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Automobile Engineering Lab (ME-314-F)

List of Experiments

1. To study and prepare report on the constructional details, working principles and operation of the **Automotive Clutches**.
2. To study and prepare report on the constructional details, working principles and operation of the **Automotive Transmission systems**.
3. To study and prepare report on the constructional details, working principles and operation of the **Automotive Drive Lines & Differentials**.
4. To study and prepare report on the constructional details, working principles and operation of the **Multi-cylinder: Diesel and Petrol Engines**.
5. To study and prepare report on the constructional details, working principles and operation of the **Automotive Engine Systems & Sub Systems**.
6. To study and prepare report on the constructional details, working principles and operation of the **Fuels supply systems**.
7. To study and prepare report on the constructional details, working principles and operation of the **Engine cooling & lubricating Systems**.
8. To study and prepare report on the constructional details, working principles and operation of the **Automotive Suspension Systems**.
9. To study and prepare report on the constructional details, working principles and operation of the **Automotive Steering Systems**.
10. To study and prepare report on the constructional details, working principles and operation of the **Automotive Brake systems**.
11. To study and prepare report on the constructional details, working principles and operation of the **Automotive Tyres & wheels**.
12. To study and prepare report on the constructional details, working principles and operation of **Automotive Emission / Pollution control systems**.

Experiment No: 1

Objective: To study and prepare report on the constructional details, working principles and operation of the **Automotive Clutches**.

Apparatus: Models of

(a) Disc Clutch (Single-plate Clutch)

(b) Multi-plate Clutch

FRICTION CLUTCHES

A clutch is a device used to transmit the rotary motion of one shaft to another when desired. The axes of the two shafts are coincident.

In friction clutches, the connection of the engine shaft to the gear box shaft is affected by friction between two or more rotating concentric surfaces. The surfaces can be pressed firmly against one another when engaged and the clutch tends to rotate as a single unit.

(a) Disc Clutch (Single-plate Clutch)

A disc clutch consists of a clutch plate attached to a splined hub which is free to slide axially on splines cut on the driven shaft. The clutch plate is made of steel and has a ring of friction lining on each side. The engine shaft supports a rigidly fixed flywheel. A spring-loaded pressure plate presses the clutch plate firmly against the flywheel when the clutch is engaged. When disengaged, the springs press against a cover attached to the flywheel. Thus, both the flywheel and the pressure plate rotate with the input shaft. The movement of the clutch pedal is transferred to the pressure plate through a thrust bearing.

Figure 1.1 shows the pressure plate pulled back by the release levers and the friction linings on the clutch plate are no longer in contact with the pressure plate or the flywheel. The flywheel rotates without driving the clutch plate and thus, the driven shaft.

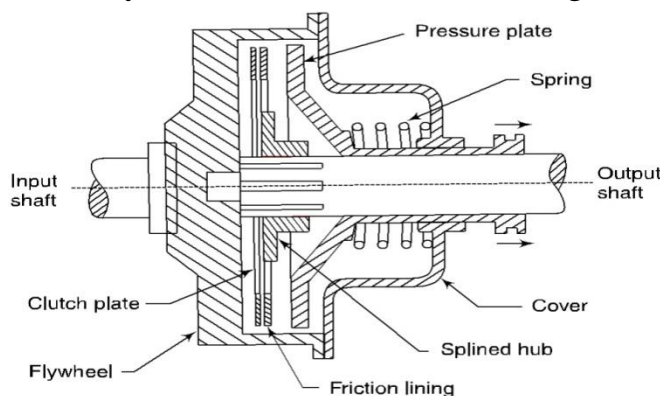


Fig. 1.1

When the foot is taken off the clutch pedal, the pressure on the thrust bearing is released. As a result, the springs become free to move the pressure plate to bring it in contact with the clutch plate. The clutch plate slides on the splined hub and is tightly gripped between the pressure plate and the flywheel.

