

4330203_AEES_UNIT_4

Relevance/Objective:

- To understand purpose and operation of each part of starter motor
- To know specification of starter motor

Learning Outcome:

- Students will be able to identify, inspect specification of starter motor

Relevant CO:

- Dismantle/Assemble the given starter motor, enlist the parts, and explain the working of each component.
-

Introduction:

The starting system is designed to change the electrical energy, which is being stored in the battery, into mechanical energy. To accomplish this conversion, a starter or cranking motor is used.

Theory:

- A simple electromagnet-style starter motor is shown (Figure). The inside windings are called the armature.
- The armature is the moveable component of the motor that consists of a conductor wound around a laminated iron core.
- It is used to create a magnetic field. The armature rotates within the stationary outside windings, called the field coils, which has windings coiled around pole shoes (Figure 9)

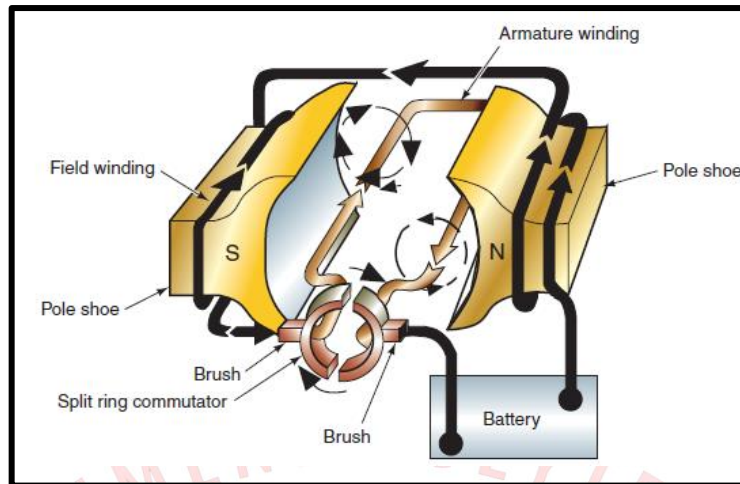


Figure : Simple electromagnetic motor

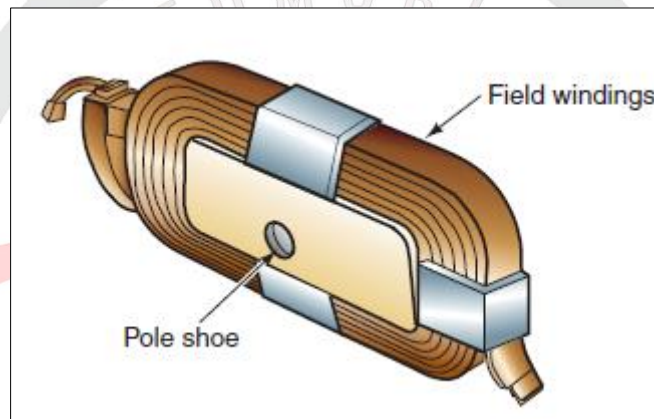


Figure : Field coil wound around a pole shoe.

- Field coils are heavy copper wire wrapped around an iron core to form an electromagnet. Pole shoes are made of high– magnetic permeability material to help concentrate and direct the lines of force in the field assembly.
- When current is applied to the field coils and the armature, both produce magnetic flux lines (Figure).

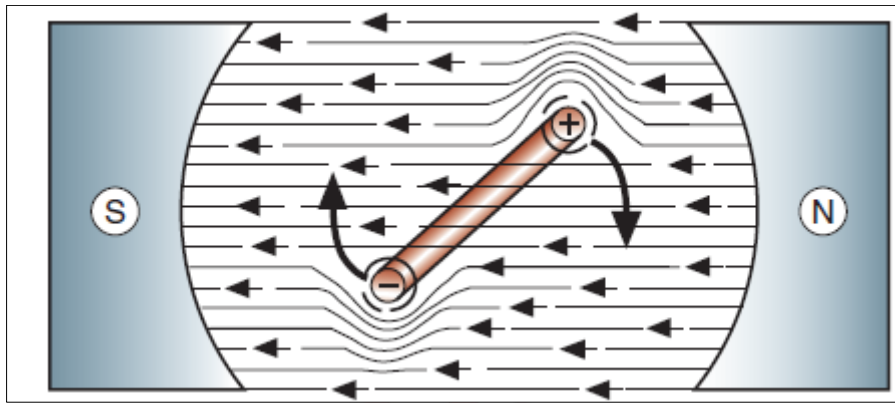


Figure : Rotation of the conductor is in the direction of the weaker field.

