

**Vocational Higher Secondary
Education (VHSE)**

Second Year

AUTOMOBILE TECHNOLOGY

Reference Book



Government of Kerala
Department of Education

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FOREWORD

Dear Learners,

This book is intended to serve as a ready reference for learners of vocational higher secondary schools. It offers suggested guidelines for the transaction of the concepts highlighted in the course content. It is expected that the learners achieve significant learning outcomes at the end of the course as envisaged in the curriculum if it is followed properly.

In the context of the Right- based approach, quality education has to be ensured for all learners. The learner community of Vocational Higher Secondary Education in Kerala should be empowered by providing them with the best education that strengthens their competences to become innovative entrepreneurs who contribute to the knowledge society. The change of course names, modular approach adopted for the organisation of course content, work-based pedagogy and the outcome focused assessment approach paved the way for achieving the vision of Vocational Higher Secondary Education in Kerala. The revised curriculum helps to equip the learners with multiple skills matching technological advancements and to produce skilled workforce for meeting the demands of the emerging industries and service sectors with national and global orientation. The revised curriculum attempts to enhance knowledge, skills and attitudes by giving higher priority and space for the learners to make discussions in small groups, and activities requiring hands-on experience.

The SCERT appreciates the hard work and sincere co-operation of the contributors of this book that includes subject experts, industrialists and the teachers of Vocational Higher Secondary Schools. The development of this reference book has been a joint venture of the State Council of Educational Research and Training (SCERT) and the Directorate of Vocational Higher Secondary Education.

The SCERT welcomes constructive criticism and creative suggestions for the improvement of the book.

With regards

Dr. P. A. Fathima
Director, SCERT Kerala

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ABOUT THE COURSE

The department of Vocational Higher secondary Education (VHSE) prior to curriculum revision offered two courses related to automobile industry. They were Maintenance and Repairs of Two Wheelers and Three Wheelers (MRTWTW) and Maintenance and Repairs of Automobiles (MRA). Currently these two courses have been merged and is renamed as Automobile Technology (AT). This endeavour will definitely enhance the job opportunities of our students. Moreover, students can also for higher education at the diploma and degree levels in automobile technology. In this revised curriculum, we have tried to incorporate the concept and ideas of modern automobile systems and its components.

As the automobile industry is a fast developing field all over the world, automobile technology has much scope in India. This is one of the fastest growing engineering sectors too with the increasing demand of cars, bikes and other vehicles, companies show their interest to set up plants in various states of India. Now many foreign car companies are competing with each other to set up their firms in our country. As India is the second largest populous country in the world there is immense scope in plenty of job opportunities are available as millions of plenty of job opportunities are available as millions of vehicles have to be maintained in trouble- less smooth condition. Presently, India is facing acute shortage of skilled workers. After completing automobile technology course in Vocational Higher Secondary, the students will get easy access to various job opportunities the automobile sector. The course is designed to help students grab opportunities in the present global crisis scenario.

Students having basic knowledge and practice in Automobile Engineering will have a lot of opportunities not only in India abroad. Automobile Technology is thus designed to perfect the students in the service and maintenance of automobiles. This course has four modules and each module helps the student to understand the various areas of an automobile. Each module is designed to acquire some specific skills as per industrial needs. The duration of one module is 340 hours, out of which thirty percentage is allotted to theory and seventy percentage to practical. Moreover four weeks of OJT is also facilitated to our students for acquiring the strategies and skills

of a real work situation. With the growth in automobile sector, the job opportunities before our students are varied. There are lots of opportunities in the areas of designing, manufacturing, servicing, transport companies, defense services, insurance, private sector etc. The Automobile Technology course is designed as per NSQF norms and it covers all the basic automobile technologies at the foreman skill level. It is specially designed to support students who opt for higher education.

MAJOR SKILLS

After the completion of the course the students are expected to achieve the following skills:

- Automotive Chassis Maintenance Skill
- Automotive Engine Mechanic
- Automotive Transmission Troubleshooting Skill
- Automotive Electrician

SUB-SKILLS

- Draftsman skill
- Suspension repair skill
- Wheel alignment
- Tyre puncture repairing
- Brake mechanic
- Diesel mechanic
- Petrol mechanic
- Calibration technician
- Radiator repairing
- Transmission repairing
- Wiring skill
- Battery maintenance
- Pollution testing skill

Syllabus

MODULE 3: AUTOMOTIVE TRANSMISSION SYSTEMS

3.1 CLUTCH

(80 Periods)

Purpose of clutch - Functions of clutch-Requirements of clutch - Types of clutch-Single plate clutch, multi plate clutch, centrifugal clutch, diaphragm spring clutch, semi centrifugal clutch -dry and wet clutches- construction and working of single plate(thrust spring type and diaphragm spring type), multi-plate, centrifugal clutch - Clutch components-clutch disc, clutch facing, pressure plate, springs, bearings- Clutch actuating mechanisms-mechanical, hydraulic, electromagnetic, vacuum and clutch-by-wire- clutch free pedal play adjustment.

3.2 MANUAL TRANSMISSION

(96 Periods)

Types of gears- straight spur gear, helical spur gear, bevel gear, spiral bevel gear, hypoid gear-Gear ratio-function and necessity of transmission-resistance on moving vehicle- necessity of providing gear box- types of gear box-sliding mesh, constant mesh, synchromesh gear box- construction and working of constant mesh gear box and synchromesh gear boxes-synchronizing unit-selector mechanisms--gear box lubrication-transfer box-transaxles

3.3 AUTOMATIC TRANSMISSION

(74 Periods)

Semi- automatic- fully automatic - epicyclic gear box- free wheel unit -fluid flywheel -torque converter-overdrive - Continuously Variable Transmission (CVT)- Automated Manual Transmission (AMT) - types of AMT, single sided clutch transmission (SSCT), double sided clutch transmission (DSCT), dual clutch transmission (DCT/DSG) modern shift control techniques - Select Shift Manual (SSM) and Auto Shift Manual (ASM) modes

3.4 DRIVE LINE

(90 Periods)

Drive line- propeller shaft- slip joint-universal joints-hooks joint(variable velocity), rzeppa joints(constant velocity) - final drive- types of crown wheel and pinion drive-straight bevel gear, spiral bevel gear, hypoid gear- construction and working of differential -limited slip differential-types of rear axle casing-rear axle drives- Hotchkiss drive, Torque tube drive rear axle shaft supporting- semi- floating axle, full floating axle and three quarter floating axle

MODULE 4 AUTOMOTIVE ELECTRICAL SYSTEMS

4.1 AUTOMOTIVE BATTERY

(60 Periods)

Function-types of battery-lead acid, alkaline battery, zinc-air battery, nickel-metal hydride battery, lithium-ion battery-construction and working of lead acid battery-characteristics of battery - cell voltage, battery capacity, battery rating - battery testing-specific gravity test, open volt test, high discharge test, cadmium test- battery charging methods- slow rate charging, quick rate charging, trickle charging - care and maintenance of battery

4.2 CHARGING SYSTEM

(50 Periods)

Function- requirements-charging circuit-generator principle-faraday's law of electromagnetic induction-alternator- construction and working of alternator-alternator regulation- comparison of alternator with DC generator

4.3 STARTING SYSTEM

(40 Periods)

Function-starting circuit-starting motor- construction and working of starting motor-starter drives-bendix drive, overrunning clutch or pre engaged type drive, dycer drive-construction and working of axial starter motor, construction and working of over running clutch drive -construction and working of solenoid switch- electronic starter control

4.4 LIGHTING SYSTEMS AND ELECTRICAL EQUIPMENTS

(58Periods)

Electrical symbols-wire color codes- lighting circuits- head lamp circuit, tail lamp circuit, stop light circuit, parking light circuit, number plate light circuit, instrument panel light circuit, interior light circuit-types of head lamps-incandescent lamps, halogen lamps, High Intensity Discharge (HID) lamps, LED lamps-lighting switches- light switch, dimmer switch, stop light switch-instrument panel indicating lights-main beam warning lights, ignition warning lights, flashing indicator warning light, oil pressure warning light, charge indicator light-direction indicator circuit-flasher unit- horn circuit-construction and working of electric horn- horn relay- wind screen wiper-speedometer and odometer-central locking-power window- - seat belts -pre tensioner and load limiter-air bags

4.5 IGNITION SYSTEM**(82 Periods)**

Function of ignition system-types of ignition system-battery coil ignition system-magneto ignition system-electronic ignition system- working of battery coil ignition system with circuit diagram - working of magneto ignition system with circuit diagram- components of ignition system- battery, ignition coil, contact breaker, condenser, distributor, spark plug , magneto -construction and working of ignition coil, spark plugs - function and working of distributor - concept and function of centrifugal and vacuum advance systems -comparison between battery coil and magneto ignition systems

Basic electronics-semi-conductors, diodes, transistors, thyristor-Electronic ignition systems- contactless distributor type, distributor less type - Capacitor Discharge Ignition (CDI) -coil on plug -timers- pulse generator, hall-effect pulse generator, optical pulse generator.

4.6 EMISSION CONTROL**(50 Periods)**

Necessity of emission control-sources of automotive emission-charts showing Euro norms of Bharat Stage 3 and 4 of passenger cars, Heavy duty diesel vehicles and 2 wheeler-implementation schedule of euro norms in India- positive crank case ventilation- vapour recovery system- EGR system- air injection system- Pulse Air- Injection Reactor (PAIR) system- catalytic converters- two way and three way catalytic converters

MODULE 3 - AUTOMOTIVE TRANSMISSION SYSTEMS

OVERVIEW

The power developed by the engine has to reach the road wheels for moving the vehicle. Transmission system deals with this objective. It transmits power to wheels as and when required by varying speed and torque. This unit comprises different components of Automotive transmission depending upon their purpose. Sometimes we may not have to transmit power; we may have to vary the torque and speed, transmit power at varied angles and lengths, and have to transmit more power to outer wheels than the inner wheels while taking a turn. These different functions and situations are tackled by this system.

This module also deals with the most modern concepts of transmission system. It describes the function, construction and working of automatic transmission. Transmission system is the biggest system in automobile technology providing several career opportunities for the students.

3.1 CLUTCH

INTRODUCTION

The engine power need not be transmitted to road wheels while shifting gears and starting the engine. A mechanism is essential for this. Clutch serves this purpose. The unit describes the function, purpose, types of clutch, construction and working of different types of clutch, clutch actuating mechanism etc. Different clutch troubles; their causes and remedies, clutch adjustment, dismantling and assembling of different clutches are also dealt with this unit.

LEARNING OUTCOMES

After the completion of this unit the learner will be achieve the following learning outcomes.

The learner ;

- understands the purpose, functions and requirements of clutch.
- classifies different types of clutch
 - Single plate clutch
 - Multi plate clutch
 - Centrifugal clutch
 - Diaphragm spring clutch
 - Semi- centrifugal clutch
 - Wet type
 - Dry type
- explains the construction and working of single plate clutch (thrust spring and diaphragm spring type)
- explains the construction and working of multi-plate clutch
- explains the construction and working of centrifugal clutch
- identifies, locate and explain the function of clutch components
 - Clutch plate
 - Clutch facing
 - Pressure plate
 - Release bearing

- explains the working of clutch actuating mechanisms
 - Mechanical
 - Hydraulic
 - Electromagnetic
 - Vacuum
 - Clutch- by- wire
- carryouts clutch free pedal play adjustment

UNIT IN DETAIL

3.1.1.1 PURPOSE OF CLUTCH

In vehicles with a manual transmission or manual transaxle the power flows through a clutch. This device engages and disengages the manual transmission or transaxle and the engine. When the driver pushes the clutch pedal down, the clutch disconnects or disengages from the engine flywheel. No engine power can flow to the transmission or transaxle. When the driver releases the clutch pedal the clutch engages. This allows power to flow to the transmission.

3.1.1.2 FUNCTIONS OF CLUTCH

The clutch has four functions:

1. It can be disengaged. This allows engine cranking and permits the engine to run freely without delivering power to the transmission.
2. While disengaged it permits the driver to shift the transmission into various gears.
3. While engaging, the clutch slips momentarily. This provides smooth engagements and lessens the shock on gears, shafts, and other drive train parts.
4. When engaged, the clutch transmits power from the engine to the transmission. All slipping has stopped.

3.1.1.3 REQUIREMENTS OF CLUTCH

1. Torque transmission

The clutch should be able to transmit the maximum torque of the engine under all condition.

2. Gradual engagement
The clutch should positively take the drive gradually without occurrence of sudden jerks.
3. Heat dissipation
During clutch application large amount of heat are generated. The rubbing surfaces should have the sufficient area and the mass to absorb heat.
4. Dynamic balancing
This is necessary particularly in the high speed clutches.
5. Size
The size of the clutch must be smallest possible so as to occupy minimum amount of space.
6. Vibration Damping
Suitable mechanism should be used within the clutch, to eliminate noise produced in the transmission.
7. Inertia
The clutch rotating parts should have minimum inertia. Otherwise, when the clutch is released for gear changing, the clutch plate will keep on spinning causing hard shifting and gear clashing in spite of synchronisation.
8. Clutch free pedal play
To reduce effective clamping load on the carbon thrust bearing and wear there of sufficient free pedal play must be provided in the clutch.
9. Ease of operation
For higher torque transmission the operation of disengaging the clutch must not be tiresome for the driver.

Assessment Activity

Ask the students to complete the blanks in each columns of the chart given below. In the first column they have to write the purpose and the other situations when clutch is used in automobiles; in the second column, the requirements of clutch and in the third, types of friction clutches. Give one score for each correct answer.

Complete the blanks.

Usage and purpose of clutch	Requirements of clutch	Types of friction clutch
1. While starting the engine	1. Gradual engagement	1. Single plate clutch
2.	2.	2.
3.	3.	3.
4.	4.	4.
5.	5.	5.

3.1.2 TYPES OF CLUTCH

The following are the main types of clutches.

1. Friction clutches
2. Fluid flywheel

Friction clutches are mainly classified into

- Single plate clutch
- Multi plate clutch
- Centrifugal clutch
- Diaphragm spring clutch
- Semi centrifugal clutch

Dry clutch

In this type of clutch friction plate is always dry. There is no oil inside the clutch assembly.

Wet clutch

The construction of wet clutch is similar to that of dry type except that here the clutch plates are always wetted by oil circulation.

Many types of wet clutches are used in trucks, simple type is spray type. Its construction is similar to that of dry type except that a different type of friction material is used and the construction of clutch plate is also different. The oil is sprayed through holes in clutch plate by a nozzle. This type of clutch is suitable for small trucks.

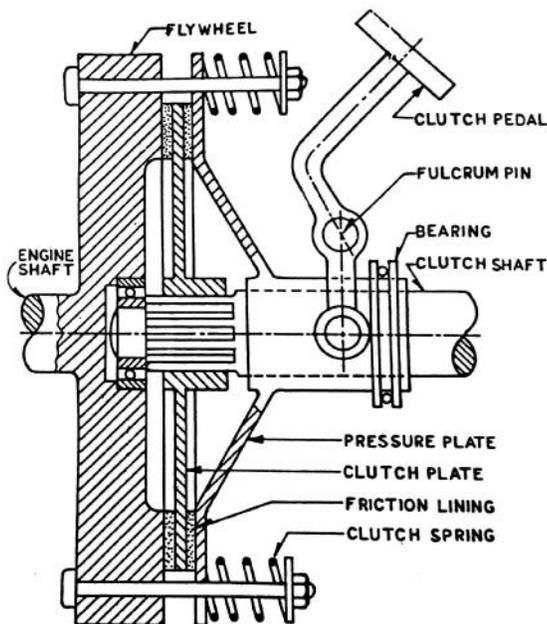
All these types of clutches are attached to the engine flywheel which acts as the driving member along with the pressure plate.

3.1.3 SINGLE PLATE CLUTCH

3.1.3.1 THRUST SPRING (COIL SPRING) TYPE

The main components of clutch are clutch plate, clutch facing, pressure plate, springs and bearing.

A simplified sketch of a single plate clutch is given. Friction plate is held between the flywheel and the pressure plate. There are springs arranged circumferentially, which provide axial force to keep the clutch in engaged position. The friction plate is mounted on a hub which is splined from inside and is thus free to slide over the gearbox shaft. Friction facing is attached to the friction plate on both sides to provide two annular friction surfaces for the transmission of power. A pedal is provided to pull the pressure plate against the spring force whenever it is required to be disengaged. Ordinarily it remains in engaged position.



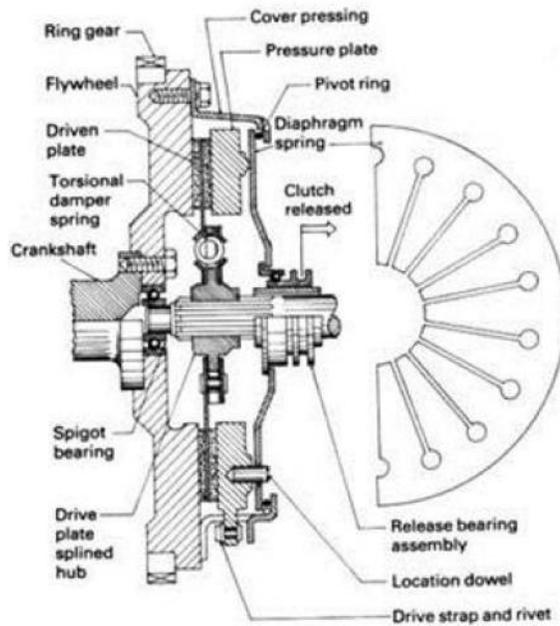
When the clutch pedal is pressed the pressure plate is moved to the right against the force of springs. This is achieved by means of a suitable linkage and a thrust bearing. With this movement of the pressure plate the friction plate is released and the clutch is disengaged.

In actual practice the construction of the clutch differs. The pressure plate, the springs, the release levers and the cover form a sub assembly called the cover

assembly. This can be mounted directly to the engine block by placing the clutch plate in between the flywheel and the pressure plate with the clutch shaft inserted in place.

3.1.3.2 DIAPHRAGM SPRING TYPE SINGLE PLATE CLUTCH

The construction of diaphragm spring type single plate clutch is similar to that of the single plate type clutch with thrust spring except that here diaphragm spring is used instead of the ordinary coil springs. In the free condition the diaphragm spring is of conical form, but when assembled it is constrained to an approximately flat condition because of which it exerts a load upon the pressure plate.



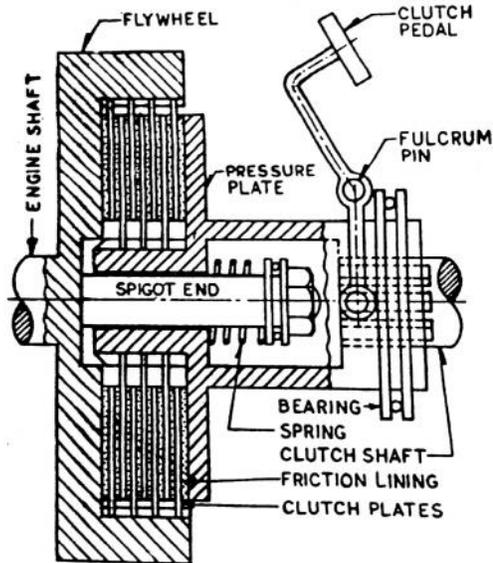
Diaphragm spring is supported on a fulcrum retaining ring so that any section through the spring can be regarded as a simple lever. The pressure plate is movable axially, but it is fixed radially with respect to cover. This is done by providing a series of equally spaced lugs cast upon the back surface of the pressure plate. The drive from the engine flywheel is transmitted through the cover, pressure plate and the friction plate to the gear box input shaft.

Assessment Activity

Role play of the working of a single plate clutch

Here we are trying to demonstrate the concept of the working of a single plate clutch. Ask any three students to come forward to participate in the role play. Let one student act as flywheel, the other one as clutch disc and the third one as pressure plate. The students who play as clutch components will explain the working of the single plate clutch during engaged and disengaged positions. Make the remaining students into 3 groups. Let one group prepare a chart showing the figure of a single plate clutch and explain its working; the second group also explain the working but by using an actual clutch and the third group may explain the function of each components of the clutch. The teacher can evaluate each student according to their performance.

3.1.4 MULTI PLATE CLUTCH



The multi plate clutch is an extension of single plate type where the number of frictional and metal plates is increased. The increase in the number of friction surfaces obviously increases capacity of the clutch to transmit torque, the size remains fixed. Alternatively the overall diameter of the clutches is reduced for the same power transmission as a single plate clutch. This type of clutch therefore used in some heavy transport vehicles the racing cars where high torque needs to be transmitted. Besides, it also finds application in case of scooters and motorcycles, where space available is limited.

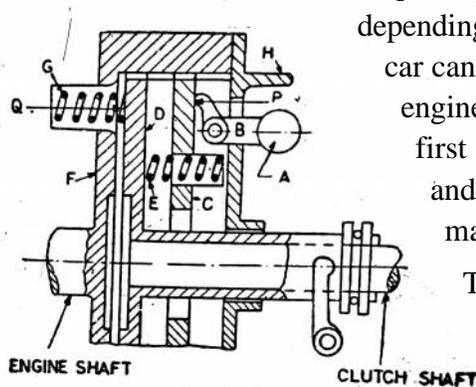
A simplified diagram of multi-plate clutch is given. The construction is similar to that of single plate type except that all the friction plates on this are in two sets, i.e., one set of plates slides in the grooves on the flywheel and other one slides on splines on the pressure plate hub. Alternate plates belong to each set.

3.1.5 CENTRIFUGAL CLUTCH`

In this type of clutch, the springs are eliminated altogether and only centrifugal force is used to apply the required pressure for keeping the clutch in engagement position. The advantage of the centrifugal clutch is that no separate clutch pedal

is required. The clutch is operated automatically depending upon the engine speed. This means that car can be stopped in gear without stalling the engine. Similarly while starting, the driver can first select the gear, put the car into the gear and simply press the accelerator pedal. This makes driving very comfortable and easy.

The following figure shows a schematic diagram of a centrifugal clutch. As the speed increases, the weight A flies,

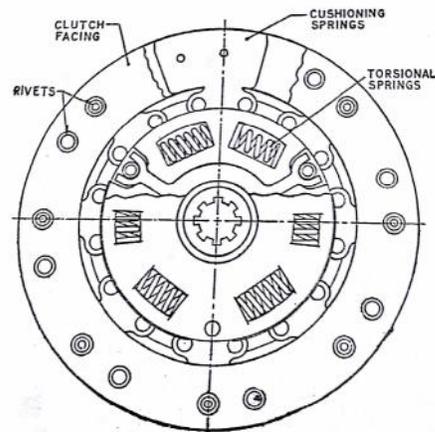


thereby operating the bell crank lever B that presses the plate C. This force is transmitted to the plate D by means of springs E. The plate D containing friction lining is thus pressed against the flywheel F thereby engages the clutch. Spring G serves to keep the clutch disengaged at low speed say 500 rpm. The stop H limits the amount of centrifugal force.

3.1.6 CLUTCH COMPONENTS

3.1.6.1 FRICTION DISC (CLUTCH DISC/PLATE)

The clutch plate consists of steel plate with a splined central hub. Annular friction facings are attached to the steel plate by rivets. Special resins are also being used to bind the friction facings. A provision of axial cushioning interposed between the clutch plate and friction facing. The curved cushioning spring segments are attached rigidly to the centre plate and the friction facings are riveted to these springs. On engagement the load applied first has to compress the spring segments to flat condition resulting in smoother engagement.



Apart from the cushioning, the clutch plates are also provided with torsional springs to absorb undesirable torsional vibrations. The clutch plate is made into two parts. i.e. a central hub sub assembly and outer ring assembly, the two being torsionally flexible with each other. The coil spring is placed between central hub and outer ring under slight compression in the slots provided.

3.1.6.2 CLUTCH FACING

A good clutch facing should have the following:

1. Good wearing properties.
2. Presence of good binder in it.
3. Cheap and easy to manufacture.
4. High co-efficient of friction
5. High resistance to heat.

There are mainly 3 types of clutch friction materials

1. Millboard type
2. Moulded type
3. Woven type
 - Solid woven type
 - Laminated type

Common clutch facing materials used are asbestos, reybestos, ferodo and non-asbestos. clutch facing. Due to environmental pollution asbestos, reybestos and ferodo are not used nowadays. Non-asbestos clutch facings are used which are made of man-made glass fiber, mixed with special rubber compound to improve frictional performance, firmly locked with elastomer- based novalac binder and moulded with pressure and heat. Some examples are SW3-AF and HWK 200.

3.1.6.3 PRESSURE PLATE

High tensile grey cast iron is the most commonly used material for pressure plate. It must be sufficiently rigid so as not to distort under high pressure of the clutch spring. The pressure plate must have sufficient mass and thermal conductivity to absorb and conduct away the heat generated during clutch operation.



3.1.6.4 RELEASE BEARING

The release bearing, also called the throw-out bearing, is a ball bearing and collar assembly. It reduces friction between the pressure plate levers and the release fork. The release bearing is a sealed unit pack with a lubricant. It slides on a hub sleeve extending out from the front of the manual transmission or transaxle.

The release bearing snaps over the end of the clutch fork. Small spring clips hold the bearing on the fork. Then fork movement in either direction slides the release bearing along the transmission hub sleeve.

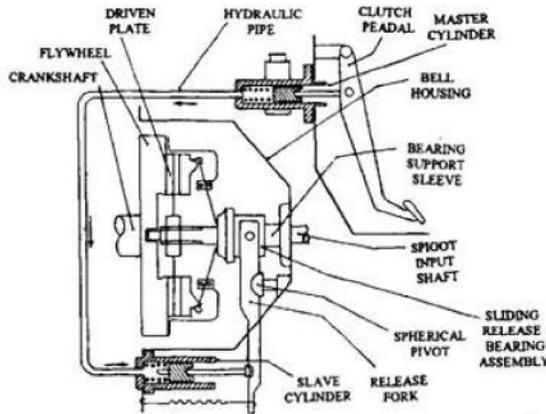
3.1.7 CLUTCH ACTUATING MECHANISMS

The clutch actuating mechanisms are of different types.

3.1.7.1 MECHANICAL OPERATION

In the mechanical type actuating force is transmitted from clutch pedal to release fork through mechanical linkages or through cables.

3.1.7.2 HYDRAULIC OPERATION

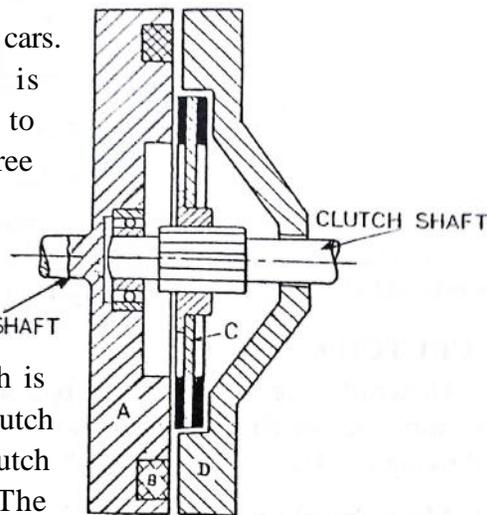


Hydraulic clutch activation systems consists of a master cylinder and a slave cylinder. When pressure is applied to the clutch pedal (the pedal is depressed), the pushrod contacts the plunger and pushes it up the bore of the master cylinder. During the first 1/32 in. (0.8 mm) of movement, the center valve seal closes the port to the fluid reservoir tank and as the plunger continues to move up the bore of the cylinder, the fluid is forced through the outlet line to the slave cylinder mounted on the clutch housing. As fluid is pushed down the pipe from the master cylinder, this in turn forces the piston in the slave cylinder outward. A pushrod is connected to the slave cylinder and rides in the pocket of the clutch fork. As the slave cylinder piston moves rearward the pushrod forces the clutch fork and the release bearing to disengage the pressure plate from the clutch disc. On the return stroke (pedal released), the plunger moves back as a result of the return pressure of the clutch. Fluid returns to the master cylinder and the final movement of the plunger lifts the valve seal off the seat, allowing an unrestricted flow of fluid between the system and the reservoir.

