rim are several types like well base, flat base, three piece rim etc.

4. To equalize tyre wear to all tyres of vehicle and to obtain maximum tyre life, the tyres must be rotated from one wheel to another frequently.

5. Wheel balancing is the placement of weight around the tyres and wheel assembly to counteract the centrifugal forces acting upon a heavy area.

6. Vulcanizing is the process of cooking and curing the vulcanizing rubber by heating it to a temperature between $120^\circ\text{C} - 150^\circ\text{C}$.

7. Tyre retreading is the special process which involves in applying new tread material to the old casing and vulcanizing it into plies.

Short Answer Type Questions

1. Explain tyre balancing

2. What is retreading?

3. What is meant by wheel base?

4. What is tyre?

5. Why do tyres have tread pattern?

6. What is ply rating of tyres?

7. What does the size $208\times400\text{ PR}$ indicates in case of tyres?
Long Answer Type Questions

1. Explain the construction of Disc wheel.
2. Explain the construction of spoke wheel.
3. Explain about tyre vulcanizing and retreading.

O.J.T Questions

1. Learn about the static and dynamic balancing of wheels.
2. Learn the process of tyre vulcanizing and retreading.
UNIT 7

Ignition System

Structure

7.1 Introduction

7.2 Basic ignition systems

Learning Objectives

On completion of this unit a learner will able

• To know the process of Ignition
• To study the wiring diagrams of magneto ignition system
• To study the battery ignition system
• To study the electronic ignition system

7.1 Introduction

Ignition process can be considered as initiation of burning a small spherical volume of air-fuel mixture entrapped between the spark electrodes. Energy in the form of high intensity spark is supplied to this minimal volume.

Thus the basic requirements of the ignition system is to supply the necessary energy with in a small volume in a time sufficiently short to ensure that minimum energy is lost other than needed for the establishment of the flame under all conditions of operations.
7.2 Basic Ignition systems

(i) Battery Ignition System

(ii) Magnet Ignition System

(iii) Electronic Ignition System

(i) Battery Ignition System

It consists of a battery, ammeter, switch, ignition coil, condenser, contact breakers, distributor, and a spark plug. The primary ignition circuit starts at the battery and passes through the switch, ammeter, primary winding, contact breaker points. One end of the condenser is connected to the contact breaker arm and the other end is grounded. The secondary ignition circuit is not connected electrically to the primary ignition circuit. It starts from ground and passes through the secondary winding, distributor, and spark plug to ground.

The ignition coil step up 6 to 12 V of battery to get high tension voltage about 20,000 volts to 30,000 volts required to jump the spark at the spark plug gap, which ignites the combustible charge in the cylinder. The rotor of the distributor revolves and distributes the current to the different cylinders. The purpose of the condenser is to reduce arcing at the breaking points and thereby prolonging their life.
When the ignition switch is on, the current will flow from the battery to the primary winding. It produces magnetic field in the coil. When the contact points open, the magnetic field collapses and the movements of the magnetic field induces high voltage current in the secondary winding coil. Because the secondary windings has many more turns about 21,000 turns, the voltage increase up to 30,000. About 15,000 volts are necessary to make the spark to jump at 1 mm gap. The distributor direct this voltage to the proper spark plug, producing a spark which ignites the combustible mixture in the cylinder.

(ii) Magnet Ignition System

In magneto ignition system uses magneto instead of a battery, which produces and supplies current to the primary winding. The remaining arrangement in this system is the same as that in the battery coil ignition system. Here the magneto consists of a fixed armature having primary and secondary windings and a rotating magnetic assembly which is driven by engine power. When the magnet rotates, the current flows in the primary winding. The secondary winding gives high voltage to the distributors, which distributes it to respective spark plug.

(iii) Electronic Ignition System

This ignition system is more suitable to racing cars due to their very high rate of engine running. This system can partly overcome the electrical limitations of the conventional method. The problem of contact ware and erosion
are avoided but the mechanical problems, like heel wear and bounce associated with the contact breaker at very high speeds are still left. For developing an improved system of ignition which must be able to provide a constant sparking rate per sec. the first step should be elimination of the contact breaker.

**Summary**

1. The basic requirements of ignition system is to supply the necessary energy to ignite the air-fuel mixture which present inside the cylinder.