- The direction of the windings will place the left pole at a south polarity and the right side at a north polarity.
- The lines of force move from north to south in the field. In the armature, the flux lines circle in one direction on one side of the loop and in the opposite direction on the other side.
- Current will now set up a magnetic field around the loop of wire, which will interact with the north and south fields and put a turning force on the loop.
- This force will cause the loop to turn in the direction of the weaker field. However, the armature is limited in how far it is able to turn.
- When the armature is halfway between the shoe poles, the fields balance one another.
- For the armature to continue rotating, the current flow in the loop must be reversed.
- To accomplish this, a split-ring **commutator** is in contact with the ends of the armature loops.
- The commutator is a series of conducting segments located around one end of the armature.
- Current enters and exits the armature through a set of **brushes** that slide over the commutator's sections.
- A single-loop motor would not produce enough torque to rotate an engine. Power can be increased by the addition of more loops or pole shoes.
- An armature with its many windings, with each loop attached to corresponding commutator sections, is shown (Figure)

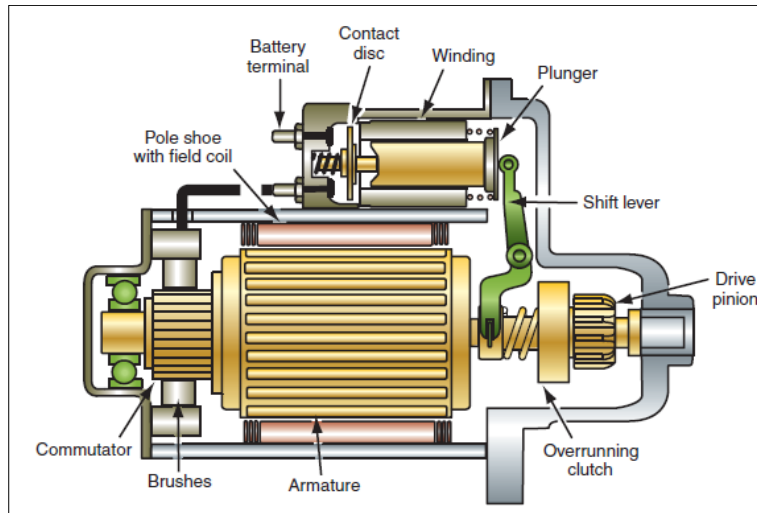


Figure : Starter and solenoid components

- In atypical starter motor there are four brushes that make the electrical connections to the commutator.
- Two of the brushes are grounded to the starter motor frame and two are insulated from the frame. Also, the armature is supported by bushings at both ends.

Armature

- The armature is constructed with a laminated core made of several thin iron stampings that are placed next to each other (Figure).

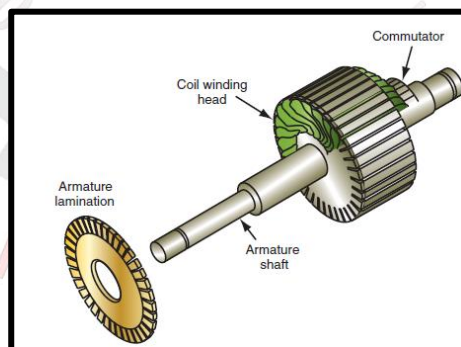


Figure : Lamination construction of a typical motor armature

- Laminated construction is used because, in a solid iron core, the magnetic fields would generate eddy currents. These are counter voltages induced in a core.

Basic winding patterns

- Two basic winding patterns are used in the armature: lap winding and wave winding. In the lap winding, the two ends of the winding are connected to adjacent commutator segments (Figure).
- In this pattern, the wires passing under a pole field have their current

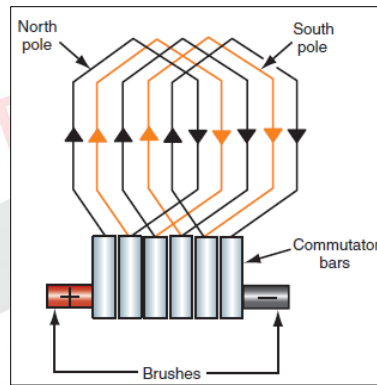


Figure : Lap winding diagram.

- Flowing in the same direction. In the wave-winding pattern, each end of the winding connects to commutator segments that are 90 or 180 degrees apart (Figure).
- In this pattern design, some windings will have no current flow at certain positions of armature rotation.
- This occurs because the segment ends of the winding loop are in contact with brushes that have the same polarity.
- The wave winding pattern is the most commonly used due to its lower resistance.