3.1.7.3 ELECTROMAGNETIC OPERATION

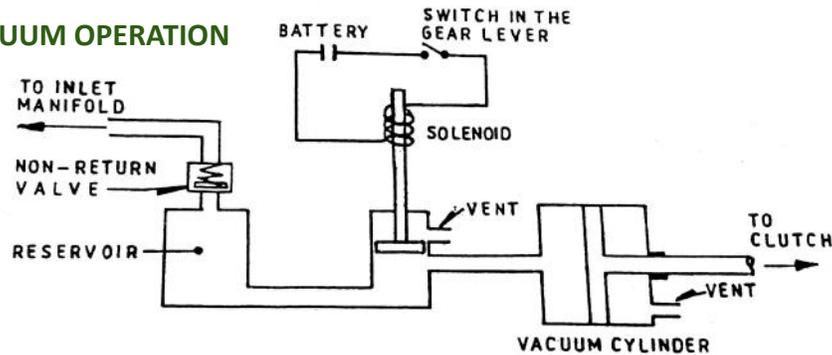
This type of clutch is employed in Renault cars. In the engine flywheel a winding is incorporated. The current is supplied to winding from dynamo. Clutch plate is free to slide on the splined clutch shaft.

When the winding is energized, it attracts the pressure plate, there by engaging the clutch. When supply to winding is cut off, the clutch is disengaged. When electromagnetic clutch is used in automobiles, there may be a clutch release switch inside the gear lever. The driver operates the switch by holding the gear



lever to change the gear, thus cutting off current to the electromagnet and disengaging the clutch. With this mechanism, there is no need to depress the clutch pedal. Alternatively, the switch may be replaced by a touch sensor or proximity sensor which senses the presence of the hand near the lever and cuts off the current. The advantages of using this type of clutch for automobiles is that complicated linkages are not required to actuate the clutch, and the driver needs to apply a considerably reduced force to operate the clutch. It is a type of semi-automatic transmission.

3.1.7.4 VACUUM OPERATION



The partial vacuum existing in the engine manifold is used for operating the clutch. A reservoir is connected to engine manifold through a non-return valve. The reservoir is further connected to a vacuum cylinder through a solenoid operated valve. The solenoid itself is operated from the battery and the circuit incorporates a switch which is connected to gear change lever which is operated when the driver change gears. Vacuum cylinder contains a piston which opens to atmosphere on one side. The piston is further connected through linkages to the clutch. The movement of the piston thus operates clutch.

In part throttle position there is enough vacuum in the manifold. But in full throttle condition, the vacuum decreases, due to this the non-return valve closes, isolating the reservoir from the manifold. Thus vacuum exists in the reservoir all the time.

In normal condition the switch in the gear lever remains open and solenoid operated valve in the bottom position, i.e. both the sides of the vacuum piston is open to atmosphere. When the driver operates the gear lever to change gear the switch closes thus energizing the solenoid which pulls the valve up, connecting the vacuum cylinder to the vacuum in the reservoir. This moves the piston to the left and disengaging the clutch. When driver releases the lever after gear changing, the switch opens and clutch is engaged due to the clutch spring pressure.

3.1.7.5 CLUTCH-BY-WIRE

The clutch-by-wire, the unit replaces the mechanical link between clutch and pedal with an electrical clutch actuator, an electric clutch pedal and an Electronic Control Unit (ECU). A pedal sensor measures the position of the clutch pedal and transmits this information to the ECU which also receives information about car behavior. The ECU in turn controls the clutch actuator and depending upon the driver's wishes, the system can not only correct driver mis-operations but offer complete clutch automation. The system is designed to require lower stroke and effort to the pedal and improves pedal feel with "virtual" resistance to foot pressure. More compact than a conventional clutch actuation, the clutch-by-wire system improves driver crash protection since it enables an optimized, less intrusive, pedal box design.

Assessment Activity

Clutch actuating mechanism

Divide the students into four groups and ask them to explain the working of one clutch actuating mechanism. They can use either chart, actual components, videos, powerpoints etc.

Teacher evaluates each student on the basis of definite parameters.

Group	Clutch actuating mechanism
I	Mechanical
II	Hydraulic
III	Electromagnetic
IV	Vacuum

3.1.8 CLUTCH FREE PEDAL PLAY ADJUSTMENT

The only adjustment required in the clutch is free pedal play adjustment. It is required because of the continuous use of clutch. Continuous use of clutch decreases the clutch free pedal play. If it is less the clutch is not engaged fully, and if it is more clutch, it is not disengaged fully. So in that case clutch adjustment is required.

In the mechanical operating type, an adjusting nut is provided in the linkage at the release fork end. We can adjust it by loosening or tightening the nut. But in the hydraulic operating type it is adjusted in the clutch pedal itself.

DETAILING OF PRACTICALS

Overhauling of Diaphragm Clutch

Procedure

- Park the vehicle on a level ground and block the wheels using wooden blocks.
- Disconnect the propeller shaft from gear box.
- Remove floor board screws and floor board.
- Remove speedometer connection from the gear box.
- Disconnect the hand brake lever from the gear box casing.
- Remove the dust boot and the gear lever.
- Remove the gear box foundation bolts, cross member and gear box foundation.
- Slide the gear box straight backward slowly and take it out.
- Remove the clutch release bearing from the fork and take out the fork assembly.
- Remove the clutch disc-pressure plate assembly, clean all the parts in kerosene and dry it with compressed air.
- Check all the parts for damages and replace if necessary.
- Assemble them in the reverse order.
- Place it on the gear box and tighten the mounting bolts.
- Reconnect the hand brake lever and the speedometer cable.
- Check the clutch free pedal play and adjust if necessary.

Multi-Plate Clutch

Procedure

- Park the vehicle on level ground and block all the wheels.
- Loosen the drain plug and drain out the lubricant.
- Disconnect clutch cable and remove the clutch cover.
- Remove the throw out bearing.
- Loosen the clutch spring bolts using clutch puller and spanner.
- Take out springs, inner drum, metallic plates, friction plates etc.

- Take out the clutch drum.
- Clean all the parts using kerosene and inspect them for damages, replace the damaged parts.
- Place the clutch drum on clutch shaft. Assemble the friction plates, metallic plates and springs on the inner drum using clutch puller and spanner.
- Insert this assembly on the clutch shaft.
- Connect the throw out bearing and clutchcover. Connect the clutch cable.
- Fill gear oil in the gear box up to the required level.
- Check the functioning of the clutch.

Assessment Activity - Class test

1. Assignment on Single Plate Clutch and Centrifugal clutch
2. Debate on whether multi plate clutch is better than single plate clutch
3. Seminar on clutch actuating mechanisms.

TE QUESTIONS

Fill in the blanks

1. Clutch is fitted between and..... (1)
2. is a mechanically operated clutch which is controlled by engine speed only. (1)
3. Identify the type of clutch which is used in scooters and motor cycles and explain its working with a simple diagram (1+5)
4. It is seen that diaphragm clutches are widely used in cars and at the same time it is not used in heavy duty vehicles. Give reasons (2)
5. After overhauling a clutch linkage of a car Mr.James fitted the linkage without giving a free pedal play. List the problems that the driver will face while driving.(3)

3.2 MANUAL TRANSMISSION

INTRODUCTION

After the clutch is the transmission or gearbox in the transmission system. The torque and speed of the vehicle have to change depending upon the various requirements of the vehicle. Sometimes we have to move the vehicle in the reverse direction. The gear box serves all these function. Various types of gear boxes, construction and working, gear ratio etc. are vividly elaborated in this unit. Dismantling and assembling, diagnosis of gear box troubles their causes and remedies etc. make the students experts in this area.

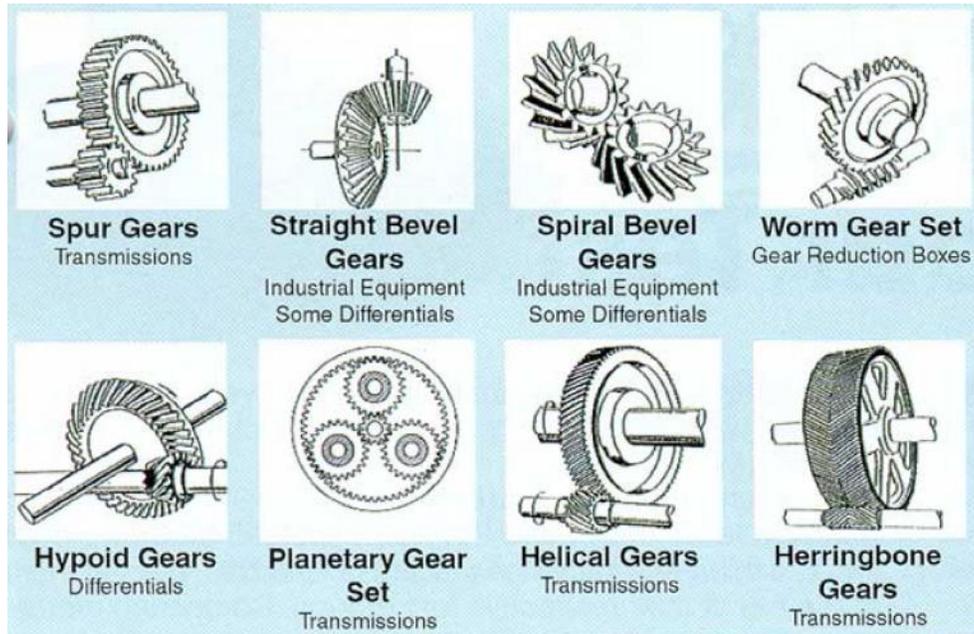
LEARNING OUTCOMES

The learner;

- identify different types of gears
 - Straight spur gear
 - Helical spur gear
 - Bevel gear
 - Spiral bevel gear
 - Hypoid gear
- calculate gear ratio
- explain the necessity of gear box
- describe various resistances on a moving vehicle
- classify different gear boxes
 - Sliding mesh
 - Constant mesh
 - Synchromesh
- explain the working of constant mesh gear box
- explain the working of synchromesh gear box
- explain the working of synchronizing unit
- explain the construction and working of selector mechanisms
- describe the necessity of gear box lubrication
- describe the function of transfer box
- explain the working of transaxle

UNIT IN DETAIL

3.2.1 TYPES OF GEARS



3.2.1.1 SPUR GEAR

Spur gears or straight-cut gears are the simplest type of gears. It consists of a disk with teeth projecting radially. The edge of each tooth is straight and aligned parallel to the axis of rotation. These gears mesh together correctly only if fitted to parallel shafts.

3.2.1.2 HELICAL GEAR

Helical or "dry fixed" gears offer a refinement over spur gears. The leading edges of the teeth are not parallel to the axis of rotation, but are set at an angle. Since the gear is curved, this angling makes the tooth shape a segment of a helix. Helical gears can be meshed in parallel or in crossed orientations. The angled teeth engages more gradually than the spur gear teeth, causing them to run more smoothly and quietly.

3.2.1.3 BEVEL GEAR

A bevel gear is shaped like a right circular cone with most of its tip cut off. When two bevel gears mesh, their imaginary vertices must occupy the same point. Their

shaft axes also intersect at this point; the angle between the shafts can be anything except zero or 180 degrees.

3.2.1.4 SPIRAL BEVEL GEAR

When it is necessary to transmit quietly and smoothly a large torque through a right angle, spiral bevel gear can be used. Spiral bevel gears have teeth cut in helix spiral form.

3.2.1.5 HYPOID GEAR

A hypoid gear is same as spiral bevel gear whose main difference is that the mating gears axes do not intersect. The hypoid gear is offset from the gear center. The teeth on a hypoid gear are helical.

3.2.2 GEAR RATIO

In mechanical engineering, a gear ratio is a direct measure of the ratio of the rotational speeds of two or more interlocking gears. As a general rule, when dealing with two gears, if the driving gear (the one directly receiving rotational force from the engine) is bigger than the driven gear, the latter will turn more quickly, and vice versa. We can express this basic concept with the formula $\text{Gear ratio} = T_2/T_1 = N_1/N_2$, where T_1 is the number of teeth on the driver gear, T_2 is the number of teeth on the driven gear, N_1 is the speed of driver gear and N_2 is the speed of the driven gear.

Assessment Activity

Teacher shows different types of gears like spur gear, helical gear, bevel gear, hypoid gear and spiral bevel gear. The students are asked to identify the gear and its function.

3.2.3.1 FUNCTIONS OF TRANSMISSION

The important functions of transmission system are;

1. to vary the torque
2. to vary the speed of the vehicle
3. to provide neutral position
4. to move the vehicle in reverse direction

3.2.3.2 NECESSITY OF TRANSMISSION

Before discussing the necessity of transmission, we should understand the following factors

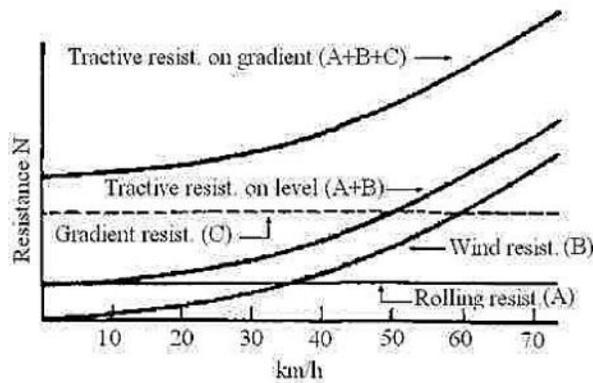
- a) Variation of resistance to the vehicle motion at various speeds.
- b) Variation of tractive effort to the vehicle available at various speeds.

3.2.4 TOTAL RESISTANCE TO THE VEHICLE MOTION.

It includes the following three factors:

- Resistance due to wind - This is taken to be proportional to the square of the vehicle speed
- Resistance due to gradients - This is the weight of the vehicle components parallel to the plane of the road
- Miscellaneous - Apart from the above two types, various other factors also contribute towards the vehicle resistance. These are-rolling resistances such as types of the road, tyre friction etc. This may also be taken approximately to remain constant with the speed.

TRACTIVE EFFORT



Tractive resistance curves

When a vehicle is travelling at constant speed, its resistance to motion is termed as the tractive resistance. Whenever the tractive effort exceeds the total resistance, the vehicle will accelerate.

It is obvious that whenever the tractive effort exceeds the total resistance of motion the vehicle starts to accelerate. So the gear box is used to vary the torque according to the resistance of motion in different conditions.

Assessment Activity

Complete the blanks in the chart suitably

Functions of transmission

1. To vary the torque

2.

3.

Total resistance

1.

2.

3.

Find gear ratio

1. 12 teeth gear rotate 36 teeth gear

2. If the small gear rotates at 750 rpm, what will be the speed of large gear?

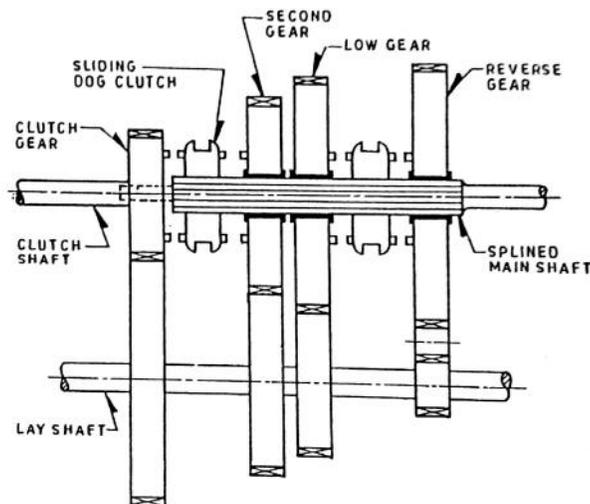
Give one score to each point, two score for gear ratio point 2

3.2.5 TYPES OF GEAR BOX

The transmission can be classified into manual and automatic types. The manual transmission is conventionally called gear boxes. The following are the important gear boxes used in automobiles:

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

3.2.6 CONSTANT MESH GEAR BOX

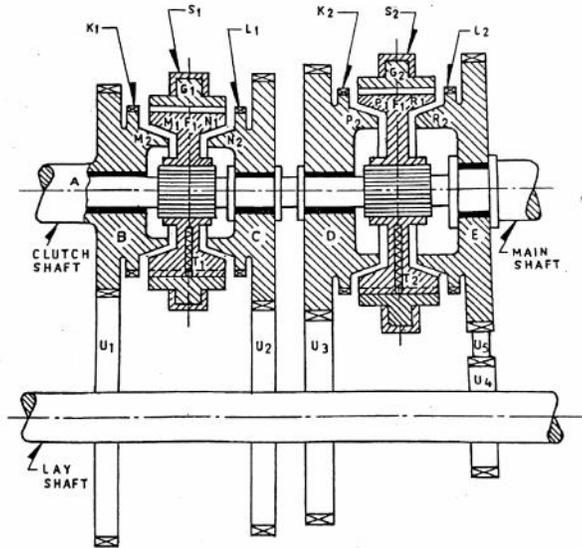


In this type of gear box, all the gears on the main shaft are in constant mesh with the corresponding gear on the lay shaft. The gears on the main shaft, which is splined, are free. The dog clutches are provided which are free to slide on the main shaft. The gears on the lay shaft are fixed.

When the left sliding dog clutch slides to the left by means of the selector mechanism, its teeth are engaged with those on the clutch gear and we get the direct gear. The same dog clutch, however, when it slides to the right makes contact with the second gear and the second gear is obtained. Similarly the movement of the right dog clutch to the left results in low gear and towards right in reverse gear position.

3.2.7 SYNCHROMESH GEAR BOX

This type of gear box is similar to the constant mesh type in that all the gears on the main shaft are in constant mesh with the corresponding gears on the lay shaft. The gears on the lay shaft are fixed to it while those on the main shaft are free to rotate on the same. Its working is also similar to the constant mesh type, but in the former there is one definite improvement over the latter. This is the provision of synchromesh device which avoids the necessity of double declutching. The parts which ultimately



are to be engaged are first brought into frictional contact which equalizes their speed, after which these may be engaged smoothly.

Figure shows the construction and working of a synchromesh gear box. In most of the cars, however the synchromesh devices are not fitted to all the gears as is shown in this figure. They are fitted only on the high gears and on the low and reverse gears ordinary dog clutches are

only provided. This is done to reduce the cost.

In the above figure the engine shaft, gears B, C, D, E are free on the main shaft and are always in mesh with corresponding gears in the lay shaft. Thus all the gears on the main shaft as well as on the lay shaft continue to rotate so long as shaft A is rotating. Members F1 and F2 are free to slide on splines on the main shaft. G1 and G2 are ring shaped members having internal teeth fit onto the external teeth members F1 and F2 respectively. K1 and K2 are dog teeth on B and D respectively and these also fit onto the teeth of G1 and G2. S1 and S2 are the forks. T1 and T2 are the balls supported by springs. These tend to prevent the sliding of members G1 (G2) on F1 (F2). However, when force is applied in G1 (G2) through fork S1 (S2) exceeds a certain value, the balls are overcome and member G1 (G2) slides over F1 (F2). There are usually six of these balls symmetrically placed circumferentially in one synchromesh device. M1, M2, N1, N2, P1, P2, R1, R2 are the frictional surfaces.

The working of the gear box is as follows- For direct gear, member G1 and hence member F1 (through spring-loaded balls) is slid towards left till M1 and M2 rub and friction makes their speed equal. Further pushing the member G1 to left causes it to override the balls and get engaged with dogs K1. Now the drive to the main shaft is direct from B via F1 and the splines. We have to give sufficient time for synchronization of speeds, otherwise clash may be the result.

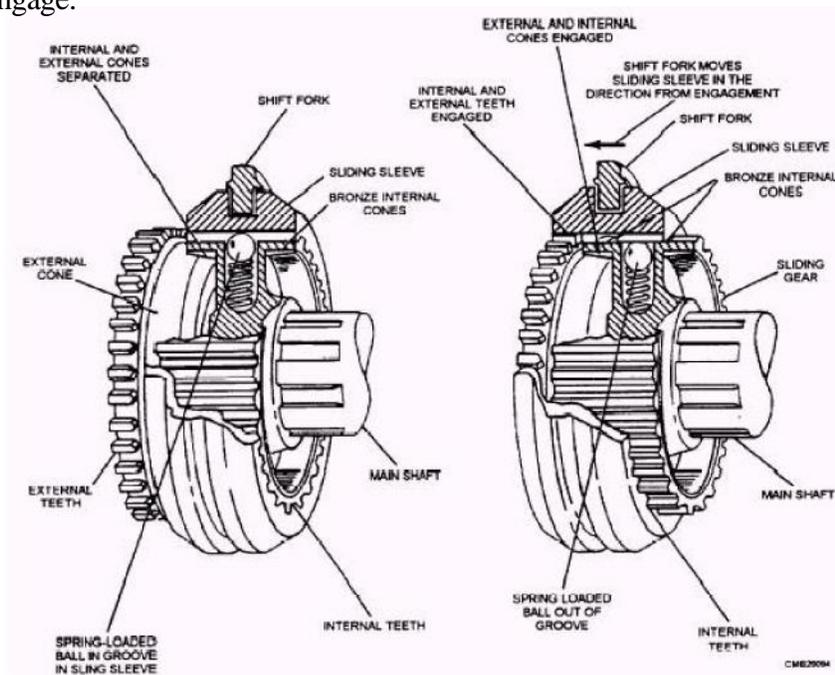
For the second gear the members F1 and G1 are slide to the right so that finally the internal teeth on G1 are engaged with L1. Then the drive to main shaft will be from B via U1, U2, C, F1 and splines. For first gear, G2 and F2 are moved towards

right. In this case the drive will be from B via U1,U3, D, F2 and splines to the main shaft. For reverse, G2 and F2 are slide towards right. In this case the drive will be from B via, U1, U4, U5, D, F2 and splines to the main shaft.

3.2.8 SYNCHRONISING UNIT

The gearbox primarily contains an input shaft and an output shaft. The input shaft is driven by the engine crankshaft through the clutch and the output shaft is coupled indirectly either through the propeller shaft or intermediate gears to the final drive. Pairs of gear wheels of different size are in mesh between these two shafts.

To engage any gear, first the input shaft is disengaged from the engine crankshaft. But the angular momentum of the input shaft, clutch drive plate and gear wheels keeps them revolving. Then the gear changing technique must judge the speeds of the dog teeth of both the gear wheels selected and output shaft. When they rotate at a uniform speed, the dog clutch sleeve is pushed over so that both sets of teeth engage and mesh gently without grating. The synchromesh incorporated in the system applies a friction clutch braking action between the engaging gear and drive hub of the output shaft to unify their speeds before permitting the dog teeth of both members to engage.



Synchromesh devices utilize a multi-plate clutch or a conical clutch to equalize the speeds of the input and the output rotating members of the gearbox during the process

of gear changing. The conical clutch method of synchronization is generally used for producing silent gear change. In this method, the male and female cone members are brought together to produce a synchronizing frictional torque of sufficient magnitudes to automatically adjust speeds of both the input and output members until they revolve as one. Once this speed uniformity is attained, the end thrust applied to the dog clutch sleeve permits to mesh quietly the chamfered dog teeth of both members into alignment.

3.2.9 SELECTOR MECHANISMS

There are many mechanisms used for selecting the desired gear. Broadly speaking these can be divided into two categories, the mechanism where the gear shift lever is mounted on the top of transmission case and the other where the gear shifting lever is mounted on the steering column. However, in these two types most of the mechanism is similar and only the external linkage is different.

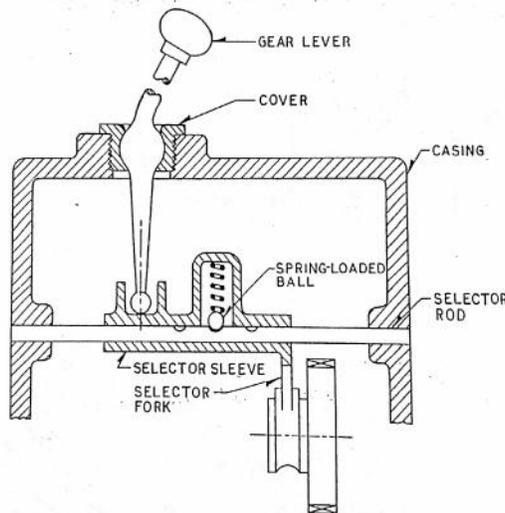


Figure shows a typical selector mechanism for a 4 forward speeds and one reverse gear box. The gear lever is ball mounted in the gear box cover. This facilitates its movement in any direction. The lower end of the gear lever fits into a slot in the selector sleeve. There are forks mounted on the sleeves on three separate selector rods which are supported in the gear box casing. Each selector sleeve

can slide on its rod. When a particular gear is to be engaged the corresponding selector rod is moved in the desired direction. To avoid unwanted engagement of gears, slots are made on the selector rods and the sleeves are provided with spring loaded balls. These balls resist the movements of the forks until some force is applied to the gear lever to overcome their resistance.

3.2.10 GEARBOX LUBRICATION

Lubrication of gearbox is done by applying oil of specification given by the manufacturer (the gear oil is thicker than the engine oil). The oil is filled in the gear box at a level atleast one gear dips in the oil. When the gear rotates the oil will be flashed.

The oil used for gear box lubrication is generally S.A.E 80 or 90. There is not much consumption of oil as such, but leakage may occur. Therefore the oil level in the gear box must be checked periodically. The entire oil in the gear box should be drained and replaced with fresh oil, when the oil becomes contaminated (about 20,000 - 25,000 km).

3.2.11 TRANSFER BOX

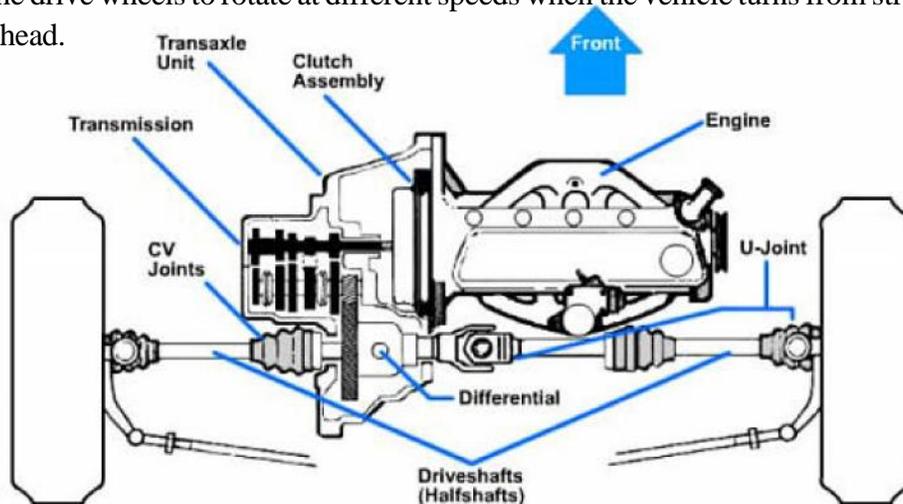
This is also called 'transfer case' and is fixed on the chassis frame behind the transmission (gear box) in four wheel drive vehicles.

It enables the driver to:

- i) Drive in two wheel drive on highways or shift to four wheel drive for cross-country operation
- ii) Drive in high gear or low gear as required

3.2.12 TRANSAXLES

The transaxle is an assembly of gears and shafts. It attached to a front-mounted transverse engine and drives the front wheels. Rear -engine cars use an engine-mounted transaxle to drive the rear wheels. The transaxle includes a final drives and a differential. The final drive is a set of gears that provide the final speed reduction or gear ratio between the transmission and the drive wheels. The differential permits the drive wheels to rotate at different speeds when the vehicle turns from straight ahead.



The operation of any transaxle is exactly the same as that of any transmission. The difference is this, instead of being connected via a long driveshaft to the rear axle, the transmission's output shaft drives a large gear that meshes directly with the

differential's ring gear. And the differential itself is located in the transaxle housing, mounted parallel to the transmission. As power is applied, the differential distributes it to the two front wheels via half shafts.