2. The basic ignition systems are battery ignition, magneto ignition and electronic ignition system.

3. Mainly the ignition system consists of battery or magneto, ammeter, switch, ignition coil, condenser, contact breaker, distributor and a spark plug plug.

4. In battery ignition system, the battery supplies electric current to the circuit through the primary winding.
5. In magneto ignition system, magneto produces and supplies current to the primary winding.

6. In electronic ignition system, the points are replaced by control module and tobes on the cam are replaced with a trigger device.

**Short Answer Type Questions**

1. What is the purpose of an ignition system in a petrol engine?
2. What are the types of ignition systems?
3. What are the parts of battery ignition system?
4. Draw the line diagram of magneto ignition system.

**Long Answer Type Questions**

1. Explain the construction and working of battery ignition system with line diagram.
2. Explain the construction and working of magnetic ignition system.
3. Explain the construction and working of electronic ignition system.

**O.J.T Questions**

1. Study and observe the line diagrams of battery and magnetic ignition systems.
2. To know the circuit diagrams of electronic ignition system.
8.1 Introduction

The main function of charging system is to recharge the battery. The electrical load of the vehicle varies over a very wide range of conditions. The charging system should be able to supply this load at varying speed conditions.
It converts mechanical energy into electrical energy to be used for head lamps, tail lamp, dash board lamp, wind screen and the radio, car heaters etc. The generator should develop sufficient electrical energy to keep the system voltage nearly constant under such low speed conditions, but at the same time should not generate a very high voltage at high engine speed to avoid over charging of battery this means that a voltage regulators system is also needed as a part of charging system.

### 8.2 Construction and working of charging system (D.C. Generator)

#### Construction of D.C. Generator

It consists of pole pieces fitted to the frame, has armature, commutator and field winding. The pole pieces or shoes are the laminated iron cores for the field windings that furnish the magnetic field for the generators. Most generators contain one pair of poles (N-S) shaped to allow the armature to rotate between them vary with little clearance. The armature is made up of conductors of insulated wire around on a laminated iron core.

The conductor ends are soldered to copper bars, separated from each other by mica, which makes the commutator. A steel shaft running armature and commutator is supported by means of bearings so that the pulley and fan mounted by the front end can be turned by an engine driver belt. Two carbon brushes are held in the brush holders, which makes the firm contact with the commutator segment in order to connect the coils of the rotating armature with the outside circuit.

#### Working of D.C. Generator

When the armature rotates, the current is induced and flows in the conductor through the load. A part of the current induced in the conductors flows through the two field windings assembled around the two magnetic poles. This current strengthens the magnetic field between the poles, thus increasing the conductors as they move through magnetic field. The armature and commutator are designed to rotate together.

They allow the generator to produce a flow of direct current that is, the current the continuous to flow in the same direction. As the two ends of a conductor rotate and change position with respect to each other, the two segments of the commutator are also changes positions so that the current continues to be fed to one brush in the same direction.
8.3 Working Principle of cut out

Cut out relay acts as circuit breaker between generator and battery, when dynamo is not generating any current. It prevents the discharging of battery in case generator is not working or running at very low speeds. This relay is nothing but a magnetic switch which closes to connect battery and generator when the generator is running. When generator does not running a spring breaks the circuit between the battery and generator.
8.4 Construction and working of voltage regulator

Voltage regulator maintains practically constant voltage in the electrical circuit. When the battery is low, it supplies current at a high changing rate by the generator and when the battery is charged, the charge rate becomes slow.

The voltage regulators consist of a field resistance which is put into or out of the field circuit of the generator with the help of contacts points. When the generator voltage reaches of pre-set maximum value, the magnetic pull opens the contact points, thereby inserting the resistance in the field circuit. This reduces the generator output and voltage, which in turn, reduces the magnetic pull on the contact points which are pulled into closed position by means of a spring. This entire process is repeated several times in a second and variable resistance is provided into the generator field circuit depending upon the connected electric load and the state of charge of the battery.