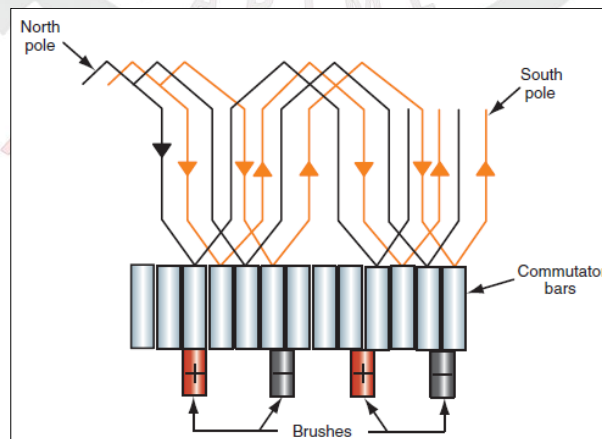


Figure : Wave-wound armature

DC Motor Field Winding

- In any DC motor, there are three methods of connecting the field coils to the armature: in series, in parallel (shunt), and a compound connection that uses both series and shunt coils the field windings and armature of the DC motor can be wired in various ways.

Series-Wound Motors

- Most starter motors are series-wound with current flowing first to the field windings, then to the brushes, through the commutator and the armature winding contacting the brushes at that time, then through the grounded brushes back to the battery source (Figure) as the motor speed increases, the torque output of the motor will decrease.
- This decrease of torque output is the result of **counter electromotive force (CEMF)** caused by self-induction

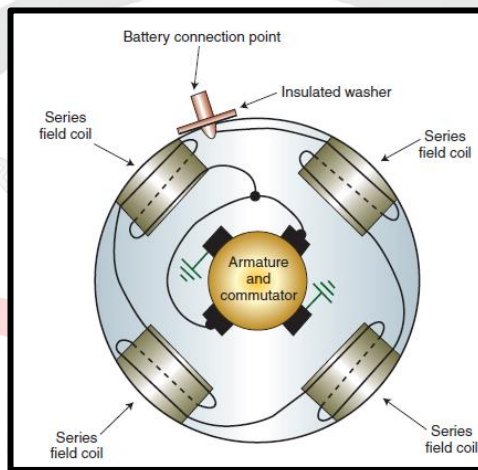


Figure Series-Wound Motors

Shunt-Wound Motors

- Electric motors, or shuntmotors, have the field windings wired in parallel across the armature (Figure).
- *Shunt* means there is more than one path for current to flow.
- A shunt wound field is used to limit the speed that the motor can turn. A shunt motor does not decrease in its torque output as speeds increase.
- Due to a shunt motor's inability to produce high torque, it is not typically used as a starter motor. However, shunt motors may be found as wiper motors, power window motors, power seat motors, and so on.

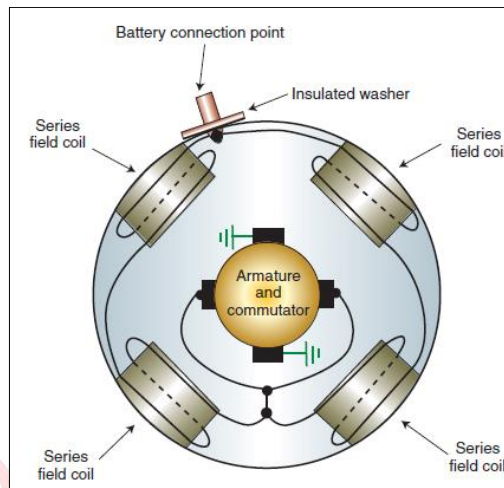


Figure Shunt-Wound Motors

Compound Motors

- In a compound motor most of the field coils are connected to the armature in series and one field coil is connected in parallel with the battery and the armature (Figure)
- This configuration allows the compound motor to develop good starting torque and constant operating speeds.

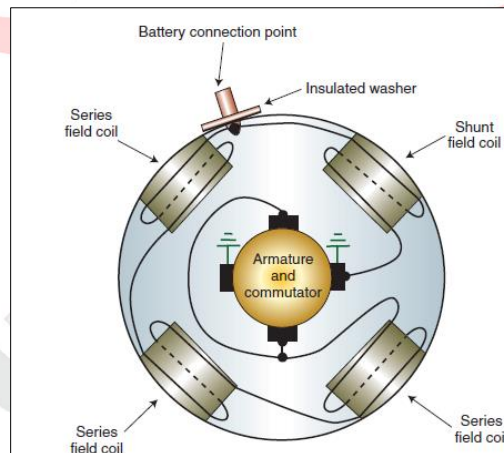


Figure : Compound motor uses both series and shunt coils

Permanent Magnet Motors

- Most newer vehicles have starter motors that use permanent magnets in place of the field coils (Figure).
- These motors are also used in many different applications. When a permanent magnet is used instead of coils, there is no field circuit in the motor.

- Another advantage to using permanent magnets is weight savings; the weight of a typical starter motor is reduced by 50%. Most permanent magnet starters are gear-reduction-type starters.
- The operation of these motors is the same as other electric motors, except there is no field circuit or windings.