DETAILING OF PRACTICALS

CONSTANT MESH GEAR BOX

Procedure

- Block the wheels and disconnect the universal joint, speedometer cable, and gear shift lever. Drain out the gear oil.
- Support the engine and the gear box. Loosen the mounting bolts of gear box and take it out.
- Remove the top cover and selector mechanism.
- Remove the bearing cover from the ends of the gear box.
- Remove the clutch shaft by soft hammering on the faces of the first gear with the help of a wooden piece.
- Then slowly pull out the main shaft. Pull out the gears, dog clutch units, bearings, idler units. Inspect all of them for any type of wear or damage. If so replace them and clean out all the parts with diesel.
- The number of teeth of the meshing gears is taken to find out the gear ratios. Refit the counter shaft assembly first inside the gear box.
- Refit the idler gear and selector mechanism. Secondly place the main shaft along with the first gear in its position.
- Slowly insert the dog clutch units and remaining gear in such a position that they are in correct meshing with the corresponding gears on the lay shaft. Then refit the clutch shaft.
- Place the gear box cover along with the selector mechanism correctly on the top of the gear box.
- Place gear box units in its position and the selector lever.
- Reconnect the speedometer cable and universal joint.
- Fill the gearbox with oil with the recommended specification up to the correct level.

SYNCHROMESH

Dismantling and inspection:

- Mount the gearbox on the work stand. Remove the selector assembly
- Lock the main shaft by engaging any two gears by shifting the respective sliding sleeve.

- Remove the driving flange. Remove the gear box rear end cover.
- Remove the speedometer drive gear. Remove the end covers. Remove the clutchshaft. Pull out the main shaft along with the bearing.
- Remove the main shaft gears, dog clutch, sliding sleeve, synchronesh unit, bearings and arrange these in the order of their fitment on the main shaft.
- Remove the reverse idler gear shaft and the idler gear. Remove the lay shaft gear set with washers. Remove the lay shaft bearings.
- Clean all the components. Check visually the following parts for wear/damage replace defective parts: main shaft gears and dog teeth, lay shaft, clutch shaft gear and pilot bearing, reverse idler gear, gear casing and bearing seats, main shaft, splines and pilot bearing seat, bearings of main shaft, counter shaft and clutch shaft, bushes and dog clutches of synchronesh unit.

Assembling procedure:

- Place all seats in the cover. Fit the counter shaft bearing.
- Clamp the counter shaft in its position. Fix the reverse idler along with its shaft and lock it.
- Assemble the gears, bushes, dog clutches, synchronesh units on the main shaft.
- Place the plot bearing on the main shaft.
- Lift the main shaft & place it in the gearbox casing. F it the main shaft rear endbearing inside the casing.
- Fix the bearing on clutch shaft & fit a circlip. Place the clutch shaft in the casing. Place the bearing housing along with the gasket on gear casing.
- Place the speedometer drive gear on the main shaft. Fit all the bearing covers along with the gasket.
- Place the drive flange on main shaft. Keep the main shaft in neutral position. Keep all the forks in neutral position.
- Mount the selector assembly on gearbox.
- Engage each gear and check the rotation by hand. Fill the recommended gear oil to the specified level.

ASSESSMENT ACTIVITY

1. Divide the students into 4 groups and assign each group as follows:

First group	-	Constant mesh gear box
Second group	-	Synchronesh gear box
Third group	-	Synchronizing unit
Fourth group	-	Selector mechanism

Let each group prepare a chart showing the construction of components and explain its working. If possible, let them use multimedia facility. Teacher can evaluate the students using different parameters like:

- Chart preparation
 - Knowledge level
 - Communicative skill
 - Content transaction
2. Assignment on Transaxle
 3. Class test

TE QUESTIONS

Fill in the blanks

1. The process of actuating the clutch pedal twice while shifting the gear in a constant mesh gear box is called (1)

Choose the correct answer

2. Transfer case is used with vehicle (Front axle drive, rear axle drive, 4 wheel drive) (1)
3. List various resistances which affect the vehicle motion. (3)
4. The gears on sliding mesh gear are straight spur gear and gears on constant mesh gearbox are spiral bevel. Why? (2)
5. Nowadays synchromesh gearboxes are fitted with all manual transmission vehicles due to its easiness of actuation. Identify the parts which enable the gear engagement operation easily. Draw a simple figure of it and explain its working. (1+5)

3.3 AUTOMATIC TRANSMISSION

INTRODUCTION

This is the new trend in transmission system in Indian automobile vehicles. Most of the new vehicles use automatic transmission. This unit provides students with the functions and concepts of semi-automatic and fully automatic transmissions. It deals with the construction and working of epicyclic gear box, freewheel unit, fluid flywheel and torque converter. It also describes the concept of Automated Manual Transmission (AMT) and modern shift control techniques.

LEARNING OUTCOMES

The learner ;

- differentiates semi- automatic and fully automatic transmission system
- explains the construction and working of epicyclic gearbox
- explains the concept and working of free wheel unit
- explains the working of fluid flywheel
- explains the construction and working of torque converter
- explains the working of overdrives
- explains the principle and working of CVT
- explains the concept of AMT and its type.
 - Single - Sided Clutch Transmission(SSCT)
 - Double - Sided Clutch Transmission(DSCT)
 - Dual Clutch Transmission(DCT)
- explains the concept of modern shift control techniques
 - Select Shift Manual(SSM) mode
 - Auto Shift Manual (ASM) mode

UNIT IN DETAIL

3.3.1 AUTOMATIC TRANSMISSION

Automatic transmission can be semi-automatic or fully automatic. In the first type, only the clutch is operated automatically, but the driver still has to change the gears manually.

A semi-automatic transmission (SAT) also known as a clutch less manual transmission or automated manual transmissions is an automobile transmission that does not change gears automatically, but rather facilitates manual gear changes by dispensing with the need to press a clutch pedal at the time of changing gears. It uses electronic sensors, pneumatics, processors and actuators to execute gear shifts on input from the driver or by a computer. This removes the need for a clutch pedal which the driver otherwise needs to depress before making a gear change.

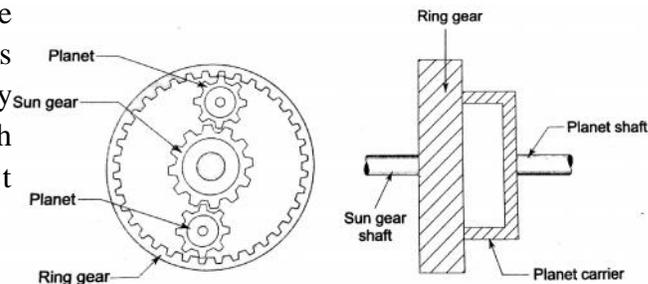
A fully automatic transmission is also called auto, self-shifting transmission and can automatically change gear ratios as the vehicle moves, freeing the driver from having to shift gears manually. Like other transmission systems on vehicles, it allows an internal combustion engine, best suited to run at a relatively high rotational speed, to provide a range of speed and torque outputs necessary for vehicular travel. The number of forward gear ratios is often expressed in a similar way as for manual transmissions (e.g., 4-speed, 6-speed).

The most popular form found in automobiles is the hydraulic automatic transmission. This system uses a fluid coupling in place of a friction clutch, and accomplishes gear changes by hydraulically locking and unlocking a system of planetary gears. These systems have a defined set of gear ranges, often with a parking pawl that locks the output shaft of the transmission to keep the vehicle from rolling either forward or backward.

3.3.2 EPICYCLIC GEAR BOX

An epicyclic gear box consists of two, three or even four epicyclic or planetary gear sets. The figure shows a simple epicyclic gear box. It has a sun gear, about which the planets turn round. These planet gears are carried by a planet carrier and a shaft and are also in mesh internal with a ring gear, which is also called annulus or internal gear.

Different torque ratios i.e. speed ratios are obtained by making any one of the parts, viz. the sun gear, the planets and the annulus stationary. Similarly by locking any two parts with each other gives direct drive.



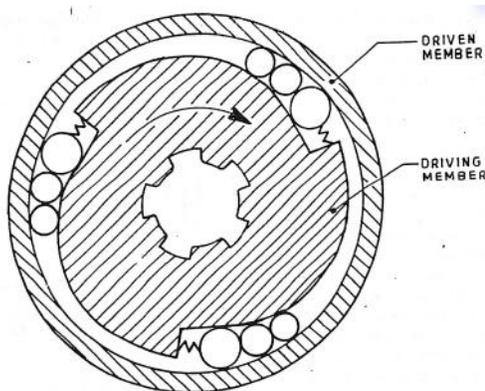
A simple epicyclic gear set can give six possible gear ratios which are summarized below:

	Forward Fast	Forward very fast	Forward slow	Forward very slow	Reverse slow	Reverse fast
Driving	P	P	R	S	S	R
Driven	R	S	P	P	R	S
Stationary	S	R	S	R	P	P

However in practice, all speed conditions given above cannot be employed because of the complexity of construction to incorporate all possibilities and also the unsuitable values of some of these ratios. So in actual epicyclic gear box combination more than one epicyclic gear sets are used. There are two controls i.e. brake bands and the clutch. The brake band surrounds a drum attached to the gear or the outer surface of the gear itself. Multi-plate clutch is used. Both brake and clutch are applied by fluid pressure. These are selected by hydraulic shift valves and is controlled by ECM

3.3.3 FREE WHEEL UNIT

It is similar in action of a bicycle free wheel. The inner driving member is connected to the gearbox shaft and outer one to the propeller shaft. The driving member has three steps. In each step there are three spring loaded rollers of different sizes.

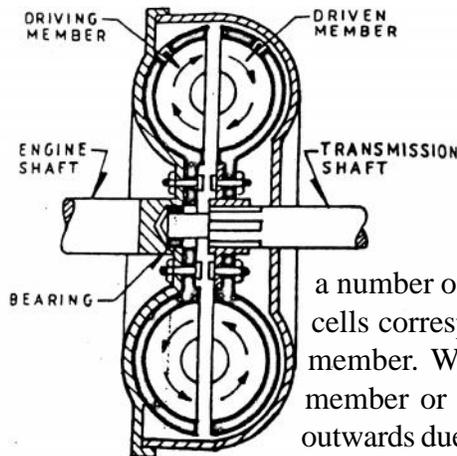


When the driving member is rotating in the direction as shown in the figure, the driven member will also be rotating in the same direction. But when the driven member becomes the driving member, the inner member will not rotate along with the outer one. Thus in this case the transmission and engine will be isolated from the wheels. This results in fuel economy.

In some instances, freewheel has to be locked, e.g. in the reverse drive. In such cases the provision of locking freewheels drive is there. Freewheel is also used as an essential component of torque converter in automotive transmission.

3.3.4 FLUID FLYWHEEL

An automotive fluid coupling consists of a split housing which is rotated by the engine crankshaft. Inside the housing is a driven member called the runner and the driven member is connected by a shaft to the gear box. The driving member is mounted on the crankshaft and it is called impeller.



The driving (input) and driven (output) members are very close with their ends facing each other and enclosed in housing, so that they can be turned without touching each other. The liquid or oil is filled in the housing.

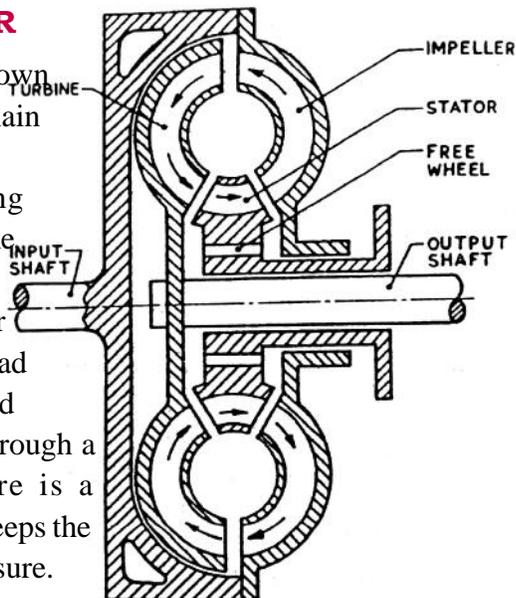
The fly wheel housing is divided into a number of cells by means of radial vanes. These cells correspond to similar openings in the driven member. When the crankshaft turns, the driving member or impeller also rotates. The fluid flows outwards due to centrifugal force and circulates from the flywheel to the driven member. The fluid tends to rotate the driven member because the fluid is also carried out round by the driving member. Thus the torque is transmitted from the crankshaft to the gear box shaft.

Liquid coupling is not suited for use with an ordinary gear box. It is generally used in conjunction with epicyclical gears to provide a semi or fully automatic gear box.

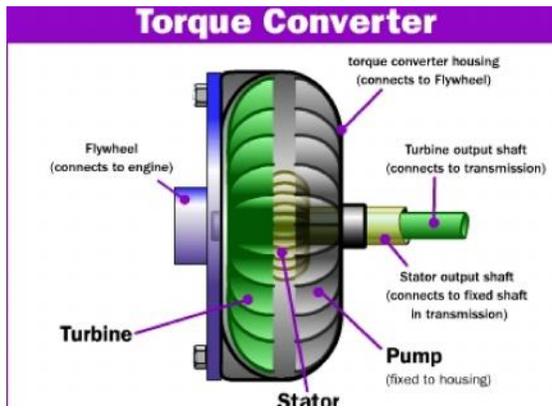
3.3.5 TORQUE CONVERTER

A single stage torque converter is shown in the figure. It consists of three main parts, viz.

- (i) the impeller (pump) or driving member which is connected to the engine,
- (ii) the turbine or driven member which is connected to the road wheels through transmission and
- (iii) the stator fixed to the frame through a freewheel. In addition there is a transmission oil pump which keeps the converter full of oil under pressure.



As soon as the flywheel of engine starts rotating, the torque converter housing as well as the pump also starts rotating in the same speed and direction. Because of the profile of the pump blades, the fluids inside the torque converter are pushed out centrifugally. As pressure is built up by the pump, the fluids are forced into the blades of the turbine and this makes it rotate in the same direction as the pump. The fluids enter the outer periphery of the turbine and leave from the inner periphery and reaches to the stator blades there. The function of the stator is to guide the incoming fluid from the turbine to reach at a specific angle to the pump.



If the turbine is rotating at a speed lower than that of the pump (i.e., when the vehicle is accelerating) then the fluids from the turbine hits the front sides of the stator blades and the one way clutch prevents it from rotating. In this condition the fluids leaving the stator hits the pump at a "helping" angle to increase the torque (or multiply

the torque) and thus increase the speed of the turbine.

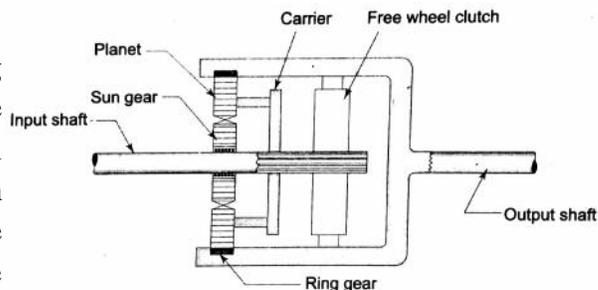
When the vehicle achieves its constant speed, then the angle at which the fluids leave the stator change and no more torque multiplications happens.

While retarding, the speed of the turbine increases than that of the pump and the fluid from the turbine hits the back sides of the stator blades and make the stator rotate at the same direction as the pump and turbine and the fluid from the stator hits the pump in such angles that the torque reduces.

3.3.6 OVERDRIVES

Overdrive is a device to step up the gear ratio in the car. Overdrive is generally fitted on the top gears only.

To understand the working of an overdrive consider the figure. It consists of an epicyclic gear train in which the sun gear is free to rotate on the input shaft, while the

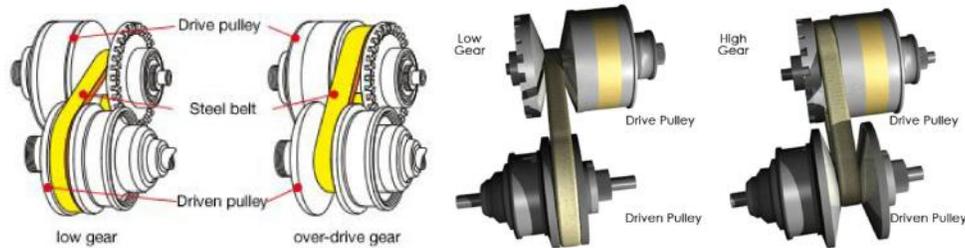


carrier can move on the splines on the input shaft. A free wheel clutch is also fitted on the input shaft splines. The output shaft is connected to the ring.

When the sun gear is locked with casing, it becomes stationary. The speed of the output shaft is increased and overdrive is engaged. When, however the sun gear is locked to the carrier or to the ring, solid drive through the gear train is obtained.

3.3.7 CONTINUOUSLY VARIABLE TRANSMISSION (CVT)

CVT is an automatic transmission that selects any desired drive ratio within its operating range.



The CVT replaces the gears with two variable-diameter pulleys, each shaped like a pair of opposing cones, with a metal belt or chain running between them. One pulley is connected to the engine (input shaft) and the other to the drive wheels (output shaft). The halves of each pulley are movable; as the pulley halves come closer together the belt is forced to ride higher on the pulley, effectively making the pulley's diameter larger.

Changing the diameter of the pulleys varies the transmission's ratio (the number of times the output shaft spins for each revolution of the engine), in the same way as a 10-speed bike routes the chain over larger or smaller gears to change the ratio. Making the input pulley smaller and the output pulley larger gives a low ratio (a large number of engine revolutions producing a small number of output revolutions) for better low-speed acceleration. As the car accelerates, the pulleys vary their diameter to lower the engine speed as the car speed rises. This is the same thing a conventional transmission does, but instead of changing the ratio in stages by shifting gears, the CVT continuously varies the ratio and thus it acquires its name.

3.3.8 AUTOMATED MANUAL TRANSMISSION (AMT)

These are basically the manual transmission operated automatically, hydraulically or electronically. They do not require clutch actuation and gear shifting manually by the driver. Thus there is no clutch pedal and no mechanical



connection between the transmission and the selector lever. The transmission is controlled electronically through shift-by-wire.

In this system Vehicle Speed Sensors (VSS) are used to give input to the ECU for gear shifting. Here electronic shifting is achieved by a stepper motor as the ECU gives signal to the motor

after analyzing the input from VSS. AMT's are operated depending upon the vehicle speed only and not according to load. The main advantage of AMT system is its cost effectiveness.

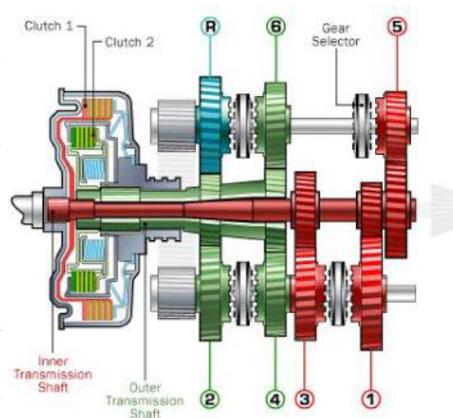
The AMT system is of three types:

1. Single sided clutch transmission(SSCT)

This type incorporates actuators with an existing manual transmission, for operating the clutch and shifting the gears, it is the cheapest method of all the AMT types.

2. Double sided clutch transmission(DSCT)

In this type, the double sided clutch allows power from the engine to be transferred between either of the two power paths in the transmission itself. Due to this the total clutch travel time is drastically reduced, consequently improving the shift quality.



3. Dual Clutch Transmission (DCT/DSG)

The heart of the Dual Clutch Transmission (DCT) is the combined dual clutch system. The DSG acronym is originally derived from the German word - "Doppel Schalt Getriebe" but it also has an English alternative of "Direct Shift Gearbox". The reason for such a naming is because two transmission systems are integrated into one. Transmission one includes the odd gears (first, third, fifth and reverse), while transmission two contains the even gears (second, fourth and sixth). The combined dual clutch system switches from one to the other very quickly, releasing an odd gear and at the same time engaging a preselected even gear

and vice versa. Using this arrangement, gears can be changed without interrupting the traction from the engine to the driven wheels. This allows dynamic acceleration and extremely fast gear shifting times that are below human perception.

3.3.9 MODERN SHIFT CONTROL TECHNIQUES

Select Shift Manual (SSM) & Auto Shift Manual (ASM) Modes

SSM mode allows a driver to control gear changes as per his personal preference as in a conventional manual transmission, whereas ASM mode provides automatic gear shifting as in an automatic transmission.

Both SSM and ASM use a combination of auto clutch and shift by wire electronic control technology. Both of these modes make use of an electro-hydraulic or electro-mechanical actuation system controlled by a separate transmission control module. The request of the driver for a particular gear shift is transmitted by a sensor to the controller which sends a command to the actuators to open or close the clutch and disengage or engage the gear with very fast responses.

DETAILING OF PRACTICALS

1. Automatic transmission and transaxle fluid check

Fluid level

- Drive the vehicle for 15 minutes or until the vehicle is at normal operating temperature
- Park the vehicle on level ground and apply the parking brake
- Let the engine be idle.
- Place the transmission selector lever in PARK/ NEUTRAL position.
- Clean any dirt from around the dip stick cap.
- Pull out the dip stick, wipe it, reinsert it, and pull it out again and note the fluid level.
- If the level is low add sufficient amount of specified fluid to bring the level within the marks.
- Do not overfill the Automatic Transmission Fluid(ATF).

Fluid colour

ATF is normally RED in colour.

PINK FLUID- indicates that the fluid cooler in the radiator is leaking.

- Repair or replace fluid cooler
- Remove and overhaul transmission or transaxle.
- Replace the seals, bands, clutch plates, washers, speedometer gears and governor gears.
- Flush the cooler lines and flush or replace the torque converter.

BROWN FLUID- ATF may turn dark in normal use. However, contaminated fluid may also have a brown colour. If contaminated;

- drain the fluid
- remove and inspect the pan.
- replace the filter.
- refill new fluid.

Fluid condition

- Check colour, odour
- A quick check of fluid condition can be made by placing one or two drops of fluid from the end of the dipstick on a paper towel. As the towel absorbs the fluid, examine the stain for specks or particles. This indicates solid material in the fluid.

ASSESSMENT ACTIVITY

1. Conduct a field visit to a reputed workshop

Divide the students into small groups. Ask the students to prepare a detailed report about the function, construction, working and advantages of work assigned to them.

The following are the list of works to be given:

- Torque convertor
- Epicyclic gear box
- Over drive
- Free wheel unit
- CVT
- AMT

Teacher can evaluate the student on the basis of the following indicators:

- Content depth
 - Completion and neatness
 - Knowledge level
 - Viva voce
2. Class test

TE QUESTIONS

1. Expand the term following :
 - a) DSCT (1)
 - b) CVT (1)
2. Some cars can be driven both manually and automatically using a synchromesh gear box. Identify the mechanism which enables the car to drive in both the modes. Explain its working. (4)

3.4 DRIVE LINE

INTRODUCTION

This unit explains how power flows from the gearbox to the road wheels. The unit describes the necessity, function, construction and working of universal joint and slip joint. It also deals with the construction and working of differential, types of crown wheel and bevel pinion, rear axle casing, rear axle drives and rear axle shaft supporting methods. The students will be able to dismantle, assemble and diagnose the troubles in the drive line.

LEARNING OUTCOMES

The learner:

- defines drive line
- explains the construction and working of propeller shaft
- explains the necessity, construction and working of universal joints
 - Variable velocity joint(hook's joint, flexible ring universal joint)
 - Constant velocity joint (rzeppa joint)
- explains the function of final drive
- differentiates various crown wheels and pinion drive gearing
 - Straight bevel gear
 - Spiral bevel gear
 - Hypoid gears
- explains the necessity, construction and working of differential
- explains the necessity of limited slip differential
- classifies rear axle casing
 - Split type
 - Banjo or separate carrier type
 - Salisbury or Integral carrier type
- explains the construction and working of rear axle drives
 - Hotchkiss drive
 - Torque tube drives

- explains the construction and working of rear axle shaft supporting
 - Semi - floating axle
 - Full floating axle
 - Three quarter floating axle

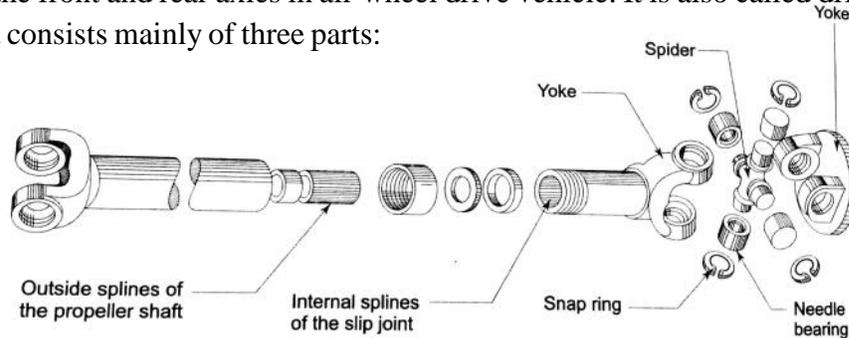
UNIT IN DETAIL

3.4.1 DEFINITION

A motor vehicle's driveline or drivetrain consists of the parts of the power train excluding the engine and transmission. It is the group of parts connecting the transmission with the driving wheels. It consists of drive shaft (also called propeller shaft), universal joints, slip joint, final drive, differential and the half shafts.

3.4.2 PROPELLER SHAFT

This is the shaft which transmits the drive from the transmission to the bevel pinion or Worm of drive in front engine, rear drive vehicles and from the transfer box to the front and rear axles in all-wheel drive vehicle. It is also called drive shaft. It consists mainly of three parts:



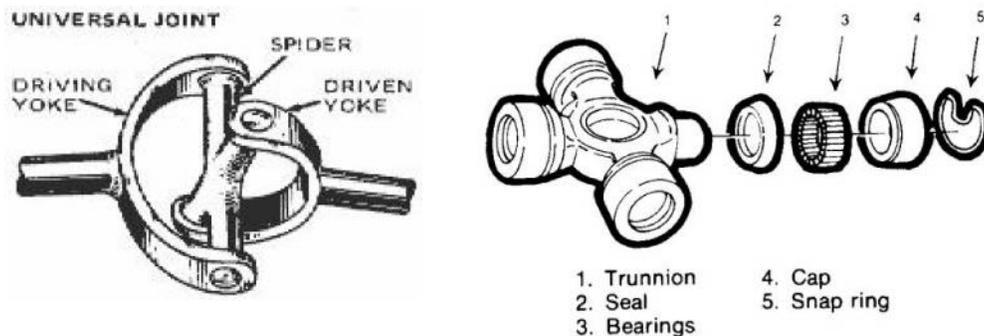
- (a) Shaft - As this has to withstand mainly torsional loads, it is usually made of tubular cross-section it also has to be well balanced to avoid whirling at high speeds. Shafts are made of steel, aluminium or composite materials.
- (b) One or two universal joints - Depends upon the type of rear axle drive used. The universal joint account for the up and down movements of the rear axle when the vehicle is running. Modern vehicles use, however, high-speed constant velocity joints, rubber couplings.
- (c) Slip joint - Depending upon the type of drive, one slip joint may be there in shaft. This serves to adjust the length of the propeller shaft when demanded by the rear axle movements. Fig. 6.1 shows a propeller shaft, with two universal joints at the ends and a slip or sliding joint. Slip joint

is formed by the internal splines on the sleeve attached to the left universal joint and external splines on the propeller shaft.

In some designs, slip arrangement is slightly different. In these a universal joint and splined slip yoke are located at the transmission end of the shaft where these are held in alignment by a bushing in the transmission rear extension. This spline is lubricated internally by transmission lubrication or grease. Sometimes a rubber element is incorporated in-between the two sliding tubes to make the relative movement smooth and noiseless.