Fig 8.3 Voltage regulator

Current Regulators

Current regulator is very similar to a voltage regulator except that its winding consists of a few turns of heavy wire through which whole of the generator output passed. When the generator output is maximum, the winding pull off the contact points to insert a resistance into the generator field circuit, thereby reducing the generator output.
Fig 8.4 Current regulator

The diagram shows a two unit control system which combines both voltage and current regulations. The two regulators never operate simultaneously, only one operates at a time when the state of battery charge is low and electric load is high, the current regulator operates to control its output within safe limits. When the battery is in a good state of charge and electrical load is low, the line voltage is sufficient to operate the voltage regulator. This reduces the voltage output. The voltage regulator protects the battery while the current regulator protects the generator.

8.5 Construction and Working of Alternator

In D.C. generator, the conductors are rotated in a stationary magnetic field and current flows in the same direction. But in A.C. Generator the magnetic field is rotated and the conductor remains stationary. The current flows first in one direction and then in other alternatively.

The rotor consists of a circular field coil encased by two end pole pieces, each having six protruding fingers spaced 60° apart. These fingers are alternatively spread to provide twelve poles. The ends of the field coil are connected to the slip rings. The carbon brushes make sliding contact with the slip rings, through which the current is taken out to an external circuit. The rotor is mounted on a shaft supported in the front by ball bearings and in the rear by needle bearings. A pulley is keyed at the front end of the shaft to turn by means of an engine driven belt.
When the ignition switch is turned on, the rotor receives current from the battery through the voltage regulator. This current produces the magnetic field of the rotor. As the rotor is turned by the pulley, current is induced in the stator winding. This alternative current is changed into direct current by rectifiers. The regulator is used to limit the generator voltage to a correct value.

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**Short Answer Type Questions**

1. What is the need of charging system?
2. What is cut-out?
3. What is the principle of voltage regulator?
4. What is purpose of current regulator?

**Long Answer Type Questions**

1. Explain the construction and working of D.C. generator.
2. Explain the construction and working of alternator.
O.J.T Questions

1. Observe the construction and working of D.C. generator.
2. Observe the construction and working of alternator.
3. Study the circuit diagrams of current and voltage regulators.
Starting System

Structure

9.0 Introduction
9.1 Construction and Working of starting motor
9.2 Working principle of Bendix drive
9.3 Solenoid

Learning Objectives

On completion of this unit learner will be able

- To know the construction and working of self starter (D.C. Motor)
- To know the working of bendix drive
- To know the working solenoid

9.0 Introduction

The starting system of an automobile is used to start the internal combustion engine. Both S.I. and C.I. engines cannot start by itself, these engines need to be cranked by a starting motor. This motor is also called a starter or crank motor. Cranking of any engine means rotating its crank shaft. Rotation of crank shaft causes to piston to reciprocate. When the piston reciprocates, suction, compression, expansion, and exhaust strokes of engine are completed. Thus the engine completes the working cycle and it starts running.
9.1 Construction and Working of starting motor

The piston engines are not self-starting. They are incapable of running below a certain minimum speed. Therefore, it is necessary to provide certain system in the engine circuit, which should provide high starting torque to start the engine.

Because of producing their peak torque under locking condition, invariably series motor are used as starters. The construction of starting motors are similar to the generator except that the conductors, brush gear and terminal are heavier to withstand the high current, of the order of 400-600 AMPS, flowing for very short duration.

Construction

The main parts of the starting motor are casing, armature, commutator, field winding, brushes, poles and terminals. A drive mechanism is provided at the end of the armature shaft.

Fig 9.1 Self starter
The starting motor uses either two fieldwinding or four field winding. The current from the battery divides when it enter the motor, each the branch leading to separate field winding. From the fields, the current is led to the commutator of the armature through the two insulated brushes. The current in the armature creates simultaneously four poles that adjacent to the four field poles to produce the attractive and repulsive forces that turns the armature. The armature current returns to the battery through the two grounded brushes.

9.2 Working principle of Bendix drive

The cranking motor makes use of some sort of gear reduction in order to transmit its cranking power to the engine. It is required to reduce the speed of the driving motor to increase its torque for starting engine. This is generally achieved by a gear reduction using the pinion on the armature shaft, which engages with the flywheel ring gear.