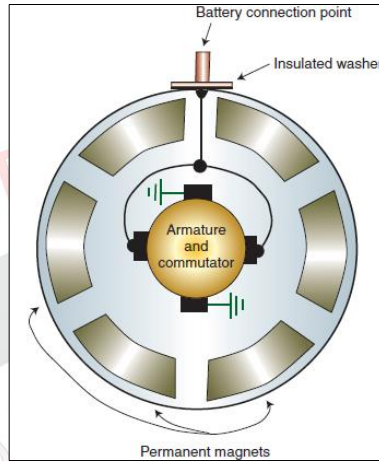


Figure : Permanent Magnet Motor

Brushless Motors

- The brushless motor uses a permanent magnet rotor and electromagnet field windings (Figure). Since the motor design is brushless, the potential for arcing is decreased and longer service life is expected.
- In addition, arcing can cause electromagnetic interference (EMI) that can adversely affect electronic systems. High output brushless DC motors are used in some HEV-drive vehicles

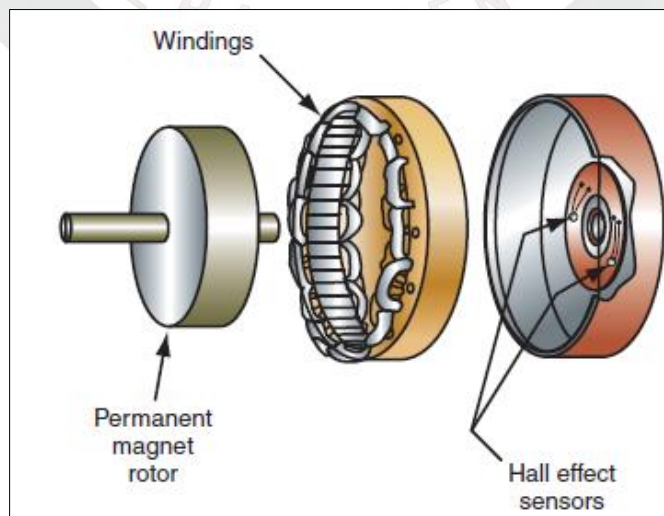


Figure : Components of a brushless DC motor.

Starter Drives

- The **starter drive** is the part of the starter motor that engages the armature to the engine flywheel ring gear.
- A starter drive includes a pinion gear set that meshes with the flywheel ring gear on the engine's crankshaft. The most common type of starter drive is the **overrunning clutch**.
- The overrunning clutch is a roller-type clutch that transmits torque in one direction only and freewheels in the other direction.
- This allows the starter motor to transmit torque to the ring gear but prevents the ring gear from transferring torque to the starter motor. In a typical overrunning-type clutch (Figure)

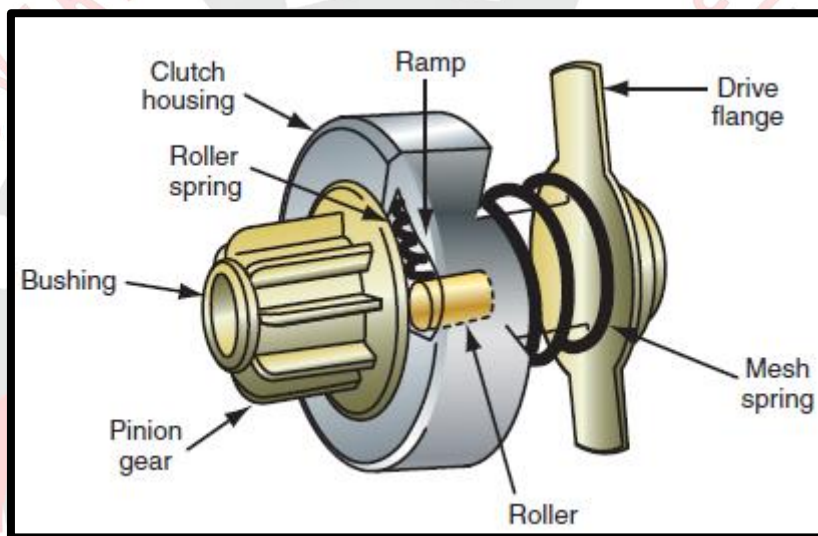


Figure : Overrunning clutch starter drive

- When the engine starts and is running under its own power, the ring gear attempts to drive the pinion gear faster than the starter motor.
- This unloads the clutch rollers and releases the pinion gear to rotate freely around the armature shaft.

Procedure for disassemble of Starter Motor.