3.4.3 UNIVERSAL JOINT

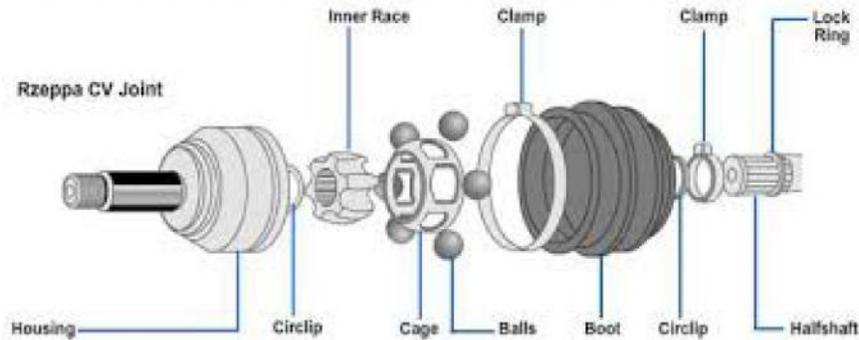
3.4.3.1 Hooke's Joint



A universal joint is a particular type of connection between two shafts, whose axes are inclined to each other. The simplest type of universal joint is the Hooke's joint which is most widely used as it is simple and compact in construction and reasonably efficient at small angles of up and down propeller shaft movement, say up to 180. The axes of shafts A and B are intersecting. Each of these shafts contains a yoke. The cross C has four arms. The two opposite arms of the cross are supported in bushes in the yoke of shaft A, while the other two arms of the cross are supported in the yoke of shaft B. Thus shaft A can have angular rotation about axis XX and the shaft B, about the axis YY. It is thus seen that it will be possible with the Hooke's joint for the shafts A and B to have positive drive while allowing angular movement between them. An improved form of the Hooke's joint uses needle roller bearing to support the cross in the yoke and this results in the increase of joint efficiency.

3.4.3.2 Rzeppa Joint (Constant Velocity joint)

The first real constant velocity joint, still in use, is the Rzeppa joint. In this six spherical - balls are held in a precise geometric position midway between the two shafts, bisecting the angle between them.



As shown in the figure, the joint consists of an outer race, inner race, cage and six balls. The joint can also slide in the axial direction on account of the balls sliding in the axial grooves of the outer race. Thus the drive shafts can accommodate the changes in their lengths.

3.4.4 FINAL DRIVE

The functions of the final drive are to provide a permanent speed reduction and also to turn the drive round through 90° . The reduction provided is about 4:1 in cars and 10:1 in heavier vehicles. This is done either in one or two stages. For lesser reduction, say up to about 7:1 single reduction is used, while higher reductions are achieved in two steps.

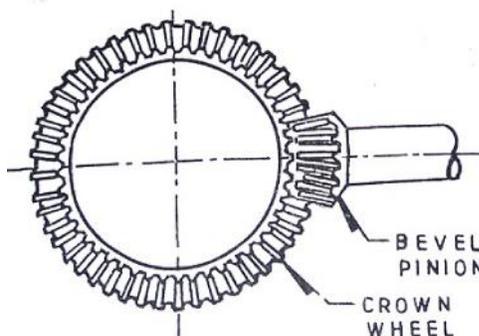
The final drive in practice consists of a bevel pinion and a crown wheel or alternatively, worm and wheel arrangement. The bevel pinion is mounted on a shaft which is connected to the propeller shaft generally through a universal joint. From the crown wheel the drive goes to the differential. Three types of gears are used for the final drive gearing.

1. Straight Bevel Gears
2. Spiral bevel gears
3. Hypoid gears

3.4.5 FINAL DRIVE GEARING

3.4.5.1 Straight Bevel Gears

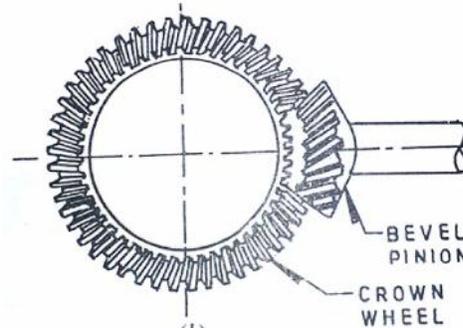
These contain the straight teeth. They are the simplest and the cheapest of all types. However, with straight bevel gears, at one instant only one pair of teeth of pinion and the crown wheel will be



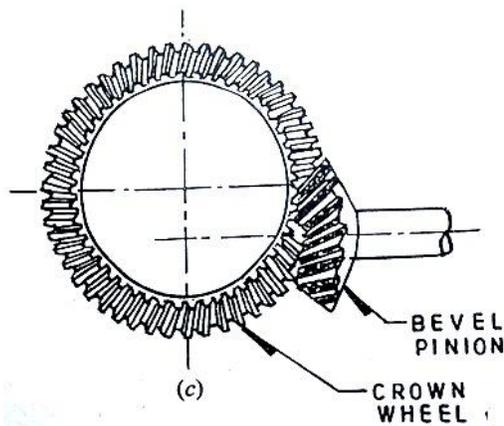
in contact. As a result an uneven transmission of motion will take place as the load is transferred from one pair of teeth to the next. Thus these gears are noisy and suffer from high wear.

3.4.5.2 Spiral Bevel Gears

The spiral bevel gears have curved teeth which result in greater contact of the teeth. Because of this spiral bevel gears are silent in running and stronger than the straight bevel gears.



3.4.5.3 Hypoid Gears

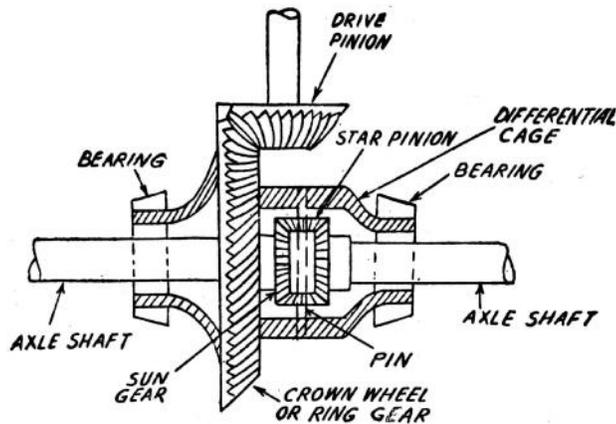


These types of gears are widely used for final drive these days. In this the pinion shaft is placed below the axis of the crown wheel. This permits a lower position of the propeller shaft, thus allowing low chassis height. The name 'hypoid' is derived from the 'hyperboloid of revolution'. The basic surface on which the teeth are cut in their case, is hyperboloid, which is a solid obtained by rotating a hyperbola about an offset axis.

3.4.6 DIFFERENTIAL

When the car is taking a turn, the outer wheel will have to travel greater distance as compared to the inner wheels. If the car has a solid rear axle only, there will be tendency for the wheels to skid. Hence if skidding of the wheel is to be avoided, some mechanism must be incorporated in the rear axle, which would reduce the speed of the inner wheels and increase the speed of the outer wheels while taking turns. It should at the same time keep the speeds of all the wheels the same when going straight ahead. Such a device which serves the above functions is called a differential.

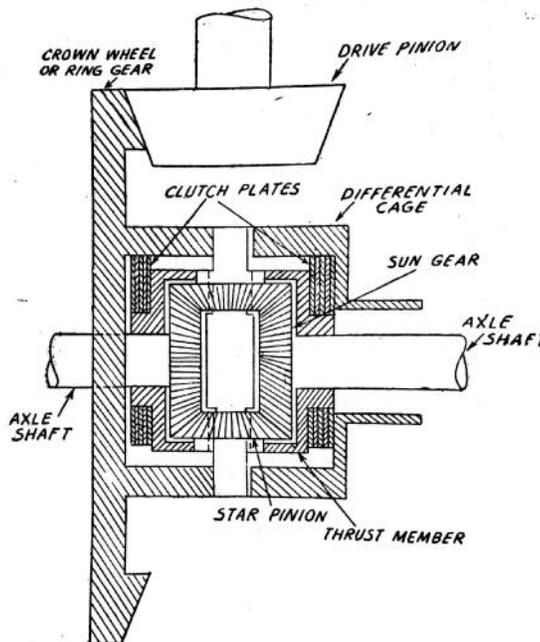
The crown wheel of the final drive is attached on a cage which carries a 'cross-pin'. Two sun gears mesh with the two planet pinions. Axle half-shafts are splined to each of these sun gears. The crown wheel is free to rotate on the half-shaft as shown.



When the vehicle is going straight the cage and the inner gears rotate as a single unit and the two half shafts revolve at the same speed. In this situation, there is no relative movement among the various differential gears. To understand what happens when the vehicle is taking a turn, assume that the cage is stationary. Then turning one sun gear will cause the other to rotate in the opposite direction. That means if left sun gear rotates 'n' times in a particular time, the right sun gear will also rotate n times in the same period but, of course, in the opposite direction. This rotation is super-imposed on the normal wheel speed when the vehicle is taking a turn. Thus the outer wheel rotates at higher speed than the inner wheel while taking a turn.

3.4.7 LIMITED SLIP DIFFERENTIAL

The torque from the final drive is also divided between the two half-shafts. As the planet pinions are free to rotate on the cross-pin or the spider arm, they cannot



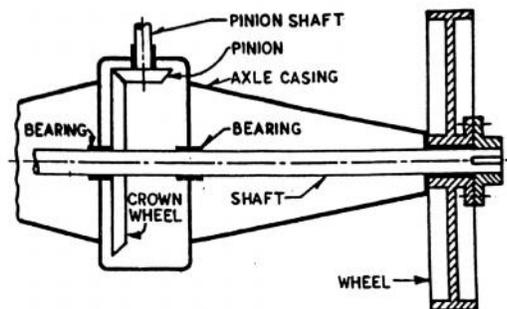
apply different torque to the teeth on one side from the one on the other side. Therefore, they act as a balance and divide the torque equally between the two wheels on the axle, even when their speeds are different.

Due to this reason if one wheel is on a slippery surface where it can simply skid and any torque that is transmitted to it will simply rotate it idly, no tractive force can be obtained from the other wheel. In this situation the slipping wheel will spin at twice the crown wheel speed, while the opposite wheel

will remain stationary. This equality of torques is true only if there is no friction present anywhere in the differential system. However, because this is not possible in practice, some inequality of torques is always there. The larger the amount of friction present in the differential, the larger is the inequality of torques and hence if one wheel of the vehicle with friction in the differential gets on to a slippery surface e.g., ice, mud or if the wheel gets lifted off the ground while turning at high speeds as in racing cars, for example, then a larger torque may be transmitted to the other wheel, which has a good grip on the road, than to the slipping wheel. Thus the grip of that wheel is utilized. This would not be possible in the absence of friction. It is for this reason that sometimes friction is introduced in differentials intentionally by employing clutch friction plates between the sun gears and the cage. These plates are loaded by means of dished springs, which are so mounted that loading increases or decreases directly as the torque is varied. The frictional resistance thus provided is such that it does not stop the normal differential action. Such a differential is called "non-slip or limited slip differential".

It may be further observed that non-slip or limited slip differentials are employed ordinarily, on rear-wheel drive vehicles, since the front of the front-wheel drive vehicles have to be steered also. If a non-slip differential is used in a front-wheel drive vehicle, it could cause the vehicle to suddenly pull toward the slipping wheel and may thus cause steering problems. This has been taken care of by means of electronic control.

3.2.8 REAR AXLE CASING



The figure shows a simplified view of the live rear axle of a front engine, rear driven automobile. The differential is not shown purposely, so as to make the general arrangement more clear. The drive from the propeller shaft comes to the pinion shaft which is supported in bearings in the axle casing. The

crown wheel is in mesh with the pinion and is mounted on shaft on the ends of which are fixed the caps which serve to restrict the wheels in axial direction. The wheels are mounted on bearings on the ends of the axle shaft. In practice, however, there are two half shafts instead of single one shown here. The weight of the body and load due to occupants is transmitted through springs to the axle casing.

The casings used for rear axles are of two types:

1. Split Type

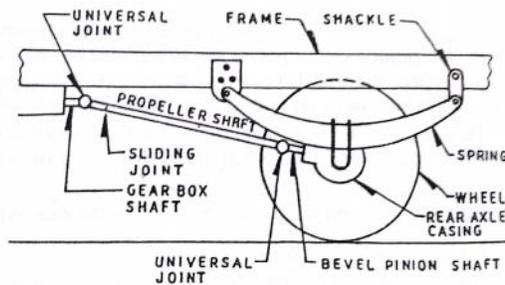
In this type the axle casing is made in two halves and then bolted together for assembly. This type has a major disadvantage that in case of any fault, the whole of the rear axle has to be removed as a unit and then disassembled. This type is obsolete now.

2. Banjo or Separate Carrier Type

This type of axle of one-piece type is shaped like a banjo. The complete differential unit is carried in a separate carrier which is bolted to the axle casing. The two half shafts are put from sides. Therefore in case of any need for repairs, the half shafts can be taken out directly from the sides and the differential assembly is removed by opening bolts only.

3.4.9 REAR AXLE DRIVES

1. Hotchkiss Drive

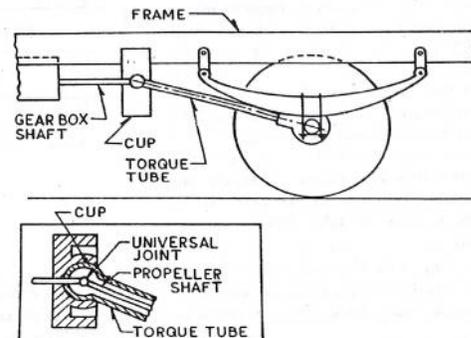


This is the simplest and most widely used type of rear axle drive. In this case the springs besides taking weight of the body, also take the torque reaction, driving thrust and the side thrust. The figure alongside shows such a drive. The propeller shaft is provided with two universal

joints and also a sliding joint. The spring is fixed rigidly in the middle to the rear axle. The front end of the spring is fixed rigidly on the frame, while the rear end is supported in a shackle. The driving thrust is transmitted to the frame by the front half of the springs. It uses two universal joints and one slip joint.

2. Torque tube drive

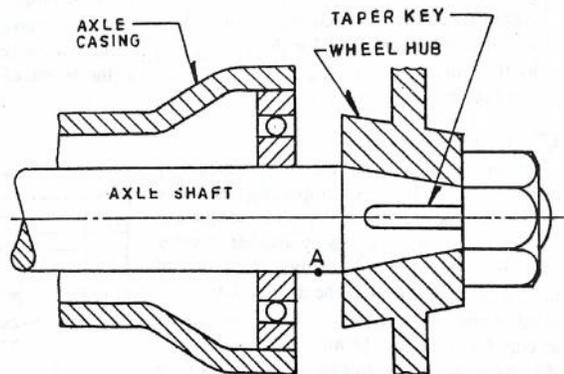
In this type of drive, the spring takes only the side thrust besides supporting the body weight. The torque reaction, braking torque and the driving thrust are taken by another member which is called the torque tube. One end of torque tube is attached to the axle casing, while the other end



which is spherical in shape fits in the cup fixed to the frame as shown in figure. The torque tube encloses the propeller shaft. Since in this case the torque tube takes the torque reaction, the centre line of the bevel pinion shaft will not shift and further it will always pass through the centre of the spherical cup if the propeller shaft is connected to the gear box shaft by means of a universal joint situated exactly at the centre of the spherical cup. In such a situation, no universal joint is needed at the rear end of the propeller shaft. Moreover, no sliding joint is provided because both the pinion shaft and the propeller shaft in this case will move about the same centre of the spherical cup. Clearly torque reaction and the driving thrust are taken by the torque tube.

3.4.10 REAR AXLE SHAFT SUPPORTING

3.4.10.1 SEMI-FLOATING AXLE



The figure shows a semi floating axle. The wheel hub is directly connected to the axle shaft or is an extension of the same. The inner end of the axle shaft is splined and is supported by the final drive unit, whereas the outer end is supported by a single bearing inside the axle casing. In this

case axle shaft supposed to take the vehicle weight, driving torque, braking torque and end thrust. The loads listed above are taken by the axle shaft. The vehicle load is transmitted to each of the half shafts through the casing and the bearing. This causes a bending load and a tendency to shear. Besides, the side forces also cause end thrust and bending moment in the axle shafts, which have to take the driving torque also. The semi-floating axle is the simplest and cheapest of all types, and hence is widely used on cars.

2.4.10.2 FULL-FLOATING AXLE

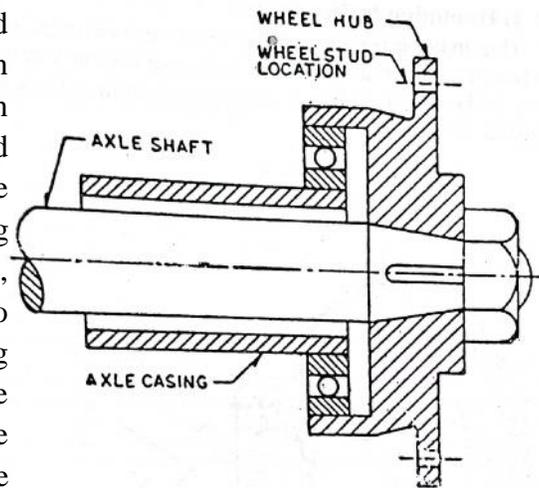
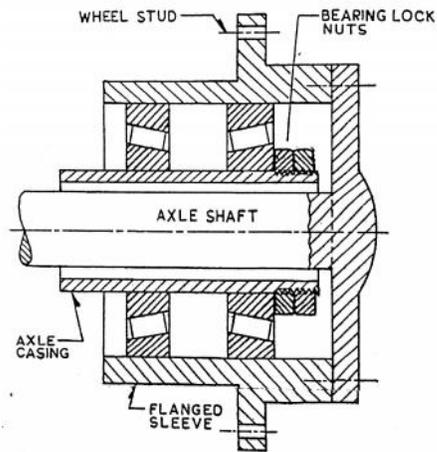
This type is a very robust one and is used in heavy vehicles. As is seen in figure, the axle shafts have flanges at the outer ends, which are connected to the flanged sleeve by means of bolts. There are two taper roller bearings supporting the axle casing in the hub, which take up any side load. Thus in this the axle shafts carry only the driving torque.

The weight of the vehicle and the end thrust are not carried by them, the weight being completely supported by the wheels and the axle casing. As the axle shafts carry only the driving torque, their failure or removal does not affect the wheels. Thus the axle shafts can be taken out or replaced without jacking up the vehicle. For the same reason the vehicle can be towed even with a broken half-shaft. However, it is the costliest type.

2.4.10.3 THREE QUARTER FLOATING AXLE

This is a compromise between the more robust full floating type and the simplest semi-floating type. In this the bearing is located between the axle casing and the hub instead of between the axle casing and the shaft as in the case of semi-floating axle. As is clear from the figure, the axle shafts do not have to withstand any shearing or bending actions due to the weight of the vehicle, which are taken up by the axle casing through the hub and the bearing, provided the bearing lies in the plane of the road wheel. However, it has to take the end loads and the driving torque.

At one time this type of axle was popular in cars and light commercial vehicles. However with improvements in design, materials and fabrication techniques, cheaper and simple semi-floating axles are being preferred these days over the three-quarter floating types.



DETAILING OF PRACTICALS

PROPELLER SHAFT & UNIVERSAL JOINT

Procedure

- Before removing the shaft, it is necessary to mark the end flanges so that they can be refitted in the same position.
- Disconnect the joints at the both ends and remove the shaft.
- Remove the dust cover on the sliding joint and separate the two parts.
- Before dismantling the universal joint make match marks on the yoke and propeller shaft. Clamp the universal joint assembly in a bench vice using soft jaws and remove the circlips.
- Then with soft drift, gently tap from above so that needle bearing on the lower side falls out.
- Reverse the joint and drive out the bearing. Likewise drive out the bearings from the other ends also.
- Remove all lubricating nipples from the joints
- Wash all the parts in paraffin. Inspect the bearing, journal trunnions and the splines of sliding joint for wear. If there is sign of wear or excessive looseness found replace the different parts.
- Grease the various rollers and assemble the needle bearings. Replace the gaskets and fit the journal and bearing trunnions to the yokes. Install the circlips. Screw the dust cover and slide in the slip joint. Lubricate the various joints with specified lubricant. Place the reassembled propeller shaft in position in the chassis, insert the bolts in the flanges and tighten them.

DIFFERENTIAL

Procedure

- Jack up the vehicle & place axle stand under axle tube on both sides.
- Remove rear axle half shafts and drain oil in tray.
- Remove end cover, remove bolts connecting propeller shall flange and pinion flange.
- Keep the propeller shaft away & remove the nuts of differential housing and take out.

- Clean the differential housing with wire brush.

Dismantling the differential assembly

- Remove cap tightening bolt, remove locking bolt, and pull out the locking clip.
- Remove cap screw adjusting nut on both sides & lift the crown wheel assembly out of the housing.
- Fasten locking plate and remove bolts to remove crown wheel, and cage. Dismantle sun gear, planetary gears, spacers and thrust washers.
- Clean all the components with kerosene.

Inspection

- Inspect each tooth for any pitting or broken tip on crown wheel, pinion, sun gear and planetary pinion. Measure the teeth on crown and pinion to find out the differential reduction.

Reassemble all the parts in the reverse order.

- Fix back differential assembly in axle housing with new gasket & tighten all nuts.
- Fix up inspection cover with new gasket and fill SAE EP 90 oil in differential assembly up to the specified oil level.
- Fix up half axle shaft and tighten its bolts & remove the iron horses.
- Connect propeller shaft & tighten its bolts fully.

Assessment Activity

1. Assignment on the construction and working of differential
2. Seminar on Limited Slip Differential
3. Seminar on Rear Axle Shaft supporting
4. Class test

TE QUESTIONS

Fill in the blank suitably:

1. Variable velocity joint can transmit the motion maximum of degree.
(1)
2. During a class room discussion Mr.Firos argued that there is no need of a universal joint and slip joint for the transmission of power from engine to drive wheels. Do you agree with his argument? Justify your opinion. (4)
3. Identify the type of axle in which all the loads of rear portion of the vehicle is carried by the axle tube only. Also mention the other advantages of this type of rear axle. (3)
4. State the functions of a differential unit. (2)
5. Write short notes on
 - a) Limited Slip differential
 - b) Hypoid Gears (4)

EXTENDED ACTIVITIES

- Field Visit
- OJT
- Survey
- Camp
- Vocational expo
- Production cum training centre (PTC)

LIST OF PRACTICALS

MODULE 3: AUTOMOTIVE TRANSMISSION SYSTEMS

3.1 CLUTCH

1. Study the various complaints that may be produced on clutches, give their causes and suggest remedies.
2. Remove, dismantle, inspect, service and assemble the single plate clutch (Thrust spring type).

3. Remove, dismantle, inspect, service and assemble the single plate clutch (Diaphragm spring type).
4. Remove, dismantle, inspect, service and assemble the Multi plate clutch.
5. Inspect, service and adjust the clutch linkage.
6. Inspect and service the release bearing and flywheel.

3.2 MANUAL TRANSMISSION

1. Study possible complaints that may be produced on the gear box, state the causes and suggest remedies.
2. Remove, dismantle, inspect, assemble and refit the constant mesh gear box.
3. Remove, dismantle, inspect, assemble and refit the synchromesh gear box.
4. Remove, dismantle, inspect, assemble and refit the transaxle.
5. Remove, dismantle, inspect, assemble and refit the gear selector mechanism.
6. Change the gear oil from the gear box.

3.2 AUTOMATIC TRANSMISSION

1. Check the fluid in automatic transmissions and transaxles and inspect fluid leakage.
2. Study various troubles and remedies in automatic transmission and transaxles.
3. Perform the linkage and band adjustments.
4. Changing the fluid and filters.
5. Adjusting neutral safety switch.
6. Overhauling automatic transmission.
7. Dismantle, inspect, service and assemble the torque converter.
8. Dismantle, inspect, service and assemble the planetary gears.

3.3 DRIVE LINE

1. Remove, inspect, service and refit the universal joint.
2. Dismantle, inspect, service and refit the propeller shaft.
3. Dismantle, inspect, service, assemble and refit the differential unit.
4. Dismantle, inspect, service, assemble and refit the limited slip differential.
5. Remove, inspect, service and refit rear axle bearings and seals
6. Calculate the gear ratio of final drive.

Module 4

AUTOMOTIVE ELECTRICAL SYSTEMS

OVER VIEW

The automobile uses a variety of electrical accessories for different purposes. This section describes the construction and working of battery which is the source of electricity in automobiles. The module enables the students to trace different electrical circuits like lighting circuit, direction indicator circuit, brake light circuit, horn circuit etc. For starting a vehicle we have to crank the engine by using starting motor, for igniting the fuel in the engine an electric spark is used, for charging the battery in the vehicle the charging system is a must. The module deals with all these areas in detail.

The module also explains the emission control system used in automobiles which is most relevant nowadays. The concepts of euro norms implementation in India and different emission control systems used for minimizing pollution are explained thoroughly. Safety features commonly used in automobiles like air bags, seat belts etc. are also mentioned in this module. The module on automotive electrical systems provide a wide range of job opportunities in the automobile industry.

4.1 AUTOMOTIVE BATTERY

INTRODUCTION

Battery is the heart of any automobile electrical system. It is the source of electricity. It is a rechargeable battery that supplies electric energy to an automobile. This unit elaborates the types, construction and working of battery. Care and maintenance, characteristics of batteries, charging methods and battery testing are other key topics in this unit.

Learning Outcomes

The learner ;

- explains the functions of battery
- classifies different types of battery
 - Lead acid battery
 - Alkaline battery
 - Zinc-Air battery
 - Nickel-metal hydride battery
 - Lithium -ion battery
- explains the construction and working of lead acid battery
- states and define cell voltage, capacity and battery rating
- explains different battery tests
 - Specific gravity test
 - Open volt test
 - High discharge test
 - Cadmium test
- describes different charging methods
 - Slow rate charging
 - Quick rate charging
 - Trickle charging
- explains the care and maintenance of battery

UNIT IN DETAIL

4.1.1 BATTERY

Battery is an electrochemical device which converts chemical energy to electrical energy when discharging and electrical energy to chemical energy while charging. The main purposes of battery are to store electrical energy and to provide a supply of current for cranking the starting motor and for other electrical units.

4.1.2 Different types of Battery

1. Lead acid battery
2. Alkaline battery
3. Zinc - air battery
4. Nickel - Metal hydride battery
5. Lithium - ion battery

4.1.3 LEAD ACID BATTERY

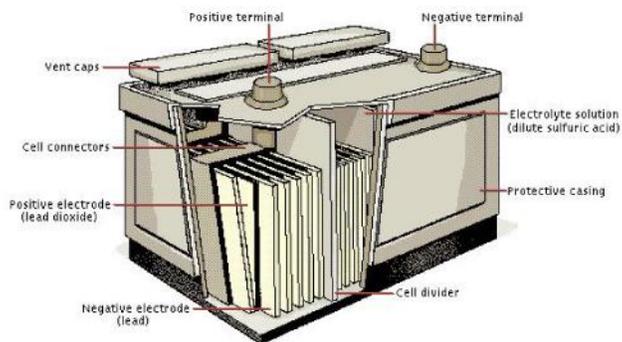
CONSTRUCTION

The major components of the battery are:

1. Container
2. Plates
3. Separators
4. Cell
5. Electrolyte

Container

They are of single piece construction made of polypropylene which is very strong and light weight plastic. There are partitions inside the container for different cells. To avoid the short of positive and negative plates, bridges are formed at the bottom of the container.



Plates

There are two types of battery plates

1. Positive plate
2. Negative plate

For each plate there is supporting grid made of alloy of lead and antimony. The function of grid is to hold the active material and to carry current in the plates.

The active material in the positive plate grid is lead peroxide (PbO_2) in chocolate colour and negative plate is spongy lead (Pb) in grey colour. These plates are immersed in dilute sulphuric acid. There are separators to keep the positive and negative plates apart. These separators are made of non - conducting porous materials and prevent short circuits. A number of positive plates are lead burnt to a post strap to form a positive plate group; while the negative plate group contains one plate more than positive group so that both side of positive plates can be utilized as greater electro chemical activity takes place. The positive plate post is usually larger in diameter than the negative plates.