The friction between the linings on the clutch plate, and the flywheel on one side and the pressure plate on the other, cause the clutch plate and hence, the driven shaft to rotate.

In case the resisting torque on the driven shaft exceeds the torque at the clutch, clutch slip will occur.

(b) Multi-plate Clutch

In a multi-plate clutch, the number of frictional linings and the metal plates is increased which increases the capacity of the clutch to transmit torque. Figure 1.2 shows a simplified diagram of a multi-plate clutch.

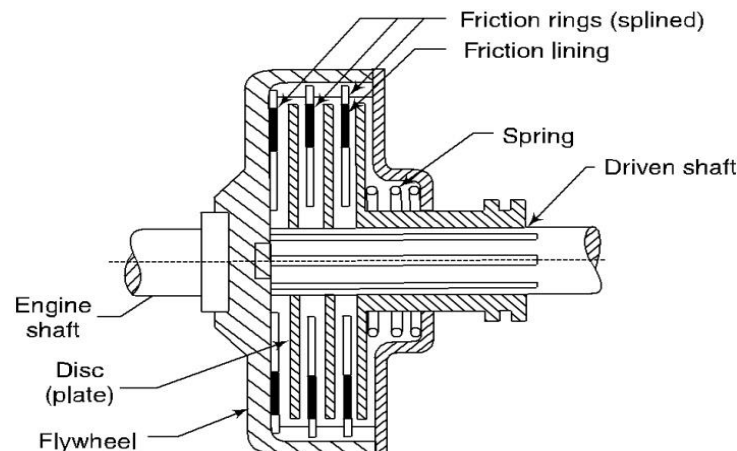


Fig. 1.2

The friction rings are splined on their outer circumference and engage with corresponding splines on the flywheel. They are free to slide axially. The friction material thus, rotates with the flywheel and the engine shaft. The number of friction rings depends upon the torque to be transmitted.

The driven shaft also supports discs on the splines which rotate with the driven shaft and can slide axially. If the actuating force on the pedal is re-moved, a spring presses the discs into contact with the friction rings and the torque is transmitted between the engine shaft and the driven shaft.

If n is the total number of plates both on the driving and the driven members, the number of active surfaces will be $n - 1$.

Experiment No: 2

Objective: To study and prepare report on the constructional details, working principles and operation of the **Automotive Transmission systems**.

Apparatus: Models of

- (a) Synchromesh – Four speed Range.
- (b) Four Wheel Drive and Transfer Case.

Theory:

The most common transmission systems that have been used for the automotive industry are manual transmission, automatic transmission (transaxle), semi-automatic transmission, and continuously variable transmission (CVT).

The first transmission invented was the manual transmission system. The driver needs to disengage the clutch to disconnect the power from the engine first, select the target gear, and engage the clutch again to perform the gear change. An automatic transmission uses a fluid-coupling torque converter to replace the clutch to avoid engaging/disengaging clutch during gear change. A completed gear set, called planetary gears, is used to perform gear ratio change instead of selecting gear manually.

Automobile or automotive transmission system consists of various devices that help in transmitting power from the engine through the drive shaft to the live axle of an automobile. Gears, brakes, clutch, fluid drive and other auto transmission parts work together for transforming the speed ratio between the engine and wheels of a vehicle.

Types of Gearboxes:

- Sliding Mesh Gear box
- Constant Mesh Gear Box
- Synchromesh Gear Box
- Epicyclic Gear Box

An engine may consist of one or more gearbox. There may be gearboxes which are a mixture of these types.