1. Always have a clean and organized work area. Tools required to disassemble the starter: rags, assorted wrenches, snap ring pliers, flat-blade screwdriver, ball-peen hammer, plastic-head hammer, punch, scribe, safety glasses, and arbor press.



2. Clean the case



3. Disconnect the field coil connection at the solenoid's M terminal.



4. Remove the two screws that attach the solenoid to the starter drive housing.



5. Rotate the solenoid until the locking flange of the solenoid is free. Then remove the solenoid.



6. Remove the through bolts from the end frame.



7. Remove the end frame



8. Separate the armature from the frame



9. Remove the armature from the drive housing. Note: On some units it may be necessary to remove the shift Clever from the drive housing before removing the armature.



10. Place a 5/8" deep socket over the armature shaft until it contacts the retaining ring of the starter drive.



11. Tap end of socket with a plastic hammer to drive the retainer toward the armature. Move it only far enough to access to the snap ring.



12. Remove the snap ring



13. Remove the retainer from the shaft and remove the clutch and spring from the shaft. Press out the drive housing bushing and the end frame bushing.



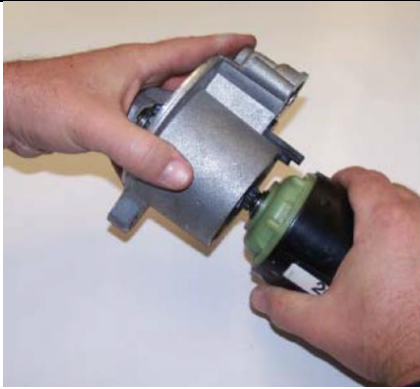
14. Disconnect the lead to the field coil and remove the solenoid retainer screws



15. Remove the solenoid housing while working the plunger off of the drive lever



16. Remove the frame through bolts



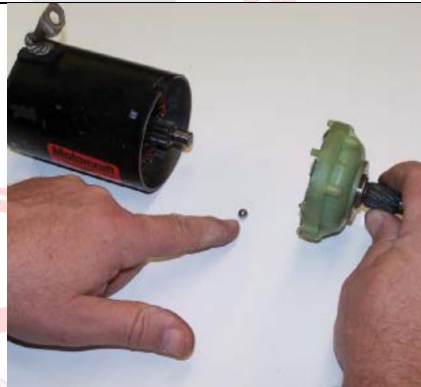
17. Separate the drive end frame from the body. Remove the seal also.



18. Remove the O-ring from the end of the drive gear and then remove the retainer ring and C-clip



19. Remove the drive from the output shaft.



20. Separate the output shaft and stationary gear assembly from the armature. Be sure to locate and retain the thrust ball located in a seat in the output shaft.