Cells

One positive and one negative group of plates are slide over each other with separators in between, to form cell. Each cell supplies a current of 2V. i.e, a 12 volt battery consists of 6 cells. The size of the plates and their number per cell determines the capacity of the battery. Cells are connected in series.

Electrolyte

After assembling completely, the battery is filled with electrolyte. It is a solution of water and sulphuric acid. It contains approximately one part of sulphuric acid and two parts of water by volume. In fully charged condition, the gravity is 1.290 at 15 degree where; the specific gravity of fully discharged battery is about 1.110.

Assessment Activity

Demonstrate each component of lead acid battery to students individually and ask them to identify and explain the function of each component.

Teacher can evaluate the students as follows:

Identifying one component	-	1 score	}	2 score
Function of that component	-	1 score		
For 5 components	-	$2 \times 5 = 10$ scores		

Working of lead acid battery

Chemical equation of a battery while discharging and charging is given below:

$$\text{PbO}_2 + 2\text{H}_2\text{SO}_4 + \text{Pb} \xrightarrow{\text{discharging}} \text{PbSO}_4 + 2\text{H}_2\text{O} + \text{PbSO}_4$$

$$\xleftarrow{\text{charging}}$$

(+ve plate electrolyte -ve plate) (+ve plate electrolyte -ve plate)

On discharging both PbO₂ and Pb are converted to lead sulphate, (PbSO₄) and water is produced, which dilutes the electrolyte solution. During recharging, lead sulphate on positive plates is converted into lead peroxide (PbO₂), while on negative plates lead sulphate is converted to spongy lead. Water is split up into oxygen and hydrogen gases during charging process. The hydrogen combines with the sulphate ions to reform sulphuric acid. In this way the specific gravity of electrolyte is increased during the charging process.

CHARACTERISTICS OF BATTERY

4.1.4.1 CELL VOLTAGE

The open circuit voltage of a fully charged battery cell is 2.1V. A six volt battery would, therefore, be made of 3 cells, while a 12 volt battery would contain 6 cells connected in series. It may be noted that cell voltage is not affected by the cell size and the number of plates.

4.1.4.2 BATTERY CAPACITY

The capacity of a battery is defined as the amount of current it can deliver. It depends upon the number and area of plates in the cell and the quality of the electrolyte. It also depends upon the temperature of electrolyte.

4.1.4.3 BATTERY RATINGS

It is determined by the current it can produce and the time for which it can sustain this current. Some types of ratings are:

1. 20 hour rate - it indicates the lasting power of battery on small load. That is the rate of current a battery can deliver continuously for 20 hours after which the cell voltage should not drop below 1.75 volts.
2. Reserve capacity - This is the length of time that a fully charged battery at 27 degree Celsius can deliver 25 Amperes. A typical rating is 125 minutes in which a battery can be discharged at 25 amperes for 125 minutes if the alternator is not working.

Assessment Activity

Assignment on characteristics of battery

4.1.5 BATTERY TESTING

The following are the important tests conducted to determine the conditions of a battery.

1. Specific Gravity Test
2. Open Volt Test
3. High Discharge Test

Specific Gravity Test

This is conducted with the help of a hydrometer. Immerse the sampler tube in the cell electrolyte, squeeze the rubber bulb and release the same which would cause a sample of the electrolyte to be drawn inside the glass body. Let the float inside rise and then read the scale at the surface level of the sample drawn in. Note down the reading of the float. If the specific gravity is 1.290, the battery is in full charged condition. If the reading is 1.20 the battery is in half charged condition. If it is 1.110 the battery is fully discharged. If the temperature is above 320 C; the specific gravity may decrease.

Open Volt Test

The vehicle fitted with maintenance free battery is sealed and hence, that cannot be checked by hydrometer. In such case, that can be checked by open volt test. The open circuit voltage of the battery cell is measured with the help of ordinary voltmeter. The open circuit voltage of a fully charged battery cell is about 2.1 volts. Connect the voltmeter to battery terminals by shutting off all the other accessories. In case of a 12 volt battery, if the voltmeter reads 12.6 volts, it is fully charged. If it reads 12.2 volts it is half charged. If the reading is below 11.9 volts, it is fully discharged.

High Discharge Test

Open voltage test is not representative of the cell voltage under actual operating conditions. The cranking motor at the time of starting draws very heavy current which causes the cell voltage to fall. To stimulate this condition a high discharge test is made with the help of a cell voltage tester. A cell voltage tester consists of a voltmeter connected to 2 legs with a high resistance placed across this. Pressing the 2 legs of the cell tester on the cell terminals causes heavy current (say 150 to 200 amperes) to flow. The test is made for 5 to 10 seconds at the end of which the voltage should not fall below 1.5 volts and the difference of cell voltages of

various cells should not exceed 0.2 volts, otherwise the battery is defective. If the cell tester is not available, this test may also be made with help of cranking motor. The voltage readings are taken with the help of a good voltmeter.

4.1.6 BATTERY CHARGING

If the battery charge has got down to a lower value, the run of vehicle is not sufficient to charge the battery. In this condition the battery is to be charged from other external sources. There are different methods of battery charging. They are :

1. Slow Rate Charging
 - i) Constant voltage charging
 - ii) Constant current charging
2. Quick Rate Charging or Booster Charging
3. Trickle Charging

1. Slow rate charging

Ordinarily batteries are charged by slow rate charging method. It takes about 12 to 20 hours for charging a battery using this method. It is the safest method of charging as it increases the life of a battery. There are 2 types of slow rate charging. They are

i) Constant voltage charging

This type of charger is a motor generator set. The generator is rated 15 volts for 12 volt batteries. When the battery in a discharged condition is connected to the generator, current will flow into the battery. As the battery nears its charge, its terminal voltage will increase with increase in opposition to charging current. That is the charging current tapers off as the battery approaches the charged condition. The battery should be removed from the charger if the temperature increases beyond the limit.

ii) Constant current charging

This type of charger is a rectifier. The charging current of this rectifier can be adjusted with the help of a rheostat. The battery may be charged at 5A rate. The charging may be continued till all the cells of the battery are gassing freely and no further rise in the specific gravity of the electrolyte takes place for another 2 hours.

2. Quick Rate Charging or Booster Charging

Boosters are devices which supply high charging currents of 40 to 100A, depending upon the size of the battery. It is possible to recharge a battery to almost the full charge condition in an hour using this process. Some precautions

should be taken before attempting booster charging. They are :

1. The battery must be in good condition.
2. A badly overcharged battery which has been allowed to stand idle for long period should not be charged this way.
3. A badly sulphated battery should not be quick charged.
4. The electrolyte temperature should not be allowed to rise above 500 C.

4.1.7 CARE AND MAINTENANCE OF BATTERY

The vehicle batteries must be inspected periodically, say, every week. The following points may be taken care of.

1. The battery terminals should be clean and tight.
2. Remove vent plugs while charging.
3. Never bring flame near vent holes while charging as it may cause explosion.
4. In case the electrolyte level in the battery is not sufficient, top up with distilled water.
5. Never let the battery remain in discharged condition, otherwise the plates will become sulphated.
6. Do not put weight on battery as it may bend the plates.
7. Do not hammer the battery terminals.
8. Put petroleum jelly on battery terminals to avoid sulphation.
9. To avoid accidental arching, always remove the negative cable first while disconnecting and connecting the battery.
10. Avoid the contact of electrolyte with eyes, skin or cloths

DETAILING OF PRACTICALS

BATTERY TEST

Specific gravity test with hydrometer

Procedure

Specific gravity of the battery electrolyte is the main test in determining the state of charge of the battery or battery cells. It is checked by using a hydrometer. The hydrometer has a reading range of 1.100 to 1.300. The scale is based on pure water, which has a reading of 1.000. We have already seen that one way of knowing the state of charge of the battery is to know the amount of sulphuric acid left in the electrolyte. This can be found out with the help of a battery

hydrometer. It can be noted that the electrolyte contains about 39% acid and 61% water by weight in a fully charged battery whereas, when discharged it is about 85% water and 15% acid. The hydrometer does not measure the percentages, but instead, it directly measures the gravity of electrolytes. When the electrolyte is drawn inside the tube, float rises or sinks, depending upon the specific gravity of the electrolyte. The reading coinciding with the marking at the electrolyte level is noted. Then correction will be considered corresponding to the normal temperature of 27°C. The specific gravity of the electrolyte varies with the temperature. The liquid expands and becomes thinner when heated and it loses its specific gravity. It is therefore essential to take into account the temperature while taking specific gravity reading to know the state charge of the battery accurately.

If the temperature is above or below 27°C , readings should be corrected, as below:

If the temperature is above 27°C, 0.004 for every 5°C is to be added to obtain the correct reading. Similarly, if the temperature is below 27°C deduct 0.004 for every 5°C to the correct reading. The specific gravity reading can be taken from the marking on the float stem. The table below shows the specific gravity readings and the state of charge of the battery.

Sl.No	Approximate specific gravity	State of charge of battery
1	1.260-1.280	Fully charged
2	1.230-1.260	¾ charged
3	1.200-1.230	Half charged
4	1.170-1.120	¼ charged
5	1.140-1.170	About rundown
6	1.110-1.140	Discharged

High rate discharge test with cell tester

Procedure

- The state of charge of a battery can be measured with an instrument, which inserts a resistance across the cell terminals, and the cell voltage reading is obtained on the voltmeter. As the prods are pressed down on to connectors across the cell or to the battery terminals and after approximately 10

seconds, the reading on the scale marked showing battery condition discharging is noted.

- If needle falls in the green band the battery is serviceable. If reading is in the red band, or the needle drops rapidly towards the red - band, the battery should be given a bench charging or be replaced.
- The high rate discharge can be done with the cranking motor also. For making the test, ground the ignition primary lead at the distributor, so that the engine does not start. Now Operate the cranking motor and check the voltage of each battery cell. Generally, if during the test, the cell voltages fall below 1.5 V or there is a difference of 0.2 V or more between the cells, battery trouble may be suspected. Before final conclusion, recharge the battery and check it again.
- Before making HRD test, the electrolyte level in all the cells should be correct, there should be no apparent defects in the battery, and it should be at least half charged. Further, the motor should not be operated for more than 20 seconds at a stretch.

Open-circuit Voltage Test

Procedure

- To conduct this test, a very accurate and sensitive voltmeter is required. In this test, the open circuit voltage (no load applied) of each cell is taken.
- Even though the voltage of a lead-acid battery cell is 2.0 V, in truth it is slightly higher than this.
- A battery cell in good condition and fully charged may have an open circuit volt of about 2.15 V. There is a difference of about 0.15 V between a fully charged and a discharged cell. Normally, each 0.01 V is equal to a difference of 0.010 specific gravity point.
- It should be noted that the batteries that have been just charged should not be tested with the voltmeter because the gases on the plate surfaces will cause a high reading.
- The battery should be allowed to stand for a sufficient number of hours to permit dissipation of these gases before the test is conducted.
- These gases can also be eliminated by subjecting the battery to high discharge for a few moments (eg:- by cranking the engine with the ignition switch off).

Assessment Activity

1. Seminar on battery testing
2. Class test

TE QUESTIONS

Fill in the blanks

1. Battery converts energy to energy. (1)
2. Choose the correct answer.
The specific gravity of a fully charged battery is -----
(1.80,1.110,1.280,1.200) (1)
3. True or false (1)
Most batteries have a negative plate more than the positive plates in each cell.
4. List the major components of a lead acid battery . (3)
5. The specific gravity of a fully discharged battery is very low. Do you agree?
Justify your answer.
6. Name the factors which affect the battery capacity. (3)
7. The various tests to detect the condition of a battery are listed below:
 - a. Specific gravity test using hydrometer
 - b. Open volt test using ordinary volt meter.
 - c. High discharge test by using high rate discharge tester

Briefly explain each type of test. (3x2=6)

UNIT 4.2

CHARGING SYSTEM

INTRODUCTION

The battery used in an automobile has to be charged by the vehicle itself. A charging system is used in every vehicle. Alternator or magneto is used for this purpose. The unit describes the basic principle of Faraday's law of electromagnetic induction. It also deals with the construction, working and testing of an alternator. The students will be able to differentiate between an alternator and a dynamo. They will also be able to service the charging system.

LEARNING OUTCOMES

The learner:

- describes the functions and requirements of charging system
- draws and explain the charging circuit
- explains the construction and working of electromagnet
- states Faraday's law of electromagnetic induction
- explains the construction and working of alternator
- describes alternator regulation
- differentiates DC generator and alternator

UNIT IN DETAIL

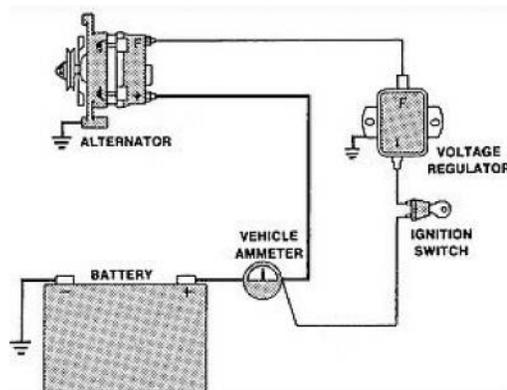
4.2.1 CHARGING SYSTEM

The function of the charging system in an automobile is to generate, regulate and supply the electric energy for charging the battery. The requirements of a charging system, when the vehicle is running are:

1. To supply the current demands of all the loads.
2. To supply the current required for charging the battery under all conditions.
3. To supply constant voltage under all conditions.
4. Should include a provision to indicate proper working.
5. Should have highest power to weight ratio.
6. Should be reliable and quiet.
7. Should require least maintenance.

The charging system consists of a generator for converting mechanical energy from the engine into electrical energy, a regulator to control the amount of electrical energy so produced, a relay to regulate the flow of the charging current from the generator to the battery relevant to the state of charge of the battery and an ammeter or indicating lamp to indicate whether the system is operating or not. In modern cars, the charging system includes an alternator only instead of a generator.

4.2.2 CHARGING CIRCUIT DIAGRAM



A typical charging system contains an alternator (generator), drive belt, battery, voltage regulator and the associated wiring. The charging system, like the starting system is a series circuit with the battery wired in parallel. After the engine is started and is running, the alternator takes over as the source of power and the battery then becomes part of the load on the charging system.

PRINCIPLE OF A GENERATOR

When a conductor is moved in a magnetic field a current is produced in it. If the magnets used are permanent, the strength of the magnetic field will be weak which leads to a weak electromagnetic force. Owing to this fact the magnets used in generators are electromagnets. A generator consists of a frame which provides room for other components, an armature winding and field coil.

4.2.3 ELECTROMAGNET

An electromagnet is a type of magnet in which the magnetic field is produced by an electric current. The magnetic field disappears when the current is turned off. Electromagnets usually consist of a large number of closely spaced turns of wire that create the magnetic field. The wire turns are often wound around a magnetic core made from a ferromagnetic or ferrimagnetic material such as iron. The magnetic core concentrates the magnetic flux and thus, makes a more powerful magnet.

4.2.4 FARADAY'S LAW OF ELECTROMAGNETIC INDUCTION

When a conductor is moved in a magnetic field, a current is induced in the

conductor. The amount of current depends upon the strength of the magnetic field, the number of turns in the conductor & speed of relative motion.

4.2.5 ALTERNATOR

In modern cars, the charging system uses an alternator instead of a dynamo. So this reference book deals with the construction and working of alternators & compares the dynamo with a alternator.

CONSTRUCTION & WORKING OF ALTERNATOR

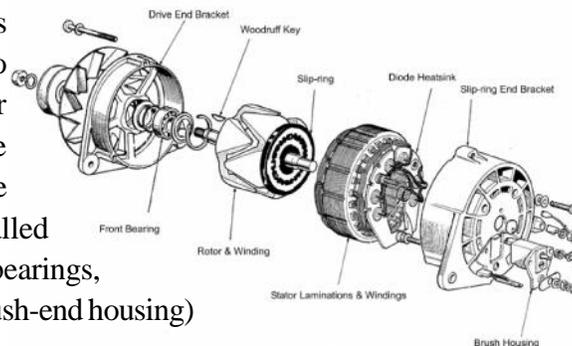
The alternator is AC generator which produces alternating currents instead of DC current as produced by a generator. The automotive electrical system requires only direct current; the alternating current produced by the alternator should be converted to direct current by a diode or rectifier.

Alternator consists of the following elements:

1. Frame or housing
2. Rotor
3. Slip rings & brushes
4. Stator

Constructional Details

1. Frame or housing - This encloses the entire alternator assembly and is made of cast aluminium in two pieces. Aluminium is light weight, non-magnetic and has higher thermal conductivity so as to keep the alternator assembly cool by more efficient transfer of heat. The front part of the frame (called drive end housing) has ball bearings, while the rear part (called brush-end housing) contains a roller bearing.



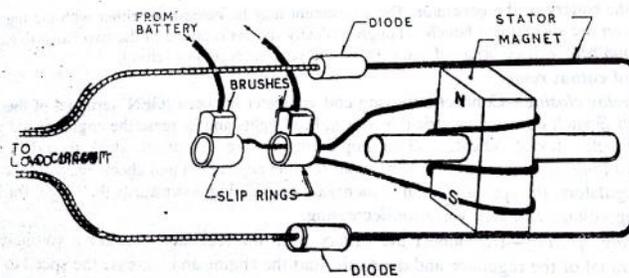
2. Rotor -The most common rotor is the claw pole rotor, which consists of an iron core around the rotor shaft. Many turns of copper wire coated with varnish are wound over the core. On both sides of the rotor, thick metal plates are bent over the winding with triangular fingers called poles. These

metal pieces are called pole pieces. The pole pieces are placed interlocking to each other so that when the current flows through the winding, these pole pieces acquire opposite polarity. This will result in alternating north and south magnetic pole on the poles fingers. This creates magnetic fields between the alternating pole fingers. Thus, the AC generator has a rotating magnetic field.

3. Slip ring & Brushes -The current to the rotor winding is carried through the copper slip rings and carbon brushes. The brushes ride the surface of the slip rings on the rotor under spring tension provided by the brush holders.
4. Stator -Three-phase alternator is commonly used in automobiles. Between two halves of the alternator casing, is situated the stator consisting of three sets of winding wound over a laminated iron core. When the rotor rotates, its moving magnetic field induces current in all the three stator windings. All alternators contain at least six diodes, one pair of a positive and a negative diode for each winding to have full-wave rectification of the ac current produced in the alternator. One diode would achieve only half wave rectification. Three positive diodes are usually included in the rectifier circuit.

WORKING OF ALTERNATOR

When the electromagnet (rotor) is rotated, the magnetic lines of force cut the stationary stator loop to produce an induced current. After every half revolution the magnet



reverses its polarities; the current produced in the stator changes in sign in a revolution. To convert the alternating current into direct current; diodes pass through them only in one direction. Thus AC current is converted into DC current to supply power for various electrical needs.

4.2.6 ALTERNATOR REGULATION

In case of alternators; diodes are employed in the stator output circuits which allow the current to flow in one direction only. Thus the cut out relay used in DC generator regulator is not required because diodes do not allow the current to flow from the battery to the alternator when it stops or slows, although the connection between the two still remains. Alternator do not require current

limiters as they do not produce enough current to cause damage to the alternator itself. However an alternator could produce more than 250 volts if not controlled. Thus only voltage regulator is required with an alternator.

4.2.7 COMPARISON OF ALTERNATOR WITH DC GENERATOR

1. At low speed, alternator produce more current than DC generator.
2. For an alternator no external current regulator is required for the control of maximum current. But for DC generator current regulation is must.
3. As the rectifiers installed in the alternator itself serve as one-way valves for the current flow, a separate cut-out relay is not required.
4. In a DC generator the output windings are in the armature which rotates, whereas in alternator the same are on the stator. Due to this the cooling is comparatively easy in alternators and hence there is maximum output. (e.g. 50 amp compared with 30 amp. in case of DC generator).
5. The maximum permissible speed in case of alternators is generally about 30 percent higher than the DC generator which is restricted to about 9000 rpm due to commutator operation.
6. The output/weight ratio of alternators is higher than that of generators. This is mainly on account of higher permissible maximum speeds in case of alternators. For alternators with built-in reel output/weight ratio is about 100% higher than DC generator.
7. In the DC generator the entire current produced has to pass through the carbon brushes. In the alternator the carbon brushes carries only the field current (approximately 2 to 5A).
8. Alternator is simpler in construction compared to the DC generator. Therefore it requires less maintenance and is more reliable.
9. The only disadvantage with alternator system is its higher initial cost than the DC generator.

DETAILING OF PRACTICALS

Alternator

Procedure

- Disconnect the grounded battery cable. Connect an ammeter in the circuit at the alternator battery terminal.
- Reconnect the grounded battery cable. Turn on the radio, windshield wipers, lights on high beam, and blower motor on high speed.

- Connect a variable resistance across the battery. Operate the engine at about 2000 rpm. Adjust the resistor to get maximum alternator output. If the alternator output is within 10 amps of the rated output stamped on the frame, it's OK.
- If the output is low, locate the test hole at the end of the alternator. Insert a screw driver into it (not deeper than 1 inch).
- Operate the engine at about 2000rpm. Adjust the resistor to get maximum output. If the output is still low, the alternator is defective.
- It must be removed for repair or replacement if the test hole is not accessible.

ADJUSTMENT OF ALTERNATOR BELT

Procedure

Inspection:

- Visually inspect the belt for cracks, cuts, deformation, wear and cleanliness. Check the belt for tension as specified with 10 kg (thumb pressure).
- Belt tension specification 10-15 mm as deflection. If the belt is too tight or loose, adjust it to the proper tension by adjusting the alternator position.

Replacement:

- Loosen the alternator adjusting bolt and pivot bolts and move the alternator inward.
- Replace the belt.
- Move the alternator outward and adjust the belt to the specified tension.
- After replacing the belt with new one, adjust its tension to 8-10mm. ((0.3 -0.4 inch)
- Tighten the alternator adjustments noted above are to be performed with engine not running.

Assessment Activity

1. Assignment on construction and working of alternator
2. Debate on 'Alternator is better than Dynamo'
3. Class test

TE QUESTIONS

1. ----- is used with alternator to convert AC to DC (1)
2. Choose the correct answer (1)
An alternator works on----- principle.
(Pascal's, Faraday's electromagnetic induction, Kirchhoff)
3. Alternator has some definite advantages over dynamo. List out any three. (3)
4. While testing an alternator rotor; the following result was obtained. (4)
 - a) when ohm meter is connected between slip ring and rotor shaft, a very low resistance is indicated.
 - b) When a test lamp is connected across slip rings; it lights up.Detect the condition of rotor by analysing the above results.

UNIT 4.3

STARTING SYSTEM

INTRODUCTION

For starting the engine we have to crank the engine. Starting system is used for this purpose. The unit illustrates the circuit of this system. It deals with the construction and working of starting motor and also describes the types of starter drive and their working. The students will be able to know the construction and working of solenoid switch and also will be capable of servicing the starting system.

LEARNING OUTCOMES

The learner;

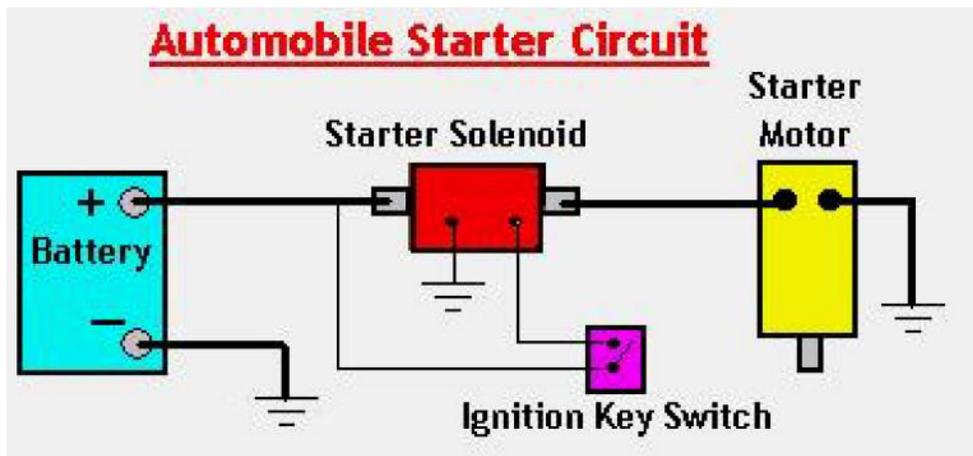
- describes the requirements of a starting system
- draws and explain the starting circuit
- explains the construction and working of starting motor
- classifies different starting drives
 - Bendix drives
 - Standard bendix drive
 - Follow thru bendix drive
 - Compression spring type bendix drive
 - Rubber spring type bendix drive
 - Overrunning clutch or pre engaged type drive
 - Dyer drive
- explains the construction and working of Axial starter motor
- explains the construction and working of over running clutch drive
- explains the construction and working of solenoid switch
- explains the functions of electronic starter control

4.3.1 Starting system

Starting system uses battery power and an electric DC motor to turn engine crankshaft for engine starting. It changes electrical energy to mechanical energy. It provides gear reduction/torque multiplication (16:1 to 20:1). When the ignition key is turned on the current flows through the solenoid coil, this closes the contacts, connecting battery to the starter motor.

4.3.2 STARTING CIRCUIT

The starting system includes the battery, starter motor, solenoid, ignition switch and in some cases, a starter relay. An inhibitor (neutral safety) switch is included in the starting system circuit to prevent the vehicle from being started while in gear.



A simplified diagram is shown below :

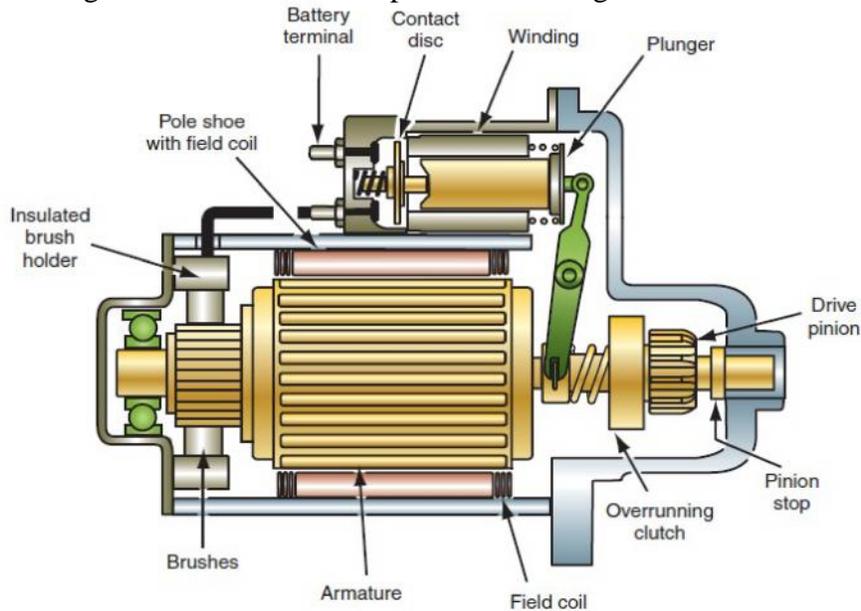
When the ignition key is turned to the start position, current flows and energizes the starter's solenoid coil. The energized coil becomes an electromagnet which pulls the plunger into the coil; the plunger closes a set of contacts which allow high current to reach the starter motor. On models where the solenoid is mounted on the starter, the plunger also serves to push the starter pinion to mesh with the teeth on the flywheel.

4.3.3 STARTER MOTOR

Starter motor is used to crank the engine. It works on the principle "like magnetic poles repels each other." When a current carrying coil is placed in a magnetic field, it will produce a force in the coil and this causes the coil to rotate. The motor must be powerful enough to turn the engine to start. It must be capable of exerting a very heavy torque when starting and at low speeds. For this purpose the starter motor is usually series wound. Currently, series shunt wound motors are also used.