The crank motor may run as fast as 3000 rpm making the engine to run up to 200 rpm. Once the engine is started operating on its own power, it may attain a speed upto 4000 rpm. In this stage if the pinion does not get demeshed the armature of the cranking motor is likely to be spum at the terrific speed of 60,000 rpm. This speed is likely to damage the cranking motor by the mechanical forces and electrical forces. In order to prevent this, there is a need to engagement and disengagement of the pinion with the flywheel achieved by drive mechanism.

Bendix Drive

It is formed to the armature shaft of the starting motor. The drive head is keyed to the end of the armature shaft. The pinion gear having internal threads, is mounted on the threaded sleeve, just like a nut on a bolt. The sleeve in not connected directly to the shaft of the starting motor but uses it only as a bearing. A spring is attached to the drive head and also to the sleeve.

When the starting motor is at rest the pinion gear is not engaged with the flywheel. When the starting motor switch on the armature begins to rotate. This causes the sleeve to rotates also, because the sleeve is fastened to the armature shaft through a spring. The pinion, because of its inertia of rest and its unbalance weight turns very little, but it moves forward on the revolving bolt, until it engages with the pinion gear helps to engage it properly with the flywheel. When the pinion gear strikes with the collar, it begins to turn with the sleeve, causing the flywheel to run with it. When the flywheel turns, the crank shaft also turns and the engine starts running. The spring between the armature shaft and the threaded sleeve takes the shock of the start.
After the engine has started, the pinion gear is turned by the engine much faster than the rotated by starting motor. This causes the pinion gear to turn back on the threaded sleeve, making it disengaged with the flywheel.

Fig 9.2 Bendix Drive

9.3 Solenoid

Fig 9.3 Solenoid Switch
It is also called Magnetic switch. It consists of plugger, contact disc, pull in windings terminates and necessary connecting cables. The switch is connected between the starting motor and the battery. The current from the battery passes through the pull in winding to form a strong electromagnet when the switch is an and circuit is completed to ground.

The electromagnet attracts the plunger against the spring, which causes the two terminals connected by the contact disc. This makes the circuit complete between the battery and the starting motor. When the switch is off, the circuit through the electromagnetic winding is broken. The spring moves the plugger and the disc back to open the connection between the battery and the starting motor.

**Summary**

1. The function of the starting system is to rotate the flywheel in order for the engine to commence running by the fuel supply.

2. The construction parts of the starting motor are
   (i) Yoke
   (ii) Pole core and poles shoes
   (iii) Field winding
   (iv) Brushes and brush holders
   (v) End cover or shields
   (vi) Armature core
   (vii) Armature windings
   (viii) Commentator
   (ix) Shaft
   (x) Driving mechanisms
   (xi) Solenoid switch

3. A driving mechanism should automatically get meshed and de-meshed with the flywheel as per the requirement.

4. The solenoid switch is an electromagnet switch used in automobiles to operate the self motor. In most of the designs it is fixed to the body of the starting motor.
Short Answer Type Questions

1. What is the function of starting motor?
2. What is the purpose of solenoid switch?
3. What is need of driving mechanism.

Long Answer Type Questions

1. Explain the construction and working of starting motor.
2. Explain the working of Bendix drive
3. Write about solenoid switch.

O.J.T. Questions

1. To know the constructional future of starting motor.
2. To know the working mechanism of Bendix drive.
UNIT 10

Lighting Horn and Wiper

Structure

10.1 Introduction
10.2 Working of head lamps
10.3 Construction and working horn circuit
10.4 Working of wiper

Learning Objectives

On completion of this unit learner will be able to

• know the working of different types of lighting systems
• Know different wiring diagrams
• Know the working principle of wiper
• Know the necessity of Traffic indicators, signal lights
• Know the fuel level circuits and speedometer, odometer and Dash board panel.

10.1 Introduction

Lighting System

In order to illuminate the roads and highways sufficiently for safe night driving, the lighting system is generally used in motor vehicles. It is generally
provided with two or more beams providing maximum illumination for night or darkness driving. For passing the other vehicles on the road, they are designed in such way as to deflect them to the ground as well as to the side of the road for minimizing glare. For the city driving, a third beam of low intensity is also used. An auto lighting system consist of head lamp side, tails, stop and reverse lamps.

In order to illuminate the passenger compartments instruments panels, direction indicators, flash lights are provided inside the vehicle body and special lights to illuminate the key holds for the ignition. Flashing light signals or traffic caterers are also provided both at the front as well as the rear to indicate the other drivers, the direction in which the motors vehicles about to turn.