21. Remove the lock ring from the output shaft and remove the stationary gear from the shaft



22. Remove the planetary gears from the output shaft



23. Remove the fasteners that attach the end plate to the brush plate.



24. Remove the armature and brush assembly from the body.



25. Separate the brush assembly from the armature

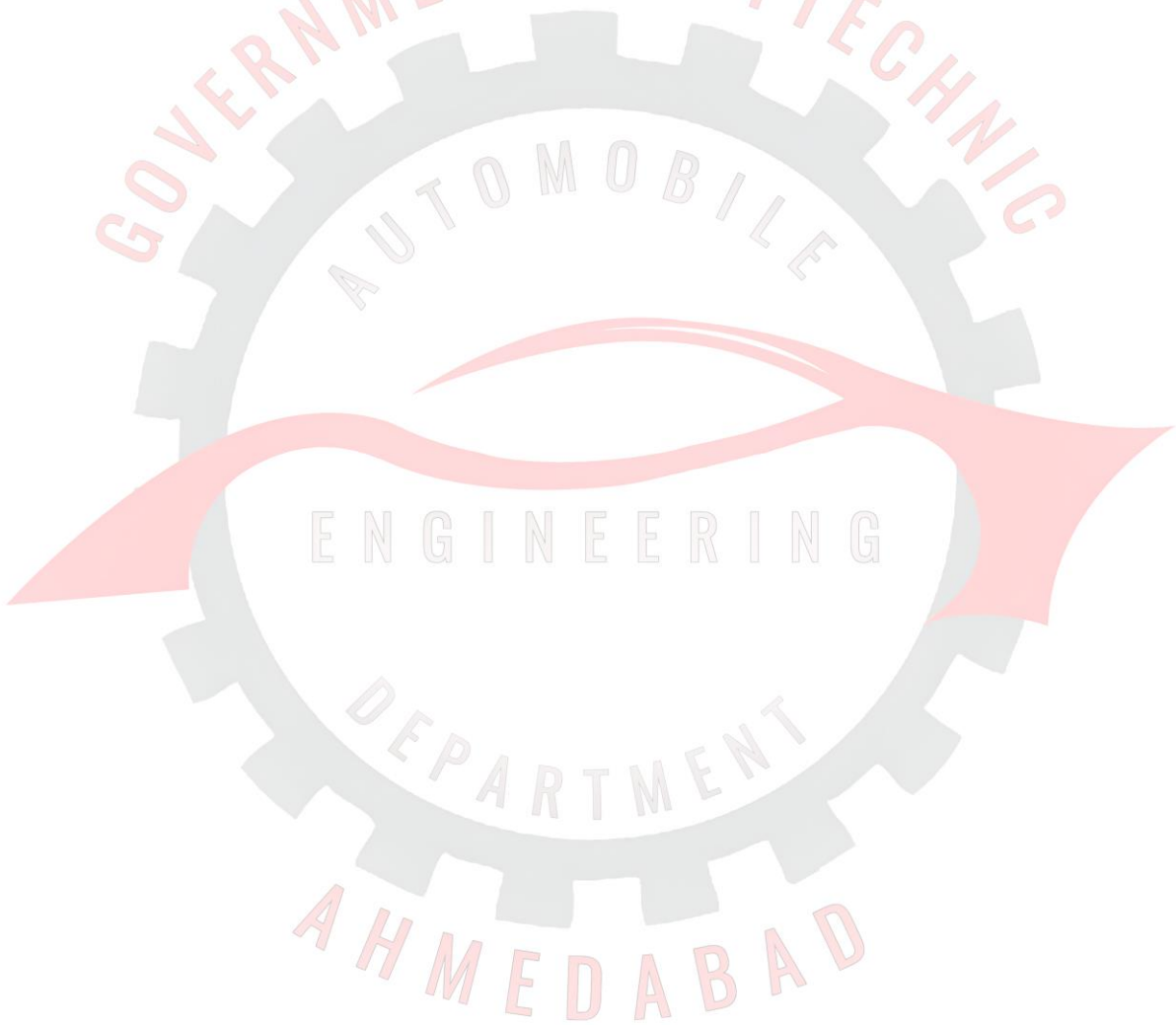
26. To reassemble the starter motor, basically reverse the disassembly procedures.

Group Task:

- 1) Prepare a display of starter motor each key components in sequential manner on hard board with name tag

Assignment questions:

- 1) Differentiate Shunt & series winding motor.
- 2) Compare any two vehicle's starter motor specification and write conclusion in your own word.



Introduction: -

it is the purpose and function of the charging system to keep the battery fully charged. All electrical alternators use the principle of electromagnetic induction to generate electrical power from mechanical power. Electromagnetic induction involves the generation of electric current in a conductor when the conductor is moved through a magnetic field. An alternator generates an alternating current (AC) because the current changes polarity during the alternator's rotation. however, a battery cannot "store" alternating current; therefore, this alternating current is changed to direct current (DC) by diodes inside the alternator. Diodes are one-way electrical check valves that permit current to flow in only one direction.

Component: -**1. Housing: -**

An alternator is constructed using a two-piece cast aluminium housing. Aluminium is used because of its lightweight, nonmagnetic properties, and heat transfer properties needed to help keep the alternator cool. A front ball bearing is pressed into the front housing, called the drive-end (DE) housing, to provide the support and friction reduction necessary for the belt-driven rotor assembly. The rear housing, or the slip-ring-end (SRE) housing, usually contains either a roller bearing or ball bearing support for the rotor and mounting for the brushes, diodes, and internal voltage regulator (if so equipped). (Figure)