Construction

The construction of the all starting motors are similar. There are, however, slight design variations. The main parts of a starting motor are as follows:



ARMATURE ASSEMBLY

The armature assembly consists of an armature shaft, armature core, commutator, and armature windings. The armature shaft supports the armature assembly as it spins inside the starter housing. The armature core is made of iron and holds the armature windings in place. The commutator serves as a sliding electrical connection between the motor windings and the brushes and is mounted on one end of the armature shaft. The commutator has many segments that are insulated from each other. As the windings rotate away from the pole shoe (piece), the commutator segments change the electrical connection between the brushes and the windings. This action reverses the magnetic field around the windings. The constant changing electrical connection at the windings keeps the motor spinning.

COMMUTATOR END FRAME

The commutator end frame houses the brushes, the brush springs, and the armature shaft bushing. The brushes ride on top of the commutator. They slide on the commutator to carry battery current to the spinning windings. The springs force the brushes to maintain contact with the commutator as it spins, thereby no power interruptions occurs. The armature shaft bushing supports the commutator end of the armature shaft.

FIELD FRAME

The field frame is the center housing that holds the field coils and pole shoes. The field coil (winding) is a stationary set of windings that creates a strong magnetic field around the motor armature. When current flows through the winding, the magnetic field between the pole shoes becomes very large. This acts against the magnetic field created by the armature, which spins the motor with extra power. Field windings vary according to the application of the starter motor.

DRIVE END FRAME

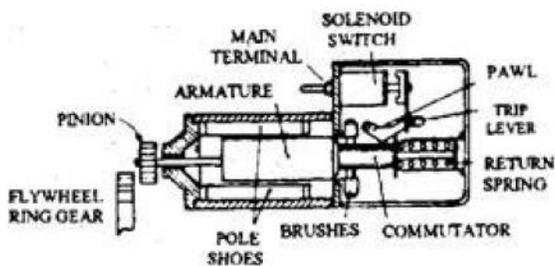
The drive end frame is designed to protect the drive pinion from damage and to support the armature shaft. The drive end frame of the starter contains a bushing to prevent wear between the armature shaft and drive end frame.

4.3.4 STARTER DRIVES

Starter drives are mainly classified as follows :

1. Bendix Drives
 - Standard Bendix drive
 - Follow thru bendix drive
 - Compression spring type bendix drive
 - Rubber spring type bendix drive
2. Overrunning clutch or pre engaged type drive
3. Dyer drive

3.3.5 AXIAL (SLIDING ARMATURE) STARTER MOTOR

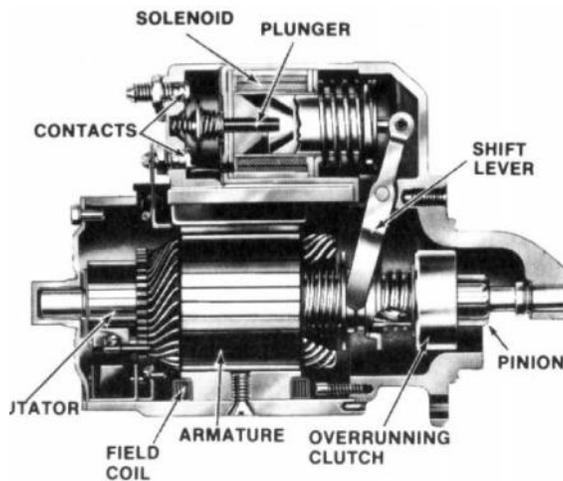


The main features of this type starter motor are its size and robust construction. For the engagement of the pinion to the flywheel ring gear, the complete armature assembly slides axially through the motor casing. A simplified construction of the starter is illustrated.

In the figure, the motor is shown in the rest position. The armature is held by a spring so that it is offset to the field poles. When the field is energized, the armature is pulled to the left and the pinion is slide into engagement with the ring gear. The main winding as usual is of thick-section and low-resistance winding, and is connected in series to the armature. The auxiliary winding is

wound with thinner wire so that it has a relatively high resistance, and is also connected in series with the armature but in parallel with the main winding. The holding winding is also a high-resistance winding but is connected in parallel with the armature as well as with the other two windings. A two-stage solenoid switch, mounted on the starter operates the starter, and is energized by the driver's switch.

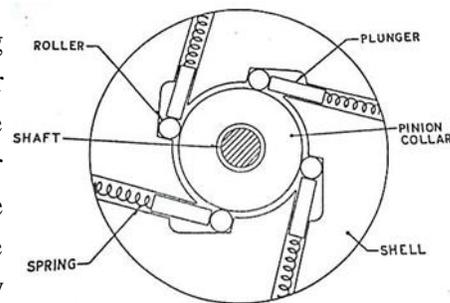
4.3.6 OVERRUNNING CLUTCH DRIVE



The overrunning clutch, which is employed in this type of drive is shown in the figure. It consists of a shell and a pinion collar connected in such a way that when the shell is rotating at a speed greater than that of the pinion collar, the former will drive the latter. However, whenever the speed of the collar becomes more than the speed of the shell, there is no more connection between the two. Such

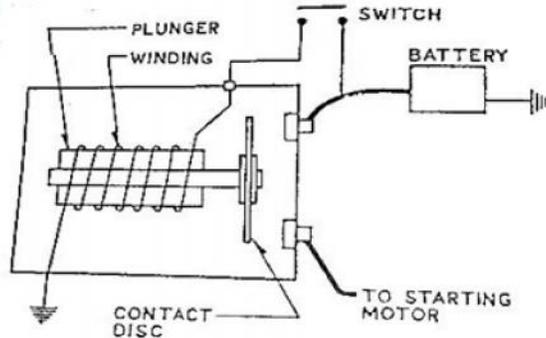
a connection is provided by the spring loaded rollers, the shell is connected with the armature shaft through splines, whereas the collar is attached to the pinion.

A starting drive employing the overrunning clutch is shown in the figure. The shift lever is attached to solenoid switch. When the driver turns ignition switch the shift lever moves about its pivot, thereby pushing the switch of starting motor and moving the overrunning clutch and the pinion assembly through the spring simultaneously. This causes the pinion to get engaged with the teeth on the flywheel and also get the armature shaft and thereby the pinion rotates, which starts the engine. However, as soon as the engine gets started, the flywheel and the pinion rotates at much faster a speed, causing the overrunning clutch to disconnect the pinion side from the motor side. Further the motor also stops as soon as the engine starts. The driver leaves the starting pedal or key



which causes the shift lever to come back to its previous position, leaving the motor switch open and disengaging the pinion from the flywheel.

4.3.7 SOLENOID SWITCH



It is also called magnetic switch. As the button is pressed, the current flows from the battery to the winding which produces a magnetic field, resulting in the movement of the plunger to close the switch connecting the battery and the starting motor. The

advantage of the solenoid switch (when compared to the manual) is that the heavy current wiring length is reduced (this reduces the voltage drop in the starter circuit) and the driver has to operate only a push button or key switch (at the dashboard) which carries a nominal amount of current only. This driver's switch is only of light duty type and its wiring is also thin and light. The solenoid switch here has got one winding only. Some solenoid switches have two windings also, viz. the pull-in winding and the hold-in winding. Both the windings exert combined force to pull the armature so as to make the contacts of the switch when the pull-in winding is short-circuited and only hold-in winding remains to hold the contacts closed. The advantage of this type is that less current is drawn from the battery during the period of hold-in, further only the leads from the battery to the solenoid terminal and from the other solenoid terminal to the starting motor need only be thick, other wires including the one going to the driver switch may be thin as explained above.

4.3.8 ELECTRONIC STARTER CONTROL

An electronic starter control consists of a static relay on a circuit integrated with the solenoid switch. Such a control, with necessary improvements of the circuit can perform the following functions:

1. To prevent cranking when the engine is running.
2. To shut off the starter at the precise instant of engine start. This would reduce wear and noise.
3. To re design the mechanical parts by modulating the solenoid current. This would result in softer operation and weight reduction

DETAILING OF PRACTICALS

STARTING MOTOR

Removing Procedure

- Disconnect the grounded battery terminal cables.
- Disconnect the wire connections to the starter motor. Note each connection leads so that they can be reconnected properly.
- Remove the bolts holding the starting motor to the flywheel housing and take the starter motor out.

Dismantling

- Remove the drive housing and shin lever.
- Remove the solenoid switch by unscrewing the appropriate nuts.
- Remove the field coils and armature by unscrewing the respective housing nuts.
- End frame can also be removed. From the armature shaft remove the over running clutch and assist spring.
- Remove the plunger and return spring.
- Different brush holders, brushes, pole shoes etc. can be removed.

Assembling

- Assembling can be done in the reverse order of above steps.

Installing

- Clean the overrunning clutch and wipe it out with cotton waste.
- Do not use solvents. It cannot be re-lubricated. Make all the connections properly.
- Try the starter motor to make sure that it works satisfactorily and crank the engine at normal speed.

Assessment Activity

1. Seminar on construction and working of starting motor
2. Assignment on Standard Bendix Drive and Over running Clutch drive
3. Class test

TE QUESTIONS

- 1) The starting motor gets the drive from ----- (1)
- 2) In automobile, the minimum speed to start an engine is ----- rpm (1)
(50,100, 200, 1000)
- 3) List any six components of a starting motor. (3)
- 4) Give any two advantages of solenoid switch in starting circuit. (2)
- 5) Identify any one type of starting motor drive and explain its working. (6)

UNIT 4.4

LIGHTING SYSTEMS AND ELECTRICAL EQUIPMENTS

INTRODUCTION

Automobile uses different types of lights like head light, park light, stop light, number plate light, interior light etc. These lights have to blow as and when required. Separate circuits are necessary for this purpose. The unit illustrates various lighting circuits and their working. Students can identify various head lamps, lighting switches and warning lights. It also describes the circuit diagram of directional indicator and horn. Then unit also deals with the construction and working of electric horn, wind shield wiper and function of speedometer, odometer, Centre lock and power windows.

LEARNING OUTCOMES

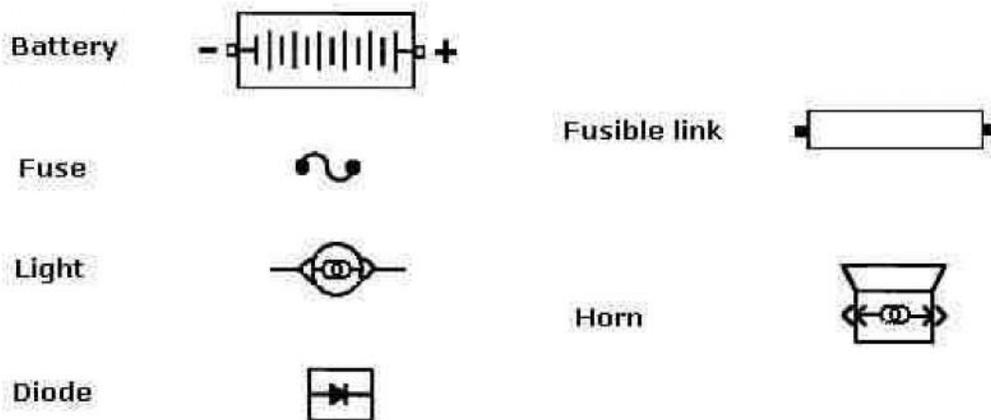
The learner :

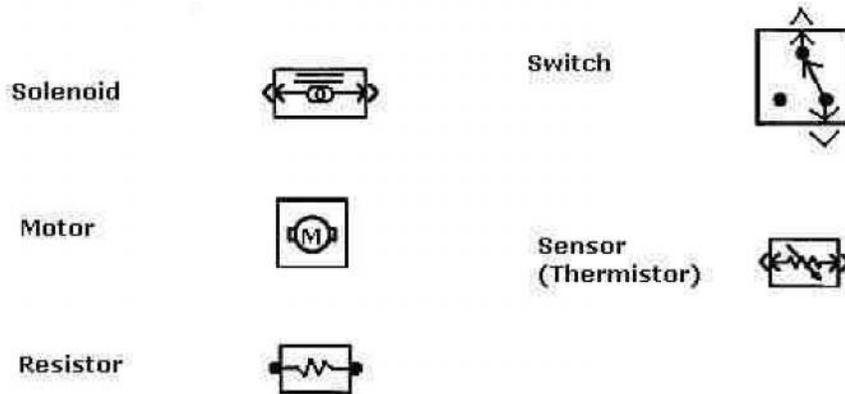
- identifies electrical symbols and wire colour codes
- draws and explain lighting circuit
 - Head lamp circuit
 - Tail lamp circuit
 - Stop light circuit
 - Parking light circuit
 - Number plate light circuit
 - Instrument panel light circuit
 - Interior light circuit
- classifies head lamps
 - Incandescent lamp
 - Halogen lamps
 - High intensity discharge lamp(HID)
 - LED lamps
- locates and explain the function of lighting switches
 - Light switch
 - Dimmer switch

- Stop light switch
- explains the functions of different instrument panel indicating lights
 - Main beam warning light
 - Ignition warning light
 - Flashing indicator warning light
 - Oil pressure warning light
 - Charge indicator light
- draws and explain direction indicator circuit
- draws the horn circuit and explain the construction and working of electric horn and horn relay
- explain sthe construction and working of wind shield wiper
- explains the function of speedometer
- explains the function of central lock
- explains the function of power window
- explains the working of air bag
- explains the function and working of seat belts
 - Pre tensioner
 - Load limiter

UNIT IN DETAIL

4.4.1 ELECTRICAL SYMBOLS





WIRE COLOUR CODES

- The following color codes are used to indicate the Colour of wires used.

Colour code	Colour
L	Blue
B	Black
Y	Yellow
G	Green
R	Red
W	White
Br	Brown
Lg	Light green
Gr	Gray
P	Pink
Or	Orange
Lb	Light Blue
V	Violet
SA	Sealed (Inner)
SB	Sealed (Outer)

The electrical wire used in automobile consists of number of strands of copper or aluminium. A single conductor is never used because that would comparatively be less flexible and would easily undergo fatigue with continuous bending. Wires are commonly specified by the number and size of the strands. For eg: 7/36 means seven strands of 36 gauge.

For quick identification, insulations of various wires in a circuit are assigned different colors. Various colour codes are in use for vehicle wiring. The table shows the colour code of some vehicles.

Assessment Activity

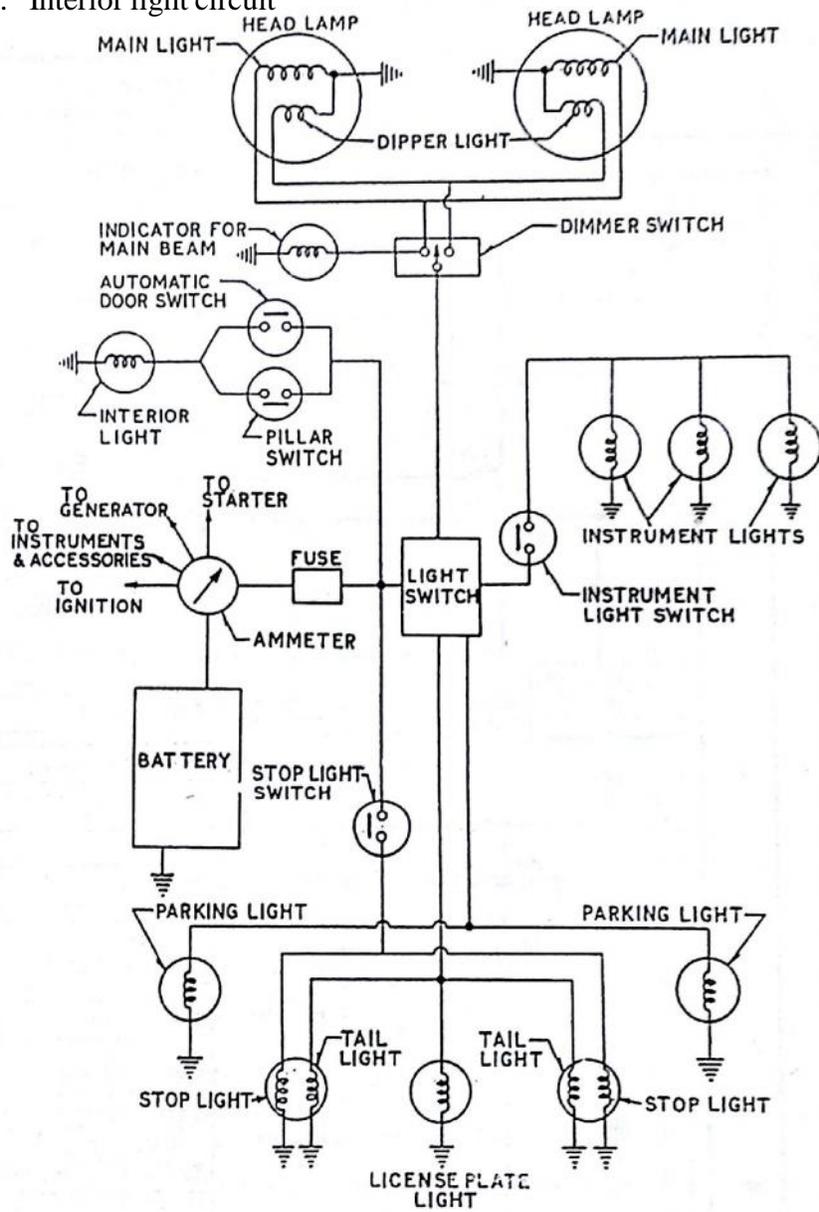
Teacher shows the chart of electrical symbols to the students individually. Asks them to identify the symbol and their function.

4.4.2 LIGHTING CIRCUIT

The purpose of the lighting system is to provide illumination for the driver to operate the vehicle safely at night, to convey information to the other driver and people on the road about the vehicle's presence, position, size, direction of

travel, illuminating instruments on the dash board etc. The automobile lighting system consists of the following circuits:

1. Head lamp circuit
2. Tail lamp circuit
3. Stop light circuit
4. Parking light circuit
5. Number plate light circuit
6. Instrument panel light circuit
7. Interior light circuit



Assessment Activity

Seminar on different lighting circuits.

4.4.3 HEAD LAMP

A head lamp is a lamp attached to the front of a vehicle to light the road ahead with a reasonable distance with sufficient intensity. For this purpose a reflector is used. The following are the important types of head lamps.

1. Incandescent lamp
2. Halogen lamp
3. High intensity discharge (HID) lamp
4. LED lamp

4.4.4 LIGHTING SWITCHES

Switches used in lighting circuit of an automobile are of different types depending upon their requirements. The important switches are

- a) Light switch: - This may be of push-pull type and is mounted on the board. It has three positions (i) off position, (ii) side lamps, tail lamps, number plate light and instrument lamps (iii) head lights. This switch is also mounted on a stick on the steering column.
- b) Dimmer switch: - This switch is mounted on the stick on the steering column. By moving the lever up and down, we can select the dim and bright position of the head lamp.
- c) Stop light switch: - This is attached to the master cylinder in the brake system. When the brake pedal is applied, the fluid pressure developed in the compression chamber is communicated to a metallic diaphragm which deflects to close the two terminals for the stop light switch.

4.4.5 INSTRUMENT PANEL INDICATING LIGHTS

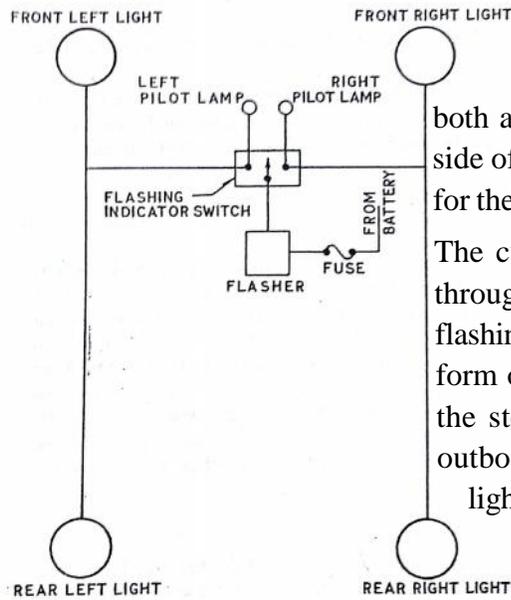
These lights are used to indicate the driver about the position and situations of different systems.

- a) Main beam warning light :- This light glows when the main beam of the head lights are on. This reminds the driver to dip the lights for the oncoming vehicles.
- b) Ignition warning light :- The red light lights up when the ignition switch is on. It goes off when the engine speed increases. This lamp serves as a warning against leaving the ignition switched on when the engine is not

running.

- c) Flashing indicator warning light:- This bulb lights up when the flashing direction indicator is operative.
- d) Oil pressure warning light:- This bulb lights up when the oil pressure in the lubricating system falls below the desired level.
- e) Charge indicator light:- When the generator is not charging the battery, the light glows.

4.4.6 DIRECTION INDICATOR CIRCUIT



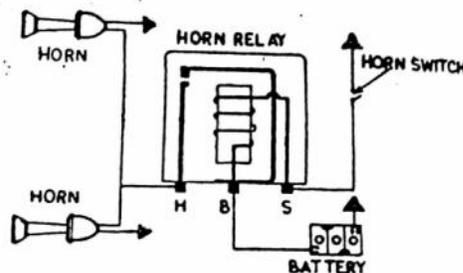
One light on each side is fitted both at the front as well as on the rear side of the vehicle. The wiring diagram for the same is shown in the figure.

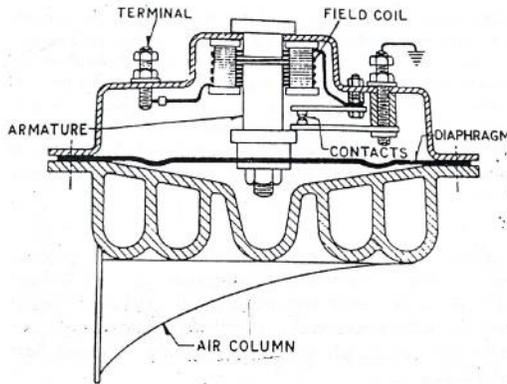
The current is taken from the battery through a fuse and a flasher unit. The flashing indicator switch is usually in the form of a horizontal lever mounted on the steering column so that when its outboard end is actuated upward, the light side indicator lights are operated and the downwards movement of the switch arm operates the right side indicator lights.

Flasher unit consists of a thermostatic bimetallic blade. The blade expands due to flowing of the current through it, warms and opens a pair of contacts, thus opening the circuit. But as the current stop flowing, the blade cools and straightens to close the circuit again. In this way the lights are made to flash.

4.4.7 HORN CIRCUIT

The horn employed on present-day automobiles is electrically operated. The construction of such a horn is shown in figure. It consist of a diaphragm and an armature inside a field coil. In the figure, the contacts are shown closed,



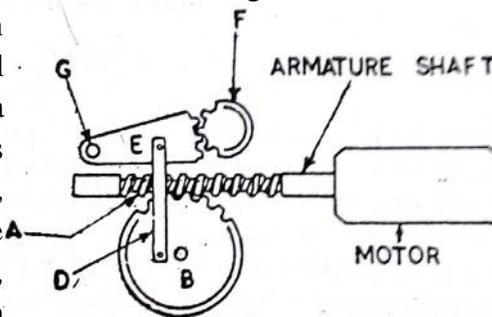


which is the position when the horn switch is in the off position. When the driver pushes the horn switch, the circuit is completed and the field coil produces an e.m.f. which causes the armature and along with it the diaphragm, to move down.

But the moment the armature moves down, the contacts separate opening the electrical circuit. The field coil is then de-energised and the armature again moves up on account of the force of a mechanical spring (not shown) which keeps it into the uppermost position. This upward movement of the armature causes the contacts to close again, thereby pulling the armature and the diaphragm down. In this way, the diaphragm starts vibrating up and down causing the vibrations of the air column below it. These vibrations of the air column subsequently produce the horn sound, which depends upon the frequency of diaphragm vibration. A relay is usually inserted in the horn circuit. It protects the contacts at the horn button and provides a more direct connection between the horn and the battery. The reason for this becomes clear when we consider that the current required for the horn operation is quite large. Therefore the least length of the current carrying cable is necessary. With the relay in the circuit, the heavy load required is only from the battery to the relay and then to the horns, which may be placed near one another thus requiring shorter leads only. The relay itself can be operated with a light current only and therefore the cable from the relay to the horn push button may be of a smaller cross-section.

4.4.8 WIND SCREEN WIPER

These are employed to keep the wind screen clean during rain, snow etc., to ensure good visibility. Wind screen wipers are operated by means of a small motor. The figure shows the layout of a wind screen wiper. The motor drives the worm A which rotate the wheel B, link D connects the wheel with the toothed sector E. As wheel B rotates, the sector E reciprocates about fulcrum



G. This motion is then imparted to a similar sector F on the spindle on which is mounted the wiper arm. Wiper blade is attached to the wiper arm by means of a spring lock. A rubber wiping element is held in place in the wiper blade. Wiper arms pivot against the windscreen under spring pressure to ensure adequate wiper blade pressure against the glass.

4.4.9 SPEEDOMETER AND ODOMETER

This is a compulsory accessory on automobiles. Infact, the instrument called speedometer consists of two separate accessories, viz. the speedometer and the odometer. Speedometer indicates the vehicle speed at a particular instant, whereas the odometer gives the total distance covered by the vehicle upon the moment of taking the reading. Both these accessories work on different principles, but because they are mounted in the single casing, the whole unit is commonly called speedometer.

4.4.10 CENTRAL LOCKING

With this facility all the doors and luggage compartment can be locked or unlocked simply by operating one key. A two position electric solenoid actuator is installed in each doors to electrically operate the door - lock or unlock with one switch or key. In case of electric locking system, the manual locking can also be operated.

4.4.11 POWER WINDOW

There is an electric motor and a switch at every window beside a master switch at the dash board which can control all motors simultaneously. The electric motor drives the windows regular mechanism forward or reveres, thus opening or closing the same.

4.4.12 AIR BAG

An airbag is a vehicle safety device. It is a type of occupant restraint system that consists of a flexible fabric bag, also known as an airbag cushion. The airbag module is designed to inflate rapidly then quickly deflate during a collision or impact with another object. The purpose of the airbag is to provide occupant protection and restraint during a crash event.

When an accident occurs, airbags inflate faster than you can blink your eye. Airbags are key components in automotive safety systems, and, although we cannot see them perform under normal conditions with the naked eye, they soften the impact of collisions by keeping passengers from contacting the steering wheel, dashboard, front glass, and other parts of the automobile. So, to explain what airbags actually do when an accident occurs, let's use an example of a typical head-on collision.

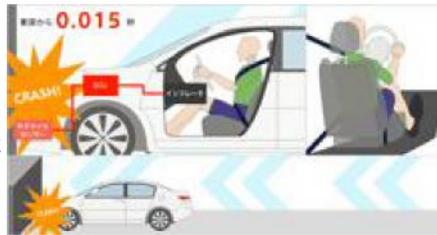
1. 0.003second-Sensors detect the impact



As the satellite sensors (collision sensors) attached to the vehicle detects the collision, a signal is sent to the ECU (Electronic Control Unit).

2. T+ 0.015second-Evaluation of the impact

The signal sent from the satellite sensors to the ECU is processed, and the ECU determines the severity of the impact based on inputted data. If the ECU determines that an airbag deployment is necessary, it sends a signal to initiate the airbag inflators (gas emitting devices).



3. T+ 0.020second-The airbags go into action



The inflators are activated through an igniter, causing a chemical reaction that emits gas, resulting in the deployment of the airbag cushion.

4. T+ 0.040second-Inflation of the airbags is completed

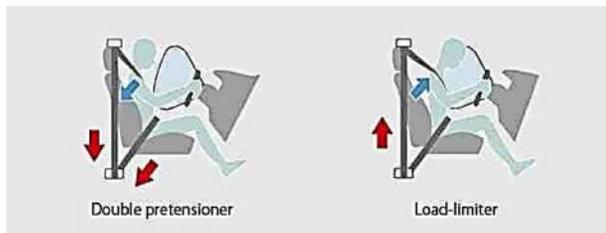
The force of the collision reaches the passengers, and they begin to move forward. By this time the airbags are fully inflated and they are ready to receive and restrict the movement of the passengers. The inflation of the driver side airbag takes between 20 - 30 milliseconds. For the passenger side airbag, it takes between 30-40 milliseconds.