Fig 10.1 Lighting system

Horn System

Horn is a sound creating device, mostly electrical horns are used in all the automobiles vehicles. When the horn is operated it creates load vibrating sound indicating that vehicle is coming so that the passengers or the other slow moving vehicles may clear off the path to pass it. Horn is used as calling bell to call the person when the vehicle is ready to start to clear the way.

Wind Screen Wiper

These are used to provide adequate forward vision under all conditions of weather to ensure safe driving. Wiper makes the front and back screens of
the vehicle dust free and to get clear view of the road when it is raining. All present day vehicles are equipped with electrically operated wind shields wipers.

10.2 Working of Head Lamps

Head lamps are capable of providing a powerful light for safe night driving for early detection of the obstacles. It must also provide more widespread illumination at the road side for some distance ahead of the motor vehicle so that pedestrians stopping out from the kerb could be picked out. It should also provided indication to driver about his position on the road as well as provide lights for cornering, but this power main beam should not dazzle an on coming driver. For this purpose a dipped beam is also provided for maintaining the reasonable speed with safety.

Fig 10.2 (a) Head Lights
An electric lamp consists of a cover reflector, bulb holder, and lens. Now modern head lights are provided with sealed beams, which consist permanently sealed glassless and reflector containing two filaments, upper and lower. When the lighting switch is put ‘ON’ current from the battery flows into the lighting circuit and glows the lights. By means of dipper or beam control switch, the driver can change from high to low beam of light to meet the required traffic conditions. While coming across a vehicle from opposite direction, the high beam filaments is put off and sitting down filaments glows for safe driving.

**Working of side or parking light**

During night time, it is necessary that a motor vehicle must exhibit to the front a white light and to the rear a red light warning to the approaching vehicles about the parking of a vehicle on the road side. A parking lamp is usually fitted about 30 cm from the outside edge of vehicle. It can be wired either through a detachable plug and socket.

**Working of Tail or Stop lights**

**Tail lights**

These are lights are at the tail of the vehicle which provide red signal for the vehicle coming behind. Tail lights are put on and off by a switch provided at
the dash board and are kept glowing all the way while the vehicle is going in darkness.

**Stop Lights**

These provide stop or slowing down signal and glows with the operation of foot brake. These lights are operated by means of a switch fitted at the outlet of master cylinder by the brake pedal.

**Dash Light**

Electric lamps fitted at the dash board to provide light of visibility of different gauges and switches are known as dash lights.

**Direction Signal Lights**

The direction indicators permit the driver to signal his intention to make a right for left turn. When ever the driver intends to take turn, an illuminated red arm will be shown on the side of the vehicle. A pilot light is provided on the instrument panel light to indicate the working of direction indicators. In modern vehicles, the flash type of direction indicator is made of a standard filaments the indicators lamp flashes will continue ‘ON’ and ‘OFF’ for 60 to 80 per minute till the direction indicator switch is closed.

![Fig 10.3 Direction Signal system](image-url)
10.3 Construction and Working of Horn Circuit

It consists of an armature, a diaphragm, a winding, and a pair of contact points connected in series. When the horn button is pushed, it connects the horn winding to the battery. Then the current passing through the winding produces the magnetic field which pulls the armature down, creating a loud click. The armature is attached to a diaphragm.

![Diagram of Horn Circuit](image)

The movement of the diaphragm opens contact points, due to which the circuit is broken. The cycle is repeated rapidly, this rapid movement of the diaphragm produces distinctive noise. The tone pitch of horn depends upon the size and shape of the diaphragm mostly. A relay is also used in some systems to avoid carrying heavy current required by the horn through the steering column and back. The relay closes its contact to connect the horn to the battery. This way the voltage drop in the wiring from battery to horn is eliminated and higher voltage is available for operating the horn with better performance.

10.4 Working of Wiper

The windscreen wiper is used to make the front and back screens of the vehicle dust free and to get clear view of the road when raining. In some automobiles where compressed air is available, the windscreen wiper is operated with the help of it. However, practically all present-day automobiles are equipped
with electrically operated wind shield wipers. The wind shield wiper is manufactured both in 12 and 24 v. The diagram shows a compound wound motor wiper incorporate thermal with overlap trip. A thermostat type of circuit breaker is incorporated to safe guard the motor against severe over loading caused due to ice or hard snow. It also shows normal and fast speed operation position.