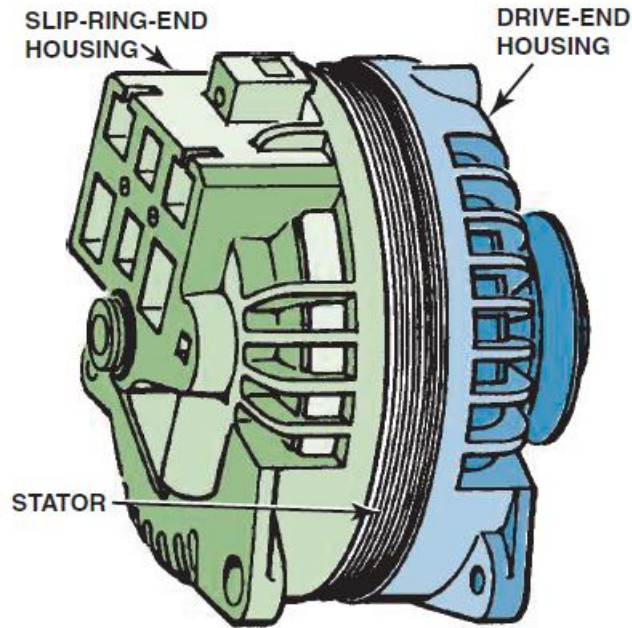


Figure : Alternator's housing

2. Overrunning Clutch: -

Many alternators are equipped with an overrunning alternator pulley (OAP), also called an overrunning clutch pulley or an alternator clutch pulley. The purpose of this pulley is to help eliminate noise and vibration in the accessory drive belt system, especially when the engine is at idle speed. At idle, engine impulses are transmitted to the alternator through the accessory drive belt. The mass of the rotor of the alternator tends to want to keep spinning, but the engine crankshaft speeds up and slows down slightly due to the power impulses. Using a one-way clutch in the alternator pulley allows the belt to apply power to the alternator in only one direction, thereby reducing fluctuations in the belt.

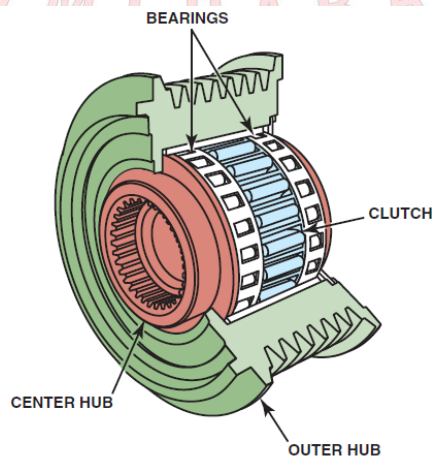


Figure : Overrunning Clutch (Pully)

3. Rotor: -

The rotor is the rotating part of the alternator and is driven by the accessory drive belt. The rotor creates the magnetic field of the alternator and produces a current by electromagnetic induction in the stationary stator windings. The rotor is constructed of many turns of copper wire coated with a varnish insulation wound over an iron core. The iron core is attached to the rotor shaft.

At both ends of the rotor windings are heavy-gauge metal plates bent over the windings with triangular fingers called claw poles. These pole fingers do not touch, but alternate or interlace, as shown in (Figure)

The current necessary for the field (rotor) windings is conducted through slip rings with carbon brushes. The maximum rated alternator output in amperes depends on the number and gauge of the rotor windings. Substituting rotors from one alternator to another can greatly affect maximum output.

The current for the field is controlled by the voltage regulator and is conducted to the slip rings through carbon brushes. The brushes conduct only the field current, which is usually between 2 and 5 amperes.

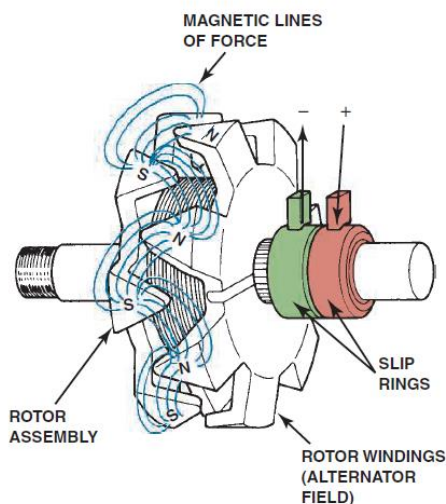


Figure : A cutaway of an alternator

4. Stator: -

The stator consists of the stationary coil windings inside the alternator. The stator is supported between the two halves of the alternator housing, with three copper wire windings that are wound on a laminated metal core. As the rotor revolves, its moving magnetic field induces a current in the stator windings. (Figure)



Figure : A stator of an alternator

5. Diodes: -

Diodes are constructed of a semiconductor material (usually silicon) and operate as a one-way electrical check valve that permits the current to flow in only one direction. Alternators often use six diodes (one positive and one negative set for each of the three stator windings) to convert alternating current to direct current. Diodes used in alternators are included in a single part called a rectifier, or rectifier bridge. A rectifier

includes not only the diodes (usually six), but also the cooling fins and connections for the stator windings and the voltage regulator. (Figure)

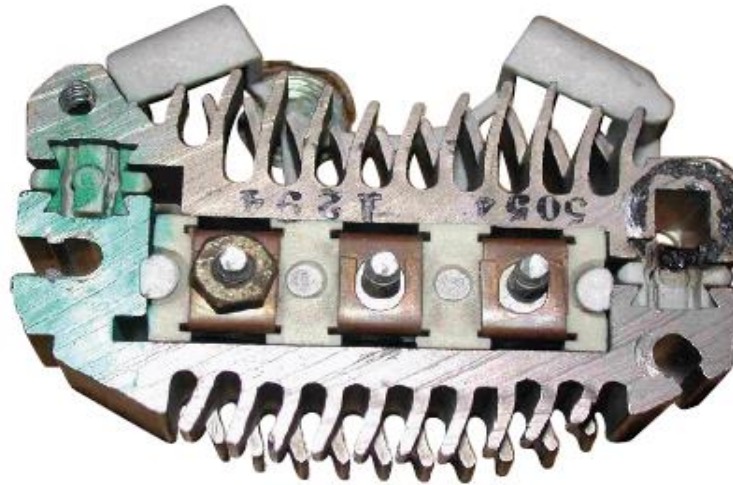


Figure : Rectifier

6. Voltage Regulator: -

An automotive alternator must be able to produce electrical pressure (voltage) higher than battery voltage to charge the battery. Excessively high voltage can damage the battery, electrical components, and the lights of a vehicle.