4.4.13 SEAT BELT

How exactly do seat belt systems work when accidents occur? We would like to give an example of how seat belts equipped with a pre-tensioner and load limiter work. When accidents occur, several systems incorporated in the seat

belt assembly go into operation simultaneously. In less time than it takes for a human being to blink an eye, the seat belt system goes into action to control the energy load the occupant endures on impact. By retracting some webbing as the collision is occurring, the pre-tensioner enhances the protective functions of the belt by removing some slack and helping restrain the passenger. The load limiter absorbs and softens the load on the occupant as the passenger moves forward because of inertia. In the latest designed motorized seat belts, there are also functions to warn the driver, as the seat belt motor gives a tug on the belt, that there is an immediate dangerous situation coming up. (a pre-impact warning)

How seat belt with pre-tensioner and load limiter works



In severe crashes, when a car collides with an obstacle at extremely high speed, a seatbelt can inflict serious damage. As a passenger's inertial speed increases, it

takes a greater force to bring the passenger to a stop. In other words, the faster you're going on impact, the harder the seatbelt will push on you.

Some seatbelt systems use load limiters to minimize belt-inflicted injury. The basic idea of a load limiter is to release a little more excess belt webbing when a great deal of force is applied to the belt. The simplest load limiter is a fold sewn into the belt webbing. The stitches holding the fold in place are designed to break when a certain amount of force is applied to the belt. When the stitches come apart, the webbing unfolds, allowing the belt to extend a little bit more.

Pre-tensioners tighten the seatbelt by a prescribed amount in a severe crash, they hold the occupant in place by removing the seatbelt slack and preventing forward motion, pre-pre-tensioners are installed in either the buckle or reel side of the seatbelt and they are operated electrically along with airbags.

DETAILING OF PRACTICALS

Head light aiming

There are three general methods of aiming headlights:

- In the first type the vehicle is arranged to stand on level ground at about 8m from a vertical white screen on which the head light pattern can be studied.
- The tyres of the vehicle should be inflated properly as per specification and vehicle should carry the correct load.

- Each upper beam is adjusted separately after throwing it separately on the white screen.
- The headlights are provided with vertical and horizontal adjusting screws with the help of which the aiming can be adjusted.
- One head light is covered while the other being adjusted.
- The second type does not require much space. In this case a series of prisms and reflectors are used which throw an accurate miniature pattern of the headlight beam on a miniature screen only about 30 cm from the headlight.
- The screws or nuts of the mounting brackets must be turned or loosened in order to allow the swinging of the light up or down, or from one side to the other.
- For the vehicles with separate sets of head lights for the low and high beams, separate adjustment should be made for each headlight.
- The third type makes use of an optical headlight beam setter.
- This is a precise adjustment device with the help of which the alignment can be made easily. Moreover it does not require much space for carrying out the alignment.

Assessment Activity

1. Assignment on directional indicator circuit and horn circuit.
2. Viva voce about different types of lighting switches, instrument indicating lights, function of speedometer and odometer.
3. Class test

T E questions

1. In automobile wiring circuit, what is the role of a relay switch? (2)
2. Draw the wiring diagram of a) head lamp b) Direction indicator. (4)
3. After starting the engine Mr. Sunil noticed that the oil pressure indicator light was blinking continuously. What are the possible reasons for this blinking? Give your opinion. (3)

UNIT 4.5 IGNITION SYSTEM

INTRODUCTION

Ignition system is the most important electrical system used in petrol vehicles. The system serves to give electric spark for igniting the compressed air fuel mixture in the cylinder. The unit describes the types of ignition systems, their circuits, the functions of the components, concept of ignition advance etc. in detail. The concepts of basic electronics like semiconductors, diodes, transistor, thyristor etc. are also included. The advanced electronic ignition system, their types and working are elaborated in depth. After completion of this unit the student will be able to diagnose the various problems, their causes and remedies, maintenance and service of ignition systems.

LEARNING OUTCOMES

The learner:

- explains the purpose of ignition system
- classifies different types of ignition system
 - Battery coil ignition system
 - Magneto coil ignition system
 - Electronic ignition system
- draws and explain the working of battery coil ignition system
- draws and explain the working of magneto ignition system
- lists the components of ignition system and mention their functions
 - Battery
 - Ignition coil
 - Contact breaker
 - Condenser
 - Distributor
 - Spark plug
 - Magneto
- explains the construction and working of ignition coil
- explains the construction and working of spark plug
- explains the function and working of distributor

- describes the concept and function of centrifugal and vacuum advance system
- compares battery coil ignition system and magneto coil ignition system
- explains the concept and function of semiconductors, diodes, transistor, thyristor
- classifies electronic ignition system
 - Contactless distributor type
 - Distributor less type
 - Capacitor Discharge Ignition (CDI) system
 - Coil on plug
- draws the circuit diagram and explain the working of basic distributor type ignition
- draws the circuit diagram and explain the working of distributor less ignition system
- explains the working of CDI and coil on plug ignition system
- explains the working of different timers used in basic distributor type ignition
 - Pulse generator
 - Hall effect switch
 - Optical switch

UNIT IN DETAIL

4.5.1 FUNCTION

The function of the ignition system is to produce a spark in the engine cylinder towards the end of the compression stroke as per the firing order and with correct intensity to burn the air fuel mixture in a spark ignition engine.

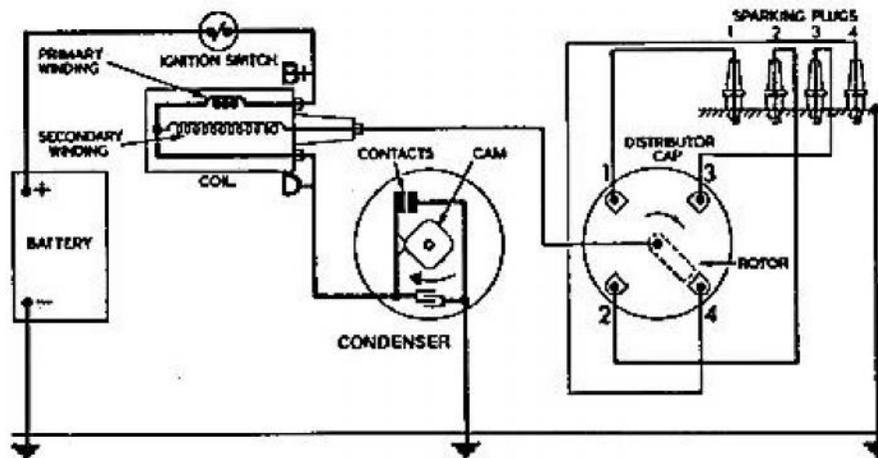
4.5.2 TYPES OF IGNITION SYSTEMS

1. Battery coil ignition system
2. Magneto ignition system
3. Electronic ignition system

- Contactless distributor type
- Distributor less type
- Capacitor discharger type

4.5.3 BATTERY COIL IGNITION SYSTEM

The figure shows line diagram of battery ignition system for a 4-cylinder petrol engine. It mainly consists of a 6 or 12 volt battery, ammeter, ignition switch, ignition coil, contact breaker, capacitor, distributor rotor, distributor contact points, spark plugs etc.



Note that the figure shows the ignition system for a 4-cylinder petrol engine- there are 4-spark plugs and contact breaker cam has 4-corners. (If it is for 6-cylinder engine it will have 6-spark plugs and contact breaker cam will be a perfect hexagon).

The ignition system is divided into two circuits:

- Primary Circuit :** It consists of 6 or 12 V battery, ammeter, ignition switch, primary winding it has 200-300 turns of 20 SWG (Sharps Wire Gauge) gauge wire, contact breaker, capacitor.
- Secondary Circuit:** It consists of secondary winding. Secondary Ignition System winding consists of about 21000 turns of 40 (SWG) gauge wire; then bottom end of which is connected to the bottom end of the primary and top end of the secondary winding is connected to the centre of distributor rotor. Distributor rotors rotate and make contacts with contact points and are connected to spark plugs which are fitted in cylinder heads (engine earth).

Working: When the ignition switch is closed and engine is cranked, as soon as the contact breaker closes, a low voltage current will flow through the primary

winding. It is also to be noted that the contact breaker cam opens and closes the circuit 4-times (for 4 cylinders) in one revolution. When the contact breaker opens the contact, the magnetic field begins to collapse. Because of this collapsing magnetic field, current will be induced in the secondary winding. And because of more turns @ 21000 turns of secondary, voltage goes upto 28000-30000 volts. This high voltage current is brought to the centre of the distributor rotor. Distributor rotor rotates and supplies this high voltage current to their proper spark plug depending upon the engine firing order. When the high voltage current jumps to the spark plug gap, it produces the spark and the charge is ignited; combustion starts; products of combustion expand and produce power.

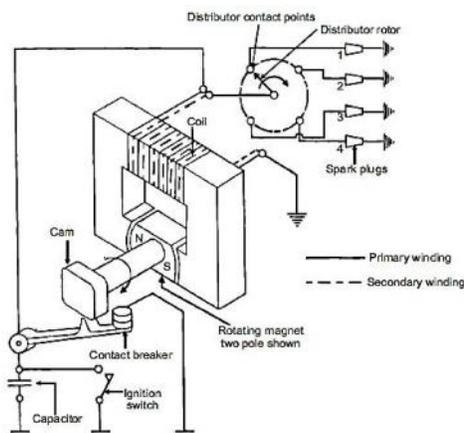
The function of the capacitor is to reduce arcing at the contact breaker (CB) points. Also when the CB opens the magnetic field in the primary winding begins to collapse. When the magnetic field collapses, capacitor gets full charge and then it starts discharging and helps in building up of voltage in the secondary winding. The contact breaker cam and distributor rotor are mounted on the same shaft. In 2-stroke cycle engines these are motored at the same engine speed. And in 4-stroke cycle engines they are motored at half the engine speed.

4.5.4 MAGNETO IGNITION SYSTEM

It is a special type of ignition system with its own electric generator to provide the required necessary energy for the vehicle (automobile) system. It is mounted on the engine and replaces all components of the coil ignition system except the spark plug. A magneto when rotated by the engine is capable of producing a very high voltage and doesn't need a battery as source of external energy.

A schematic diagram of a high tension magneto ignition system is shown in the figure. The high tension magneto ignition system incorporates the windings to generate the primary voltage as well as to set up the voltage and thus does not require a battery to operate the spark plug. Magneto ignition system can be either rotating armature type or rotating magneto type.

1. In the first type, the armature consisting of the primary and



secondary windings rotate between the poles of a stationary magnet.

2. In the second type, the magnet revolves and windings are kept stationary.
3. A third type of magneto called the polar inductor type is also in use. In the polar inductor type magneto both the magnet and the windings remain stationary but the voltage is generated by reversing the flux field with the help of soft iron polar projections, called inductors.

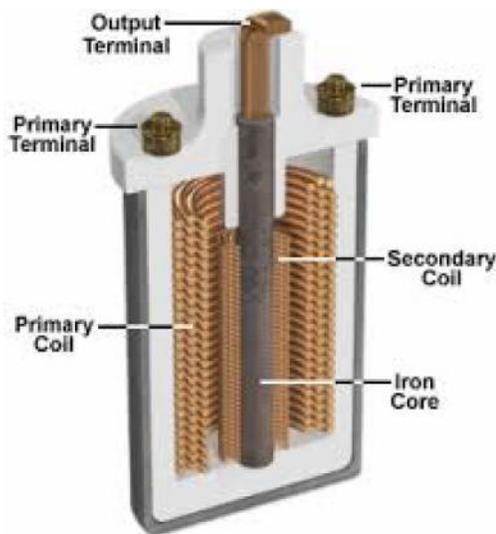
The working principle of the magneto ignition system is same as that of the coil ignition system. With the help of a cam, the primary circuit flux is changed and a high voltage is produced in the secondary circuit.

4.5.5 COMPONENTS OF IGNITION SYSTEM

The main components of ignition system are

1. Battery
2. Ignition coil
3. Contact breaker
4. Condenser
5. Distributor
6. Spark plug
7. Magneto

4.5.6 IGNITION COIL



The ignition coil is simply a transformer. It serves to convert the relatively low battery voltage into high voltage. In this, the secondary is first wound over the core and then the primary over this. The inner end of the secondary winding is connected to the H.T terminal, while the other end of the secondary is connected to the primary winding. The ends of primary winding are connected to the L.T terminals of the coil, one of which is connected further to the contact breaker and other to the ignition switch.

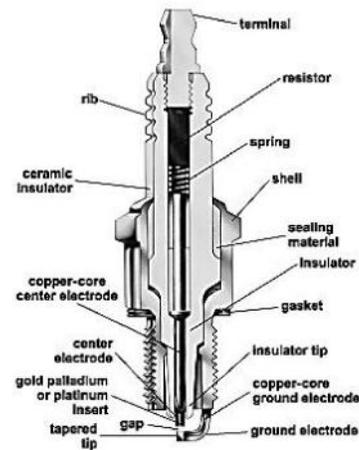
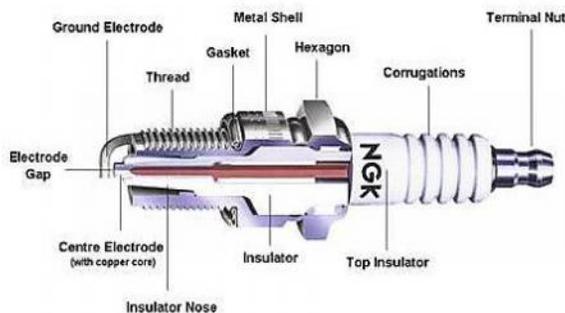
The core assembly is put in a steel casing. This casing is fitted with a cap of moulded insulating materials.

4.5.7 SPARK PLUGS

A spark plug is composed of a shell, insulator and the central conductor. It passes through the wall of the combustion chamber and therefore must also seal the combustion chamber against high pressures and temperatures without deteriorating over long periods of time and extended use.

Spark is produced across the spark plug in an ignition system. The spark plug has two electrodes with a gap in between. The central electrode is connected to the high tension wire coming from the distributor. The ground electrode is earthed to the engine metal body. A high tension current at 20,000 V is required to overcome the gap between the electrodes. Thus, spark is produced at the correct moment inside the cylinder and is used to ignite the mixture of petrol and air inside the cylinder.

CONSTRUCTION



The above figures show clearly the construction of a spark plug. The plug has three main parts, the centre electrode, the ground electrode and the insulator separating them. Besides these, there are the body shell, the sealing ring and the gasket washer. The upper end of the centre electrode is connected to the spark plug terminal, where H.T. cable from the ignition coil in case of single cylinder engines (or from distributor in case of multi-cylinder engines) is connected. The lower end of the centre electrode projects beyond the insulator to form a gap with the ground electrode. The insulator is meant to fulfill the following functions;

- (i) To insulate the centre electrode from body shell, thereby preventing the leakage of high voltage surge from leaking to earth within the shell.

- (ii) To control the working temperature of the centre electrode by suitably adopting the thermal conductivity of the insulating material, its shape and the length of the heat path, while designing the spark plug for a given engine.

The body shell serves to house the electrodes and the insulator. Gas-tight seal is necessary to prevent the hot gas from leaking between the insulator and the body shell and between the insulator and the central electrode. Such seals may be of different types, e.g. solid ring, dry powder metal powder fused into glass etc. Besides above the hot gas from the combustion chamber may also leak between the plug and the cylinder head. To seal this, a flat ring gasket washer is commonly used.

In some modern spark plugs, the centre electrode is made in two pieces. By doing so the designer can use different metals to suit best the different requirements of the upper piece which has to be connected to the high tension cable and the lower piece which has to go into the combustion chamber. The spark plugs may be long reach or short reach type depending upon the length of threaded portion and should be used only in the corresponding hole in the combustion chamber as described earlier

From the heat dissipation point of view, the spark plugs are again divided into two classes, viz. 'hot' or hard and cold or soft. Hot plug runs hotter than the cold plug because the path of heat dissipation of the cooling water in the jackets is longer in the hot plug than in the cold plug. Some cold plugs have a copper core in the centre electrode to help carry heat from the tip of the electrode. Cold plugs are generally used in heavy duty, high speed engines where high temperatures are encountered.

4.5.8 DISTRIBUTOR



The distributor is rotated by the distributor shaft, which in turn is driven by the camshaft of the engine. The distributor has a rotor which rotates at half the speed of the engine crankshaft. The distributor itself rotates at the same speed as the camshaft.

The four distributor points lead to the corresponding spark plugs. When the rotating arm comes in contact with these points a high tension current passes through the rotor to the corresponding spark plug, causing a spark at the spark plug. The

connections between the distributor points and the spark plugs are arranged in a particular order. This order is the same as the firing order of the engine.

4.5.9 IGNITION ADVANCE

Ignition timing is very important, as the charge is to be ignited just before (few degrees before TDC) the end of compression. When the charge is ignited, it will take some time to come to the required rate of burning.

The purpose of spark advance mechanism is to assure that under every condition of engine operation, ignition takes place at the most favourable instant in time i.e. most favorable from a standpoint of engine power, fuel economy and minimum exhaust dilution. By means of these mechanisms the advance angle is accurately set so that ignition occurs before TDC point of the piston. The engine speed and the engine load are the control quantities required for the automatic adjustment of the ignition timing. Most of the engines are fitted with mechanisms which are integral with the distributor and automatically regulate the optimum spark advance to account for change of speed and load. The two mechanisms used are :

- (a) Centrifugal advance mechanism:- it advances spark according to the engine speed.
- (b) Vacuum advance mechanism:- it advances spark according to the engine load.

4.5.10 COMPARISON BETWEEN BATTERY AND MAGNETO IGNITION SYSTEMS

Battery Ignition	Magneto Ignition
Battery is a must.	No battery needed.
Battery supplies current in the primary circuit	Magneto produces the required current for primary circuit.
A good spark is available at low speed.	During starting the quality of spark is poor due to slow speed.
Occupies more space.	Very much compact.
Recharging is a must in case the battery gets discharged.	No such arrangement required.
Mostly employed in car and bus for which it is required to crank the engine.	Used on motorcycles, scooters, etc.
Battery maintenance is required.	No battery maintenance problems.

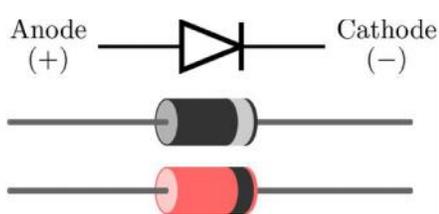
4.5.11 BASIC ELECTRONICS

SEMICONDUCTOR

There are some substances which are not good conductors. They are not good insulators too. Such substances are called semiconductors. In other words, a semiconductor is halfway between a conductor and a non-conductor. Transistors used in automobile alternator regulator and ignition circuits, are prepared using semiconductors.

One example of a semiconductor material is germanium. Silicon also is a semiconductor material. Semi-conductors are of two types; N- type semiconductor and P-type semiconductor.

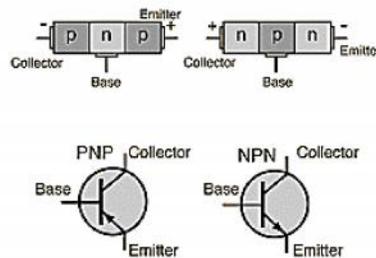
DIODE



Diode is a device which permits electric current to flow through only one direction, and it will not allow the current to flow in the other direction. Diodes are useful to rectify AC to DC. Alternators in automobiles use the diodes for the rectification of an AC supply.

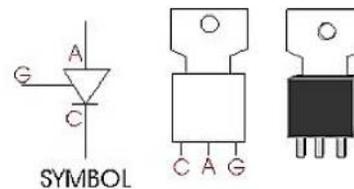
TRANSISTOR

A transistor consists of three alternate sections of N-type and P-type materials. There are two PN⁺- junctions. It may be a NPN transistor or a PNP transistor. This is shown in the figure given along side. The PNP transistor is predominantly used in the central section is called the base which controls the current through the transistor. The section at one end is called the emitter and the section at the other end is called the collector. This depends upon their functioning.



THYRISTORS

Thyristor is usually a semiconductor having three or more junctions. Such a device operates as a switch without any bias. Further it can be constructed to have voltage ratings of several hundred volts. It can also be made to have

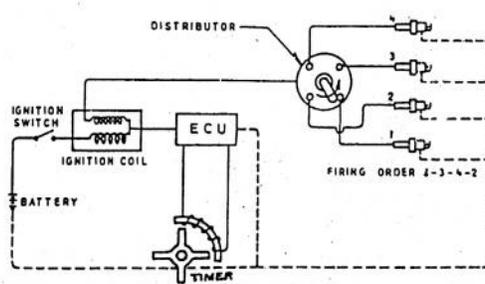


current ratings from a few amperes to very nearly thousand amperes. The family of thyristors consists of PNP diode (Shockley Diode), SCR, LASCR, TRIAC, DIAC, UJT etc.

4.5.12 TYPES OF ELECTRONIC IGNITION SYSTEM

1. Contactless distributor type
2. Distributor less type
3. Capacitive Discharge Ignition (CDI)
4. Coil on plug type

4.5.13 CONTACTLESS DISTRIBUTOR TYPE IGNITION SYSTEM



The workings of the basic distributor type electronic system is similar to the conventional electrical ignition system, except that in the electronic ignition system a timer is employed in the distributor instead of contact breaker. This timer may be a pulse generator or a Hall-effect

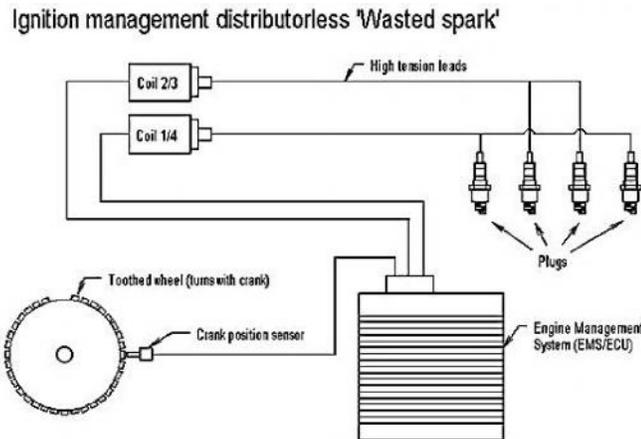
switch or an optical switch which triggers the ignition module and is called the Electronic Ignition Control Unit (E.C.U.). This control unit primarily contains transistor circuit whose base current is triggered off and on by the timer which results in the stopping and starting of the primary current. Other than this, the electronic ignition system works similar to the conventional electrical point type system.

4.5.14 DISTRIBUTORLESS IGNITION SYSTEM

In this system, the spark plugs are fired directly from the coils. The spark timing is controlled by an Ignition Control Unit (ICU) and the Engine Control Unit (ECU). The distributor less ignition system may have one coil per cylinder, or one coil for each pair of cylinders.

Some popular systems use one ignition coil per two cylinders. This type of system is often known as the waste spark distribution method. In this system, each cylinder is paired with the cylinder opposite it in the firing order (usually 1-4, 2-3 on 4-cylinder engines or 1-4, 2-5, 3-6 on V6 engines). The ends of each coil secondary leads are attached to spark plugs for the paired opposites.

These two plugs are on companion cylinders, cylinders that are at Top Dead Center (TDC) at the same time. But, they are paired opposites, because they are always at opposing ends of the 4 stroke engine cycle. When one is at TDC of the compression stroke, the other is at TDC of the exhaust stroke. The one that is on compression is said to be the event cylinder and one on the exhaust stroke,



the waste cylinder. When the coil discharges, both plugs fire at the same time to complete the series circuit.

Since the polarity of the primary and the secondary windings are fixed, one plug always fires in a forward direction and the other in

reverse. This is different than a conventional system firing all plugs in the same direction each time. As additional energy is demanded; the coil design, saturation time and primary current flow are also different. This redesign of the system allows higher energy to be available from the distributor less coils, greater than 40 kilovolts at all rpm ranges.

The Direct Ignition System (DIS) uses either a magnetic crankshaft sensor, camshaft position sensor, or both, to determine crankshaft position and engine speed. This signal is sent to the ignition control module or engine control module which then energizes the appropriate coil.

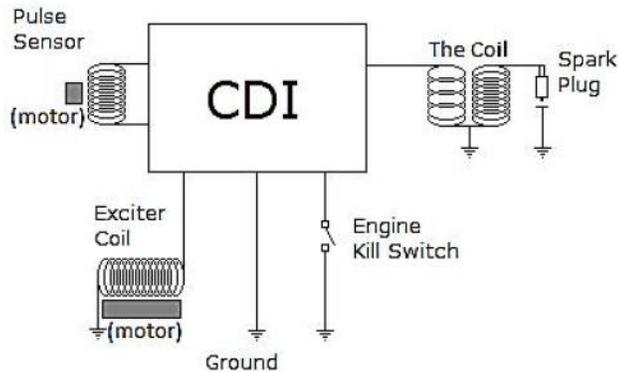
The advantages of distributor less ignition are:

- No timing adjustments.
- No distributor cap and rotor.
- No moving parts to wear out.
- No distributor to accumulate moisture and cause starting problems.
- No distributor to drive thus providing less engine drag.

The major components of a distributor less ignition are:

ECU or Engine Control Unit, ICU or Ignition Control Unit, Magnetic Triggering Device such as the Crankshaft Position Sensor and the Camshaft Position Sensor Coil Pack

4.5.15.1 CAPACITOR DISCHARGE IGNITION (CDI)

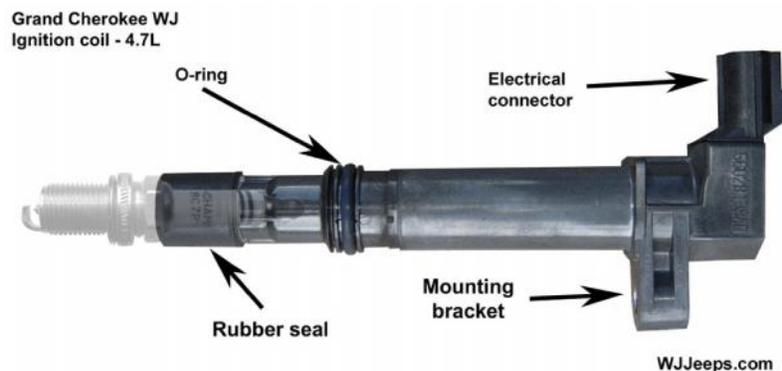


This system is mainly used in two wheelers, three wheelers and racing cars. The main advantage of this system is the availability high secondary voltage at starting. This system stores high voltage electrical energy in a capacitor until the trigger releases the charge to the

primary winding of a coil. The coil in this case is a pulse transformer instead of normal energy-storage device. To provide a voltage of about 400 V to the capacitor, the battery current is inverted to AC and then voltage is raised through a transformer. When the spark is required, the trigger releases the energy to the coil primary winding by 'firing' a thyristor, which is a type of transistor switch. Once the thyristor is triggered, it continues to pass current through the switch even after the trigger current has ceased. Due to sudden discharge of the high voltage energy to the primary winding, a rapid rise in the magnetic flux of the coil takes place, which induces a voltage in excess of 40 KV in the secondary circuit to produce a high intensity short duration spark.

4.5.15.2 COIL ON PLUG

Distributorless Ignition Systems (DIS) have been around for more than two decades, but in recent years the trend has been to multi-coil systems such as Coil-On-Plug (COP) or Coil-Per-Cylinder (CPC) ignition systems, and Coil-Near-Plug (CNP) ignition systems.



Coil On Plug systems have become the hot setup for a number of packaging, performance, emissions and maintenance reasons. Placing individual ignition coils directly over each spark plug eliminates the need for long, bulky (and expensive) high voltage spark plug cables. This reduces radio frequency interference, eliminates potential misfire problems caused by burned, chaffed or loose cables, and reduces resistance along the path between the coil and plug. Consequently, each coil can be smaller, lighter and use less energy to fire its spark plug.