**Fig 10.5 Wind Screen Wiper Circuit**

**Summary**

1. In order to illuminate the roads and highways sufficiently for safe night driving proper lighting is necessary.

2. Horn is used as calling bell to call the person when the vehicle is ready to starts.

3. Wipers are used to provide adequate forward vision under all conditions of weather to ensure safe driving.

4. Head lights provides a powerful light for safe night driving for early detection of the obstacles.

5. Parking lights gives warning to the approaching vehicles about the parking of a vehicle on the road side.

6. In modern vehicles the flash type of direction lamp flashes ‘ON’ and ‘OFF’ 60 to 80 times per minute till the switch off.
Short Answer Type Questions

1. Define lighting system.
2. What is the purpose of head lamp?
3. What is the necessary of horn?
4. What is the purpose of wiper?

Long Answer Type Questions

1. Explain the construction and working of wind screen wiper.
2. Explain about horn system with neat sketch.

O.J.T Questions

1. To study the wiring diagrams various lighting systems.
2. To understand the working of wind screen wiper.
3. To learn to adjustments of head lights.
UNIT 11

Battery

Structure

11.1 Introduction
11.2 Types of Batteries
11.3 Parts of Lead Acid Battery
11.4 Electrolyte ratio by weight and volume
11.5 Understand the Ampere hour and watt-hour efficiency of battery
11.6 Various types of Battery charging are
11.7 Indicators of fully charged battery
11.8 Testing methods of lead acid battery

Learning Objectives

On completion of this unit a learner will be able to

• Know about battery and types of batteries
• Know the parts of lead acid battery
• Know about the parts of alkaline battery
• Know about efficiency of battery
• Electrolyte ratio
• Know different battery charging methods
11.1 Introduction

Battery is an electro-chemical device for storing energy in chemical form so that electrical energy is released whenever needed. The battery supplies current for operating the starting motor, ignition system, lights, radio, heater and several other units. A set of electrodes, electrolyte and the container together is called cell. A group of cells connected together is called battery.

11.2 Types of Batteries

1. Primary
2. Secondary Battery

1. Primary Batteries

If the primary cell is in working, one of the plates is consumed and cannot be recovered by reversing the direction of flow of current through the cell. Thus the chemical action in this case is not reversible and the cell cannot be recharged.

E.g: Voltage cell, Dance cell, Dry cell

Fig 11.1 Primary Cells

Secondary Batteries

The cell in which chemical action is reversible are called as secondary cells.

E.g: Lead acid cell, Nickel iron cell, Nickel cadmium cell.
Fig 11.2 Secondary Cells

These are electrical cells in which a reversible electro chemical process can takes place at high efficiency. In these cells no electrode is consumed during charging. It may be noted that when a secondary cell is charged, the electrical energy is converted into chemical energy. When the cell is discharged, the stored chemical energy starts converting into electrical energy.

Parts of lead Acid Battery, Alkaline Battery and its functions.

11.3 Parts of Lead Acid Battery

(i) Container
(ii) Plates
(iii) Separators
(iv) Cell covers
(v) Electrolyte
(vi) Grids
(vii) Cell connectors
(viii) Tapered terminals
(ix) Sealing compound
(i) **Container**: It is in single piece construction and made of hard rubber, plastic. It must withstand extreme heat and cold as well as mechanical shocks and must be acid resistant.

(ii) **Plates**: several plates are spaced properly and consists of perforated grinds into which lead or lead peroxide has been pressed. There are two types of plate groups in each cell. Positive plate and negative plate. The plate group is connected to positive terminal of the cell consist of grids filled with a paste of lead peroxide (brown in colour). The plate group which is connected to negative terminal on the cell filled with metallic lead (in dull grey colour). Each group of plates are held together by a post trap, to which each individual plate is welded. These straps extended up through the cell cover to provide the cell terminals to connect to the other. They are arranged in alternate.