(a) Synchromesh – Four Speed Range: Most modern manual-transmission vehicles are fitted with a synchronized gear box or synchromesh. Transmission gears are always in mesh and rotating, but gears on one shaft can freely rotate or be locked to the shaft. The locking mechanism for a gear consists of a collar (or dog collar) on the shaft which is able to slide sideways so that teeth (or dogs) on its inner surface bridge two circular rings with teeth on their outer circumference: one attached to the gear, one to the shaft. When the rings are bridged by the collar, that particular gear is rotationally locked to the shaft and determines the output speed of the transmission. The gearshift lever manipulates the collars using a set of linkages, so arranged so that one collar may be permitted to lock only one gear at any one time; when "shifting gears", the locking collar from one gear is disengaged before that of another is engaged. One collar often serves for two gears; sliding in one direction selects one transmission speed, in the other direction selects another. In a synchromesh gearbox, to correctly match the speed of the gear to that of the shaft as the gear is engaged the collar initially applies a force to a cone-shaped brass clutch attached to the gear, which brings the speeds to match prior to the collar locking into place. The collar is prevented from bridging the locking rings when the speeds are mismatched by synchro rings. The synchro ring rotates slightly due to the frictional torque from the cone clutch. In this position, the dog clutch is prevented from engaging. The brass clutch ring gradually causes parts to spin at the same speed. When they do spin the same speed, there is no more torque from the cone clutch and the dog clutch is allowed to fall in to engagement. With continuing sophistication of mechanical development, fully synchromesh transmissions with three speeds, then four, and then five, became universal.

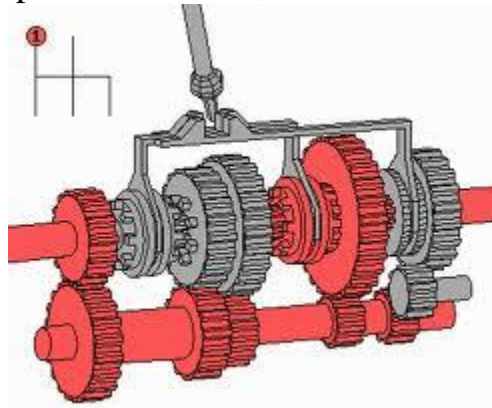


Fig: 4 speed gearbox

Construction, Working Principle and Operation of Synchromesh –Four Speed Range:

If the teeth, the so-called dog teeth, make contact with the gear, but the two parts are spinning at different speeds, the teeth will fail to engage and a loud grinding sound will be heard as they clatter together. For this reason, a modern dog clutch in

an automobile has a synchronizer mechanism or synchromesh, which consists of a cone clutch and blocking ring. Before the teeth can engage, the cone clutch engages first which brings the selector and gear to the same speed using friction. Moreover, until synchronization occurs, the teeth are prevented from making contact, because further motion of the selector is prevented by a blocker (or baulk) ring. When synchronization occurs, friction on the blocker ring is relieved and it twists slightly, bringing into alignment certain grooves and notches that allow further passage of the selector which brings the teeth together.

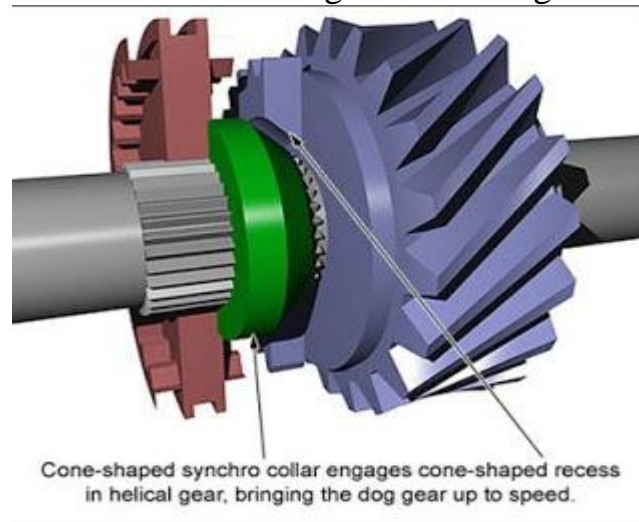


Fig: Synchromesh Concept

(b) Four Wheel Drive and Transfer Case: A transfer case is a part of a four-wheel-drive system found in four-wheel-drive. The transfer case is connected to the transmission and also to the front and rear axles by means of drive shafts. It is also referred to as a "transfer gear case", "transfer gearbox", "transfer box" or "jockey box".