From a performance standpoint, having a separate coil for each cylinder gives each coil more time to recharge between cylinder firings. With single coil distributor systems, the coil must fire twice every revolution of the crankshaft in a four cylinder engine, and four times in a V8. With a multi-coil system, each coil only has to fire once every other revolution of the crankshaft. This provides more saturation time for a hotter spark, especially at higher rpm when firing times are greatly reduced. The result is fewer misfires, cleaner combustion and better fuel economy.

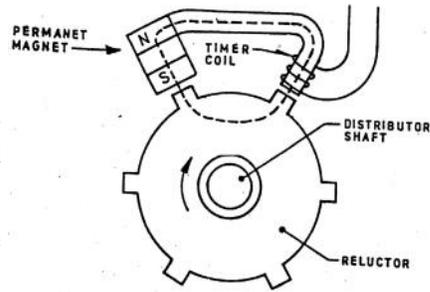
According to the original equipment suppliers who make multi-coil ignition systems, having a separate coil for each cylinder also improves the engine's ability to handle more exhaust gas recirculation to reduce oxides of nitrogen emissions (important with today's low emission vehicle standards). A hotter spark also makes spark plugs more resistant to fouling and helps 100,000 mile plugs go the distance. A multi-coil ignition system also improves idle stability and idle emissions too.

In most of the older DIS ignition systems, an electronic module was part of the coil pack assembly and controlled the switching of the coils on and off. On most of the newer systems, the switching function is handled by the power train control module, though there may be some additional electronics and diodes built into the top of each coil. The PCM receives a basic timing signal from the crankshaft position sensor and sometimes a camshaft position sensor to determine engine speed, firing order and timing. It then looks at inputs from the throttle position sensor, airflow sensor, coolant sensor, MAP sensor and even the transmission to determine how much timing advance to give each plug. Most of today's multi-coil ignition systems are capable of making timing adjustments between cylinder firings which makes these systems very responsive and quick to adapt to changing engine loads and driving conditions.

4.5.16 IGNITION TIMERS

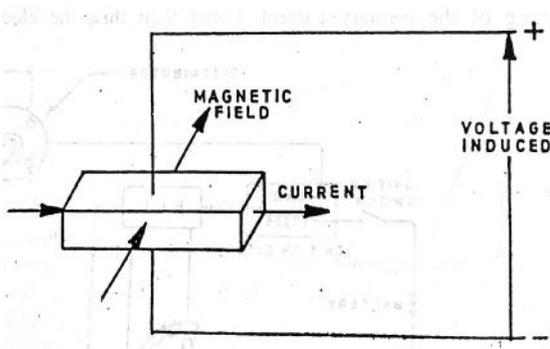
Pulse generator

A pulse generator is used to generate an alternating voltage which is used, instead of contact breaker points, to control the make and break of the current build-up in the primary winding of the ignition coil.



A magnetic (inductive) pulse generator consists of three main components, viz. a permanent magnet, a timer coil and a reluctor. Out of these the first two are stationary, while the reluctor (also called timer core or armature) which is in the form of a toothed wheel, is mounted on the distributor shaft. It has the same number of teeth as the number of engine cylinders. As the reluctor wheel rotates its teeth come very close to the pole plates of the permanent magnet as shown in the figure. This reduces the reluctance of the air gap between the reluctor tooth and the timer coil and the other reluctor tooth and the magnet. This results in a strong magnetic field around the timer coil permitting the control current to flow across the emitter-base circuit through the timer coil to the electronic control unit where the primary current in the emitter-collector circuit flows. This allows the ignition coil to build up a strong magnetic field. However, when the reluctor tooth passes away from the timer coil, the wide air gap offers high reluctance and results in weak magnetic field for the timer coil, which reverses the induced voltage and turns off the base current and hence the emitter-collector (primary) current of the transistor. This collapses the magnetic field in the ignition coil to produce high voltage at the spark plug.

Hall Effect pulse generator



The principle of operation of this type of pulse generator is based on the Hall effect. When a chip made of semiconductor material carries a signal current across it and is exposed to a magnetic field, a small voltage called the Hall voltage is generated between the chip edges at 90 degrees to the path taken by the

signal current. The Hall voltage is altered due to the change in the magnetic field strength and this effect can be used as a switching device to trigger the ignition point by varying the Hall current.

Optical pulse generator

This type works on sensing the spark point by using a shutter to interrupt a light beam projected by a light-emitting diode (LED) on to a phototransistor.

The principle of this type of trigger is that an invisible light, at a frequency close to infra-red, is emitted by a gallium arsenide semi-conductor diode and its beam is focused by hemispherical lens to a width of about 1.25 mm at the chopping point. A steel chopper, having blades to suit the number of cylinders and dwell period, is fixed to the distributor spindle. This controls the time periods of the light falling on the silicon phototransistor detector. This transistor forms the first part of a Darlington amplifier, which builds up the signal and includes a means of preventing timing change due to variation in line voltage or due to dirt accumulation on the lens. The signal sent by the generator to the control module switches on the current for the primary coil. Therefore, when the chopper cuts the beams the primary circuit is broken and a spark is produced at the plug.

DETAILING OF PRACTICALS

SPARK PLUG

- Remove and clean the spark plugs "one at a time" from your engine using a ratchet wrench with a spark plug socket.
- Label and number each wire with tape and its matching hole with the same number, then you could remove all of the spark plugs at once. Don't remove the wire from the distributor unless you accurately number each outlet to match the plug and its cable.
- Brush off any visible dirt and debris from your spark plugs with a clean rag.
- Clean the firing end of the spark plugs with a quick drying liquid. 90% strength alcohol, brake or carburetor/injector cleaner or mineral spirits are good choices that all work well when cleaning spark plugs.
- Blow any excess particles while cleaning spark plugs with low air pressure.
- Apply a dry compound to clean any excess dirt from the spark plugs that might not be visible to the eye.
- Blast the clean spark plugs again with the pressurized air. This extra blast of air simply eliminates any debris left on the spark plugs.

- Use a wire brush to clean the threads of the spark plugs.
- Gap the clean spark plugs to your automobile's specifications using a spark plug gap tool.
- Remove dirt oil and grime from each of the spark plug holes with a rag.
- If the holes are extremely dirty, you can use the same solution to clean them that you used for your spark plugs.
- Reinstall the clean spark plugs into the spark plug holes, tightening to the correct torque. Double-check that each wire/cable is replaced onto the correct spark plug as your go.
- Start your vehicle to see how well it runs now that the spark plugs are clean.

Assessment Activity

1. Seminar on battery coil ignition and magneto ignition systems
2. Assignment on construction and working of ignition coil and spark plug
3. Debate on 'Battery coil ignition is better than Magneto ignition system'
4. Seminar on Distributer less Ignition System and CDI system
5. Class test

TE QUESTIONS

1. Fill in the blanks
In two wheelers----- types of ignition system is used (1)
2. State true or false
The function of an ignition coil is to step up the voltage from a primary source.
(1)
- 3) Ignition coil, contact breaker, distributor, spark plugs, battery etc. are the components of an ignition system. Identify the type of ignition system. Draw the wiring diagram of it by joining these components and explain its working (6)
- 5) The function of a spark plug is to produce spark to ignite the air fuel mixture. But the spark plugs of different size engines are different. Why? (2)
- 6) In a distributor less ignition system, the current to spark plug is not supplied by a distributor. Then how does the spark plug get its current according to the firing order? (3)
- 7) Give short notes on: (4)
 - a) Capacitor Discharge System (CDS)
 - b) Coil on plug (COP)

4.6 EMISSION CONTROL SYSTEM

INTRODUCTION

Vehicle emission control system is the study of reducing the motor vehicle emission. Emissions of many air pollutants have been shown to have a variety of negative effect on public health and the natural environment. The unit describes the sources of automotive pollutions, euro norms and their implementation in India. The workings of various emission control systems are also explained in this unit.

LEARNING OUTCOMES

The learner;

- describes the necessity of emission control
- identifies the sources of automotive emission
- states EURO III and IV norms of petrol and diesel vehicles and their implementation year in India
- explains the working of positive crankcase ventilation
- explains the working of vapour recovery system
- explains the working of exhaust gas recirculation system
- explains the working of air injection system
- explains the working of Pulse Air Injection Reactor (PAIR) system
- explain the working of two way and three way catalytic converter

UNIT IN DETAIL

4.6.1 NECESSITY OF EMISSION CONTROL

Air pollution can be defined as the addition to our atmosphere any material which will have a serious effect on life upon our planet. The main pollutants contributed by automobiles are carbon monoxide (CO), unburned hydrocarbons (UBHC), oxides of Nitrogen (NOX), sulphur oxides and lead and other particulate emissions. In advanced countries and cities, air pollution by automobiles is about 50% of the global air pollution. Pollutants from a single car are not too much. But if we consider the large number of cars, and with their number rising rather too rapidly, the increase in pollutants is by millions of tonnes. Thus it is clear that serious attempts should be made to conserve earth's environment from degradation. Since the last twenty years, much work has been done to control emission from IC engines.

4.6.2 SOURCES OF AUTOMOBILE EMISSION

There are 3 possible sources of atmospheric pollutions from an IC Engine. They are evaporative loss, crank case blow by and tailpipe exhaust. The evaporative losses are the direct losses of raw gasoline from the engine fuel system; the blow by gases is the vapours and gases leaking into the crank case from the combustion chamber and the pollutants from the exhaust pipes are due to incomplete combustion.

4.6.3 EURO NORMS IN INDIA

Bharat stage emission standards are emission standards instituted by the Government of India to regulate the output of air pollutants from internal combustion engineering equipment, including motor vehicles. The standards and the timeline for implementation are set by the Central Pollution Control Board under the Ministry of Environment & Forests and Climate Change.

The standards based on European regulations were first introduced in 2000. Progressively stringent norms have been put to effect since then. All new vehicles manufactured after the implementation of the norms have to be compliant with the regulations. From October 2010 onwards Bharat Stage (BS) III norms have been enforced across the country. Since April 2010, Bharat Stage IV emission norms have been put to vogue in 13 cities in India. The Indian government announced that the country would skip the Euro V norms altogether and adopt Euro VI norms by 2020.

While the norms help in bringing down pollution levels, it invariably results in increased vehicle cost due to improved technology & higher fuel prices. However,

this increase in the private cost is offset by savings in health costs for the public, as there is lesser amount of disease causing matters and pollution in the air.

The below tables shows the details

Standards	Reference	Date	Region
India 2000	Euro 1	2000	Nationwide
Bharat Stage II	Euro 2	2001	National Capital Region(NCR), Mumbai, Kolkata, Chennai
		2003-04	NCR, 11 cities
		2005-04	Nationwide
Bharat Stage III	Euro 3	2005-04	NCR, 11 cities
Bharat Stage IV	Euro 4	2010-04	Nationwide
		2010-04	NCR, 13 cities
		2015-07	Above plus 29 cities mainly in the state of Hayana, Uttar Pradesh, Rajasthan and Maharastra
		2015-10	North India plus bordering districts of Rajasthan (9 States)
		2016-04	Western India plus parts of South and East India (10 States and Territories)
		2017-04	Nationwide
Bharat Stage V	Euro 5	N.A	
Bharat Stage VI	Euro 6	2020-04	Nationwide

Emission Norms for passenger cars

Norms	CO(g/Km)	HC+NO ₂ (g/Km)
Bharat Stage-III	2.3	0.35(combined)
Bharat Stage-IV	1.0	0.18(combined)

Emission norms for Heavy Diesel vehicles

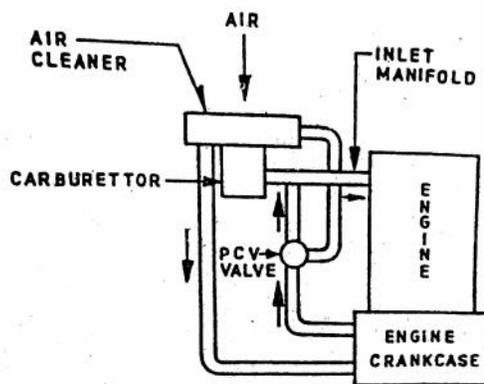
Norms	CO(g/kmhr)	HC(g/kmhr)	NO ₂ (g/kmhr)	PM(g/kwhr)
Bharat Stage-III	2.1	1.6	5.0	0.10
Bharat Stage-IV	1.5	0.96	3.5	0.02

Emission Norms for 2/3 wheeler

Norms	CO(g/Km)	HC+NO ₂ (g/Km)
Bharat Stage-III	1.0	1.0

4.6.4 POSITIVE CRANK CASE VENTILATION

In order to remove blow by gases, the crank case must be ventilated. In earlier engines, the crankcase was ventilated by an opening at the front of the engine and vent tube at the rear. The forward motion of the vehicle and rotation of crankshaft caused air to flow through and remove blow by gases, water and



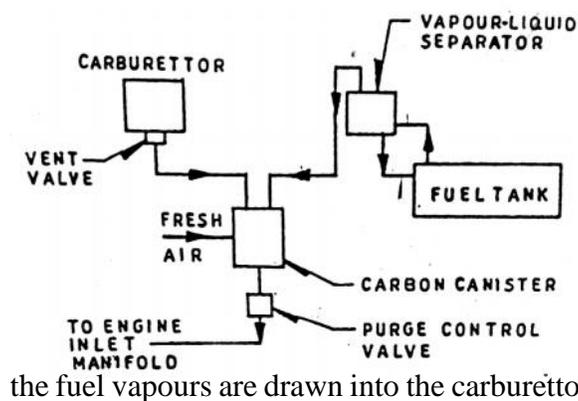
fuel from crankcase, which appear when the engine is cooled. The discharge of fuel vapours or partly burnt gases into the atmosphere cause air pollution. For preventing air pollution, the modern engines have a closed system known as Positive Crank-case ventilation (PCV) system. In this system filtered air from the air cleaner is drawn through the crank

case from where it picks up water, fuel vapours and blow-by gases. The air then flows back to the induction manifold and enters the engine where the unburned fuel is burned.

A positive crank case ventilation (PCV) valve is placed between the crankcase and induction manifold to prevent the air flowing through induction manifold during idling. This automatic valve allows only a small amount of air to flow through idling. When the engine speed increases, fall in manifold vacuum allows the PCV valve to open wide to allow more air through the crankcase.

4.6.5 VAPOUR RECOVERY SYSTEM (VRS)

Petrol in the tank & carburetor evaporates away through the vent holes due to temperature effects. To prevent this Vapour Recovery System (VRS) is incorporated with the fuel system of petrol engine. A vapour recovery system captures these petrol vapours and prevents them from escaping into air thereby reducing pollution. Almost all modern cars are equipped with VRS under different names such as Vapour Saver System (VSS), Vehicle Vapour Recovery (VRR), Evaporation Control System (ECS) and Evaporation Emission System (EES).

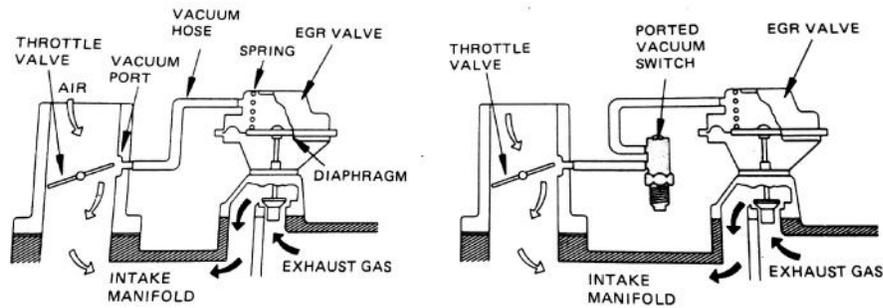


A VRS consists of a canister filled with activated charcoal is placed between the carburetor and fuel tank. Petrol vapours pass through the canister and are trapped in there. When the engine is started, induction manifold vacuum acts at the canister and the fuel vapours are drawn into the carburettor to mix up with fresh charge.

A stand pipe assembly between the fuel tank and canister is used to separate petrol vapours from the liquid petrol. The petrol tank contains a sealed cap of pressure and vacuum type. The cap valve opens when too much pressure develops in the tank. It also opens to admit air as fuel is withdrawn.

4.6.6 EXHAUST GAS RECIRCULATION (EGR) SYSTEM

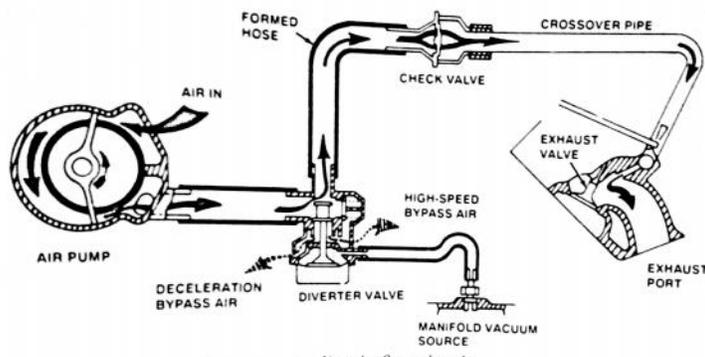
In this system a portion of exhaust gas is re-circulated to the cylinder intake charge. This reduces the peak combustion temperature, since the inert gas serves as a heat sink. This also reduces the quantity of oxygen available for combustion.



The exhaust gas for recirculation is directly taken from the stove area through an orifice, passed through the butterfly control valve for regulation of the rate and ducted down to the intake port. The recycle rate control valve is connected to the throttle shaft by an appropriate linkage and the amount of valve opening is regulated by throttle position. The link is designed so that recycled exhaust is normally shut off during idle to prevent rough engine operation. This is also shut off during full throttle acceleration to prevent loss of power when maximum performance is needed. There will be a little effect on NO₂ emission even if the above arrangement is not made because NO₂ concentration is idle and full throttle are already very low.

4.6.7 AIR INJECTION SYSTEM

If compressed air is passed into combustion chamber in addition to air fuel charge from the carburetor, better combustion and hence, reduced hydrocarbon and carbon monoxide emissions will result. This will also give a variable power boost with some saving in fuel, but extra equipment in the form of air compressor and air valves will raise the cost very much. In this system compressed air is injected into each exhaust port slightly down stream of the exhaust valve. The injected air mixes with very hot, fully and partially burned exhaust gases and causes oxidation of the CO and hydrocarbons.

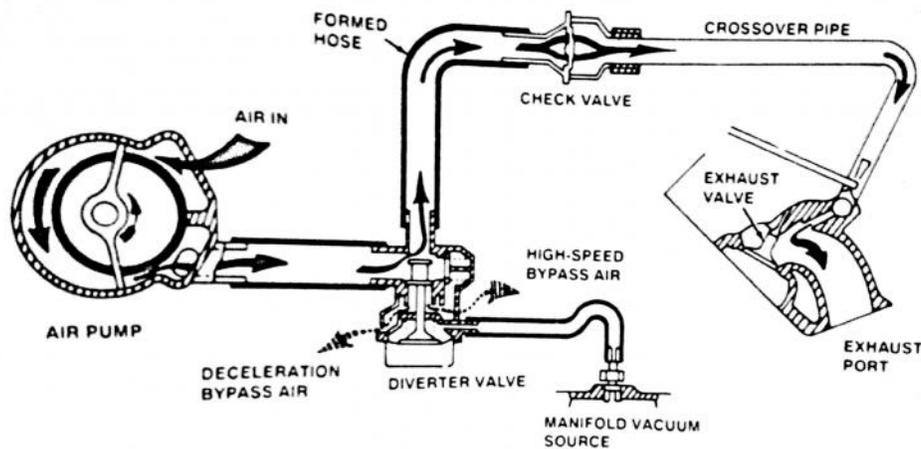


Such an air injection system is used to reduce the hydrocarbons and carbon monoxide is shown in the figure

Fresh air from the belt driven vane pump goes through a diverter valve,

one-way check valve and piping into the exhaust manifold. This fresh air supplies excess oxygen to oxidize HC and CO into CO₂ and watervapour. Check valve is meant to prevent backflow whenever exhaust pressure is greater than air pump pressure. This may happen in the event of pump belt failure, excessively high exhaust system pressure or rupture of air hose. The diverter valve is operated by a vacuum diaphragm. When idling or in part or full throttle conditions, the manifold vacuum is not enough to move the diverter valve diaphragm. However, on sudden deceleration, manifold vacuum increases to lift the diverter valve diaphragm thereby diverting the air to the atmosphere or air cleaner. High manifold vacuum draws rich mixture from the carburettor which is too difficult to ignite in the combustion chamber, and because of which it goes out in the exhaust manifold. When air is pumped into the exhaust manifold, the mixture becomes lean and would ignite when hot exhaust gases are released next from the cylinder. This may result in a dangerous explosion into the exhaust system. The diverter valve by diverting the air flow under conditions prevents this backfiring. Air injection systems work more precisely when computer control is used. This method of exhaust cleaning does not affect engine efficiency.

4.6.8 PULSE AIR INJECTION REACTOR (PAIR) SYSTEM



Some engines do not require all the air supplied by the pump in the air injection system. Such engines may be provided with pulse air system. The system employs the pressure pulses of the exhaust to pull air into the exhaust system. When exhaust valve opens, exhaust gases rush out at high speed. Due to their inertia, more exhaust is pulled from the cylinders as the exhaust valve closes, causing there by a partial vacuum in the exhaust ports. Negative pressure in the exhaust manifold moves air from the air cleaner through the check valves and pipes in the exhaust

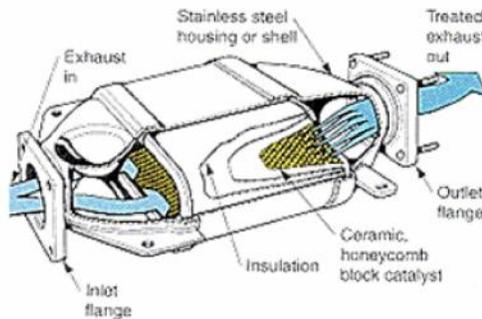
ports. This system has an advantage that no engine power is consumed to run a belt driven pump. Such systems are usually employed on engines with catalytic converters.

4.6.9 CATALYTIC CONVERTERS

A catalytic converter is a cylindrical unit about the size of a small silencer and is installed into the exhaust system of vehicle such as a car, scooters etc. It is placed between the exhaust manifold and the silencer. Inside the converter there is a honeycomb structure of a ceramic or metal, which is coated with alumina base material and thereafter a second coating of precious metals like platinum, palladium or rhodium or combinations of the same. This second coating serves as a catalyst.

A catalyst is a substance which causes a chemical reaction that normally does not happen in the given conditions. As a result of catalytic reaction, as the exhaust gases pass over the converter substrate and toxic gases such as CO, HC and NO₂ are converted into harmless CO₂, H₂ and N₂. There are two types of catalytic converters:

1. A twoway converter, which is used to control only CO and HC emissions by oxidation.
2. A three way converter, which is used almost in all petrol cars. It controls CO and HC by oxidation as well as NO₂ by reduction.



Three-way converters (TWC) are now commonly being used for petrol engines and operate in two stages. The first converter stage uses rhodium to reduce the NO₂ in the exhaust into nitrogen and oxygen. In the second converter stage, platinum or palladium acts as oxidation catalyst to change HC and CO into harmless water and CO₂. For

supplying the oxygen required in the second stage, air is fed into the exhaust after the first stage. The catalyst allows the oxidation of the exhaust gases at a much lower temperature than in the combustion chamber. With temperatures exceeding 300°C, the steady-state conversion efficiencies of a new converter are about 98% for carbonmonoxide and about 95% for hydrocarbons. The outgoing exhaust gases in a petrol engine are at a temperature of 300-400°C during idling and may reach 900°C under full-load conditions. Converters should be best operated between 400°C and 800°C. The temperature, at which catalyst is 50% effective, is known as the light-off temperature, which should be as low as possible.

DETAILING OF PRACTICALS

PCV Valve

Procedure

Car manufacturers suggest that PCV valves be cleaned or replaced after about 20,000 to 50,000 miles of driving. Consult your owner's manual to see where the PCV valve is located on your vehicle and what the recommended service intervals are. The valve is usually replaced during scheduled tune-ups. There are several ways to check whether your PCV valve is functioning properly.

Method 1: Remove the PCV valve from the valve cover with the hose still attached. Then place your finger over the open end of the hose. If the valve's working well, you will feel strong suction. Try shaking the valve. If it's unobstructed, it should rattle. If it's fouled, the rattle will be indistinct or non-existent.

Method 2: Remove the cap from the oil filler hole on the valve cover and place a stiff piece of paper over the opening. If your PCV valve is working properly, the paper should be sucked against the hole within seconds.

If the valve doesn't seem to be working properly, before you go to the trouble to replace it, try cleaning it to see if that makes a difference.

Clean it yourself by immersing it in carburettor cleaner. There should be no gummy deposits or discolouration on a clean valve. If your PCV valve must be replaced, buy a new valve, remove the old one, and insert the new one in its place.

Assessment Activity

1. Seminar on Emission Control Systems

Divide the students into 5 groups. Assign the groups to present any one of the emission control systems as listed below.

Group No.	Name of Emission Control System
I	Positive crank case ventilation
II	Vapour recovery system
III	Exhaust gas recirculation system
IV	Air injection system
V	Catalytic convertor

2. Class test

TE QUESTIONS

1. The common catalyst used in automobile emission control system is
.....
(1)
2. Name any two constituents of automobile exhaust gas. (2)
3. There are various methods to control the emission from automobile. Identify any one type and explain about it. (6)

EXTENDED ACTIVITIES

- Field Visit
- OJT
- Survey
- Camp
- Vocational expo
- Production cum training centre (PTC)

LIST OF PRACTICALS

4.1 AUTOMOTIVE BATTERY

1. Removing and installing lead acid battery from a vehicle.
2. Cleaning battery top, terminals, cable clamps and apply petroleum jelly on terminals.
3. Conduct different battery testing
 - a. Specific gravity test
 - b. Open voltage test
 - c. Load test.
 - d. High rate discharge test
4. Charging of battery
 - a. Constant voltage
 - b. Constant current
 - c. Booster charging

4.2 CHARGING SYSTEM

1. Study the charging circuit and its various components.
2. Remove, Dismantle, inspect, service and refit the alternator.
3. Replace the drive belt of alternator and adjust the tension of belt.
4. Checking of output current and voltage from alternator, check the condition of current and voltage regulator and also check the cutout relay.

4.3 STARTING SYSTEM

1. Study the starting circuit and its various components
2. Inspect the circuit of starting system
3. Study the trouble shooting of starting system
4. Remove, dismantle, inspect, service and refit starting motor
5. Model test connection between booster battery and dead battery for jump starting
6. Familiarize the components of solenoid switch; inspect and service it

4.4 LIGHTING SYSTEMS AND ELECTRICAL EQUIPMENTS

1. Do the wiring circuit of:
 - b) Head lamp, park lamp and tail lamp

- c) Horn
 - d) Indicators
 - e) Wind shield wiper
2. Replacing of head lamp, tail lamp, park lamp, indicator etc..
 3. Focusing of head lamp
 4. Diagnose and repair horn and tuning it
 5. Servicing and repairing of wind shield wiper and motor
 6. Service and repairing of indicator lamp circuit
 7. Servicing and repair of speedometer and odometer
 8. Servicing and repair of fuel gauge
 9. Servicing and repair of oil pressure gauge
 10. Servicing and repairing of temperature gauge
 11. Servicing and repairing of power window
 12. Servicing and repairing of various accessories like log lamp, music system, defogger, power mirror etc.

4.4 IGNITION SYSTEM

1. Do the wiring of various ignition system
2. Remove and inspect spark plug, clean and adjust the gap
3. Check and adjust the contact point of distributor
4. Remove, dismantle, inspect, service and refit the various types of ignition system
5. Setting of ignition timing with timing light
6. Check and service the distributor

4.5 EMISSION CONTROL

1. Diagnosis and service positive crankcase ventilation(PCV)
2. Diagnosis and service air injection system
3. Diagnosis and service of EGR
4. Diagnosis and service catalytic converter
5. Diagnosis and service evaporative control system
6. Checking the crankcase ventilation by PCV vacuum tester
7. Remove and service oxygen sensor

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