(iii) **Grids**: The plates of a lead acid battery has electrically conducting grid framework in the meshes of which the active materials are incorporated by electrochemical process. These grids serve to conduct the current to and from the active material of the positive and negative plates. An alloy consisting essentially of lead and antimony is used for grids.

(iv) **Separates**: These are placed between the negative and positive plates to keep them separate between each other. These are designed to hold the plates so that they do not touch, and they must be porous to permit liquid to circulate between the plates. These are usually made of treated wood, hard rubber, resin etc.

(v) **Electrolyte**: The sponge lead and lead peroxide that fills the respective plates are the active elements of battery. But these materials cannot becomes active until they are covered by sulphuric acid called electrolyte. The sulphuric acid of the electrolyte supplies the sulphur ions which combines with each of the plate materials and releases the electrical energy.

(vi) **Cell Covers**: Each cell is scaled by a cover of hard rubber through which the positive and negative terminal project. Each cover has an opening through which liquid can be added. A filler tap has an air vent for the escape of gases.

(vii) **Cell connectors**: These cells are connected in series, so the elements are placed in each cell so that the negative terminal of one cell will be adjacent to the positive terminal of the next cell and so on through the battery. There are heavy enough to carry the high current required for starting without over heating.
(viii) **Tapered Terminals**: Battery terminals are of special design, being tapered to specified dimensions as per standards. The positive terminal are slightly larger at the top so as to minimize the danger of installing a battery in reverse.

(ix) **Sealing Compound**: These used to form an acid tight joint between covers and containers. These are made of rigid plastic resins having resistance to flow at high summer temperature and cracking at winter.

**Parts of Alkaline Battery**

These batteries usually suited for portable work. Like lead acid cells also consist of positive and negative plates immersed in an electrolyte. The plates and electrolyte are placed in a suitable container.

**There are two types of alkaline batteries**

(i) Nickel -Iron type

(ii) Nickel - Cadmium type

Parts of Nickel -Iron cells (Alkaline Battery)

(a) **Positive plate**

Nickel hydroxide \( \text{Ni(OH)}_4 \) is used for the positive plate. It is a mixture of nickel oxide and hydroxides. A small quantity of metallic nickel or graphite is added to increase the conductivity.

(b) **Negative plate**

Powdered iron and its oxides (Fe) is used as negative.

(c) **Electrolyte**

Potassium hydroxide (KOH) is used as electrolyte. It consists 20% of solution of potassium hydroxide and a small quantity of lithium hydroxide (LIOH) is added to increase the capacity. The vessel containing the electrode and electrolyte.
11.4 Electrolyte ratio by weight and volume

Electrolyte contains about 31% of sulphuric acid and 69% of distilled water by weight.

or

About 21% of sulphuric acid and 79% distilled water by volume for specific gravity of 1.23 at 70°C.

11.5 Understand the Ampere hour and watt-hour efficiency of battery

(a) Ampere-hour (A-H) efficiency

The ratio of output in ampere hour during discharge to the input in ampere hours during charging of cell is known as A-H efficiency.

\[ \text{A-H efficiency of } \eta_{\text{AH}} = \frac{\text{Output in ampere hours}}{\text{AH Input in ampere hours}} \]

\[ \% \text{ of } \text{AH} = \left( \frac{I_d \cdot T_d}{T_c \cdot T_c} \right) \times 100 \]
(b) **Watt hour efficiency**

The ratio of output in watt-hour during discharge to the input in watt-hour during charging of the cell is known as W-H efficiency.

\[ \eta_{WH} = \frac{\text{Output watt-hour } V_d I_d T_d}{\text{Input in watt hour } V_c I_c T_c} \times 100 \]

### 11.6 Various types of Battery charging are

1. **Constant current method**

2. **Constant voltage method**

3. **Trickle charging method**

When the supply is given to the battery, the chemical reactions takes place inside the battery which converts the electrical energy to chemical energy.

#### 1. Constant current method

In this method, the charging current through the battery is kept constant throughout by charging the supply voltage. As the battery is charged, the opposing e.m.f. of increases, which necessitates to increase the supply voltage to maintain constant current. This is accomplished by progressively reducing the variable resistance ‘R’. This method is safe and causes less damage to the plates. However this method takes comparatively longer time and the charging current should be so chosen that the cell temperature does not exceed beyond 45°C or so.