Construction, Working Principle and Operation of Four Wheel Drive and Transfer Case:

A manually shifted 2-speed transfer case in the 4-wheel drive controls the power from the engine and transmission to the front and rear driving axles (Fig). The transfer case shift lever positions, from front to rear, are 4L (low gear, all wheels), N (Neutral), 2H (high gear, rear wheels), and 4H (high gear, all wheels).

- ✓ **POWER FLOW - NEUTRAL POSITION:** When the transfer case gears are in neutral (Fig), power from the front main transmission drives the transfer case input shaft and drive gear. The drive gear drives the idler shaft and the high-speed gear that free-runs on the front output shaft. Therefore, no power can be delivered to either the front, or rear axle, even when the front main transmission is in gear.

- ✓ **POWER FLOW— 4L POSITION (LOW GEAR, ALL WHEELS):** When the transfer case shift lever is shifted into the 4-wheel low position, it pushes the two sliding gears back into engagement with the idler shaft low-speed gear teeth. The power flows from the main drive gear to the idler drive gear and shaft, and to the idler low-speed gear. From the low-speed, the power flows through the two sliding gears to their respective output shafts to give speed reduction.
- ✓ **POWER FLOW— 2H POSITION (HIGH GEAR, REAR-WHEELS):** When the transfer case shift lever is shifted into the 2-wheel high position, the two sliding gears are pulled forward out of engagement from the idler shaft low-speed gear, leaving the front output sliding gear in neutral and pulling the rear output sliding gear farther forward into engagement with the clutch teeth of the main drive gear. This locks the main input shaft directly to the rear wheel output shaft. The power flows directly from the transmission to the rear axle without any reduction of speed. The front output sliding gear remains in a neutral position, the idler shaft drive gear turns the high-speed gear free on the front output shaft, and there is no power to the front axle.
- ✓ **POWER FLOW— 4H POSITION (HIGH GEAR, ALL WHEELS):** When the transfer case shift lever is shifted into the 4-wheel high position, it pulls the rear output and front output sliding gears forward into engagement with the clutch teeth of the main drive gears. This locks the rear output shaft directly to the main input shaft, and the front output shaft to the high-speed idler shaft gear. The power from the transmission flows from the drive gear in two directions. Direct drive to the rear axle flows through the rear output shaft. Direct drive to the front axle flows through the idler shaft drive gear, high-speed gear, and front output shaft.