Current for the rotor flows from the battery positive post, through the rotor positive brush, into the rotor field winding, and exits the rotor winding through the rotor ground brush. Most voltage regulators control field current by controlling the amount of field current through the ground brush.

The voltage regulator simply opens the field circuit if the voltage reaches a predetermined level, then closes the field circuit again as necessary to maintain the correct charging voltage.

The electronic circuit of the voltage regulator cycles between 10 and 7,000 times per second as needed to accurately control the field current through the rotor, and therefore control the alternator output.



Figure : A typical electronic voltage regulator with the cover removed showing the circuits inside.

Procedure for disassemble of Alternator: -

27.



ys have a clean and organized work area. Tools required to disassemble the alternator: rags, assorted wrenches, snap ring pliers, flat-blade screwdriver, ball-peen hammer, plastic-head hammer, punch, scribe, safety glasses, and arbor press.



28. The first step is to remove the drive pulley. This rebuilder is using an electric impact wrench to accomplish the task.



29. Carefully inspect the drive galley for damage of embedded rubber from the drive belt. The slightest fault can cause a vibration, noise, or possible damage to the alternator.



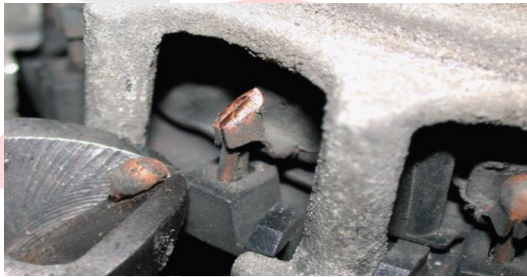
30. Remove the external fan (if equipped) and then the spacers as shown.



31. Next pop off the plastic cover (shield) covering the stator/rectifier connection.



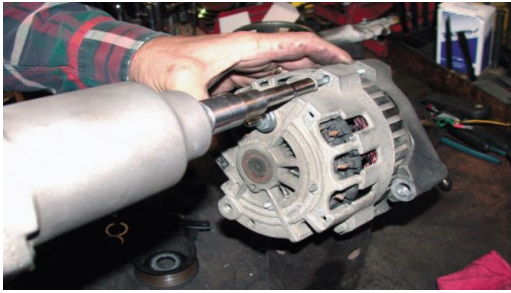
32. After the cover has been removed, the stator connections to the rectifier can be seen.



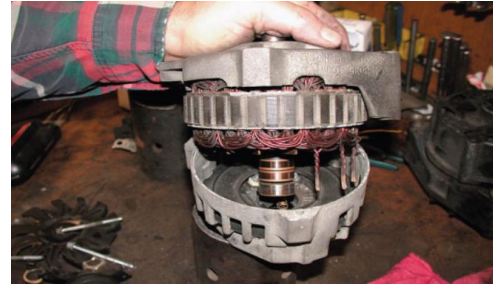
33. Using a diagonal cutter, cut the weld to separate the stator from the rectifier. (If required to replace rectifier, skip this step if you want to use same rectifier)



34. Before separating the halves of the case, this technician uses a punch to mark both halves.



35. After the case has been marked, the through bolts are removed.



36. The drive-end (DE) housing and the stator are being separated from the rear (slip-ring-end) housing.



37. The front bearing is removed from the drive-end housing using a press.



38. A view of the slip-ring-end (SRE) housing showing the black plastic shield, which helps direct air flow across the rectifier.



39. A punch is used to dislodge the plastic shield retaining clips.



40. After the shield has been removed, the rectifier, regulator, and brush holder assembly can be removed by removing the retaining screws.



41. The heat transfer grease is visible when the rectifier assembly is lifted out of the rear housing.



42. The parts are placed into a tumbler where ceramic stones and a water-based solvent are used to clean the parts.

43. To reassemble the alternator, basically reverse the disassembly procedures

Task:

Prepare a display of alternator each key components in sequential manner on hard board with name tag.

Assignment questions:

- 1) Differentiate working of rectifier & voltage regulator.
- 2) Compare any two vehicle's alternator specification and write conclusion in your own word.