#### 2. Constant voltage method

In this method the voltage of the battery is kept constant but, it results vary large charging current in the beginning when the back e.m.f. of the battery is low and a small charging current when the back emf of the battery starts rising with this methods, the time of charging is almost reducing to half. It increases the capacity of the battery by 20% but reduces the efficiency by 10%.

#### 3. Trickle Charge Method

When a storage battery is kept entirely as an emergency reserve, it is essential that it should be found fully charged and ready for service when an emergency arises. Due to open circuit losses and local action, the battery voltage falls (when it is idle for some time). Hence to keep it fresh, the battery is kept on trickle charge. The trickle charge is extremely a low rate charge and is applied to stand by batteries for compensating open circuit losses. The trickle charge current should be small.
Know the different methods of testing of a lead-acid battery for full charged and discharged position.

### 11.7 Indicators of fully charged battery

The specific gravity of a fully charged cell rises to 1.23. A fully charged cell will gassing taking place at both the places. When the cell is fully charged its terminal voltage increases to 2.35 volts. When the cell is fully charged the positive plate becomes dark chocolate brown in colour and negative plate becomes grey colour. The colour of electrolyte becomes milky white. Hissing noice comes not of the battery due to gassing at both the plates.

**Indicators of a fully discharged battery**

The specific gravity of a fully discharged battery cell decreases to about 1.13 when the call is fully charged its terminal voltage increases to 1.85 volts. The colour of the electrolyte dilutes due increase in water content. When the cell is fully discharged both the positive and negative plates becomes white colour due to the formation of PbSO4 layer.

### 11.8 Testing methods of lead acid battery

**Visual inspection test**

Before going on for any equipment based testing visually inspect the battery for any cracks in the container, damage of the terminal posts, vents caps, leakage of electrolyte etc.

**Specific gravity test**

A hydrometers measures the specific gravity of the electrolyte. It is made of glass tube containing a weighted float with making on its stem in figures, so that specific gravity readings can be seen directly. At the specific gravity reading can be taken from the marking on the float stem. Here the specific gravity indicators the state of the charge.

**Open circuit voltage test**

The open circuit voltage cross the terminals of a battery can found by using a multimeter. The voltage of a discharged battery decrease and voltage of completely damaged battery may not increase even after charging. A fully charged cell voltage is around 2.3v. A cell can be used or discharged up to the voltage level of 1.85 v. If the voltage of the cell reaches further below the level of 1.85v, it indicates that the battery is completely damaged.

**Cell Damage testing : Sulphation and De sulphation :-** If a cell not fully charged periodically, then the lead sulphate formed during discharge and is not
converted back to PbO₂ and Pb of the unreduced PbSO₄, which is left, gets deposited on the plates which are then said to be sulphated. PbSO₄ is the form of minute crystal which gradually increases in size if not reduced by thoroughly charging the cell. It increases the internal resistance of the cell thereby reducing its efficiency and capacity. Sulphation also sets in if the battery is over charged or left discharged for a long time.

Sulphated cell can be cured by giving them successive over charges, for which purpose they are cut out of the battery during discharge, so that they can two charges with no intervening discharge. The other method, in which sulphated cells need not to be cut out of the battery, is to continue charging them with a milk booster even after the battery as a whole has been charged.

**Summary**

1. Batteries are two types
   (i) Primary cell
   (ii) Secondary cell
2. Primary cell are not rechargable cells
3. Recharge cells are called secondary cells.
4. Lead acids battery is most in expensive secondary cell and is widely for commercial purposes.
5. These are three battery charging methods
   (i) Constant voltage method
   (ii) Constant current method
   (iii) Trickle charging method
6. The specific gravity of a fully charged cell rises to 1.23 and its terminal voltage increases to 2.35 volts.
7. If the cells voltage full below the level of 1.85 volts, it indicates that the battery is completely damaged.

**Short Answer Type Questions**

1. What is primary and secondary cells?
2. What are the parts of lead acid battery?
3. Define ampere hour efficiency.
4. Define watt-hour efficiency.
Long Answer Type Questions

1. Explain the parts of lead acid battery.

O.J.T Questions

1. Observe the parts of lead acid battery
2. Know the cell damage testing.
3. Know the checking of specific gravity of fully charged battery, discharged battery.