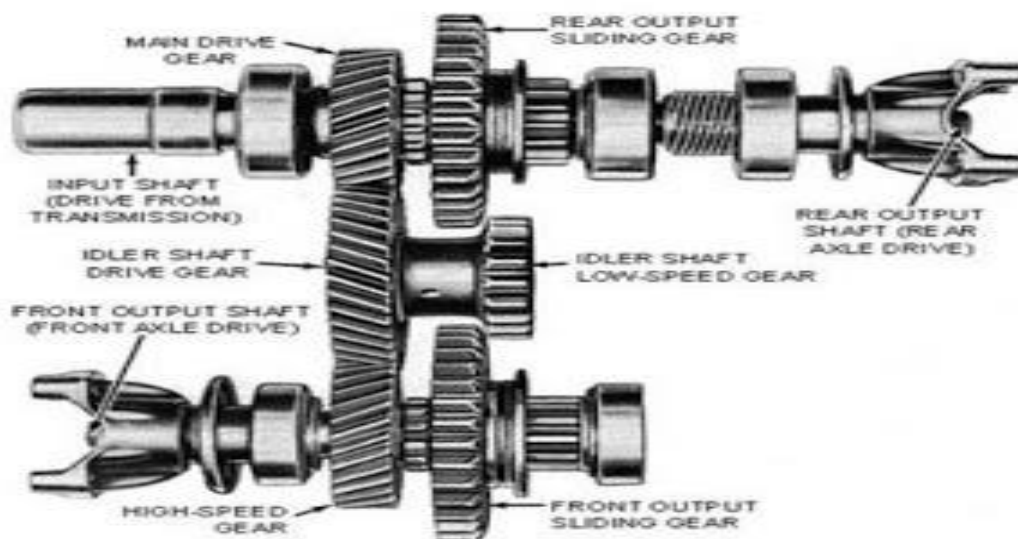


Figure – Transfer Case Gear Train in Neutral

Experiment No: 3

Objective: To study and prepare report on the constructional details, working principles and operation of the **Automotive Drive Lines & Differentials**.

Apparatus: Models of

(a) Rear Wheel Drive Line.

(b) Front Wheel Drive Line.

(c) Differentials, Drive Axles and Four Wheel Drive Line.

Theory:

(a) Constructional details, Working Principles and Operation of Rear Wheel Drive Line:

Rear-wheel drive (RWD) typically places the engine in the front of the vehicle and the driven wheels are located at the rear, a configuration known as front-engine, rear-wheel drive line. The vast majority of rear-wheel-drive vehicles use a longitudinally-mounted engine in the front of the vehicle, driving the rear wheels via a driveshaft linked via a differential between the rear axles. Some FRL(front engine rear wheel drive line) vehicles place the gearbox at the rear, though most attach it to the engine at the front. Some of the advantages of FRL are even weight distribution, weight transfer during acceleration, steering radius, better handling in dry conditions, better braking, towing, serviceability and robustness.

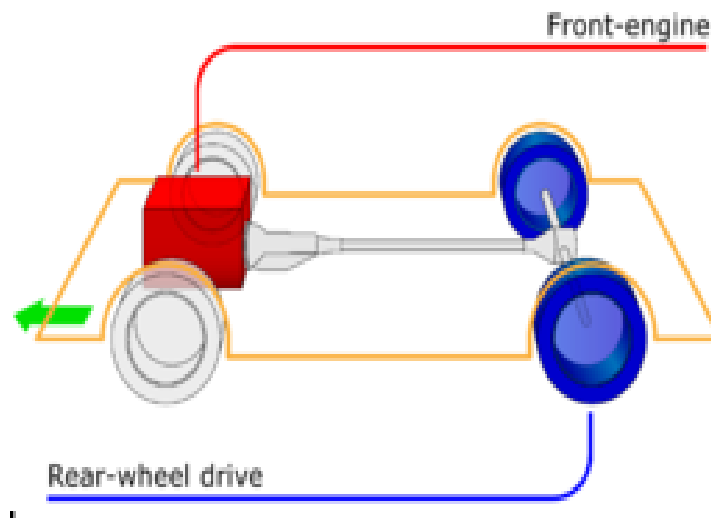


Fig: Rear Wheel Drive Line

(b) Constructional details, Working Principles and Operation of Front Wheel Drive Line.

Front-wheel-drive lines are those in which the front wheels of the vehicle are driven. The most popular lines used in cars today is the front-engine, front-wheel drive, with the engine in front of the front axle, driving the front wheels. This line is typically chosen for its compact packaging; since the engine and driven wheels are on the same side of the vehicle, there is no need for a central tunnel through the passenger compartment to accommodate a prop-shaft between the engine and the driven wheels. As the steered wheels are also the driven wheels, FFL (front-engine, front-wheel-drive line) cars are generally considered superior to FRL (front-engine, rear-wheel-drive line) cars in conditions such as snow, mud or wet tarmac. Some of the advantages are interior space, cost, improved drive train efficiency, placing the mass of the drive train over the driven wheels moves the centre of gravity farther forward than a comparable rear-wheel-drive layout, improving traction and directional stability on wet, snowy, or icy surfaces.

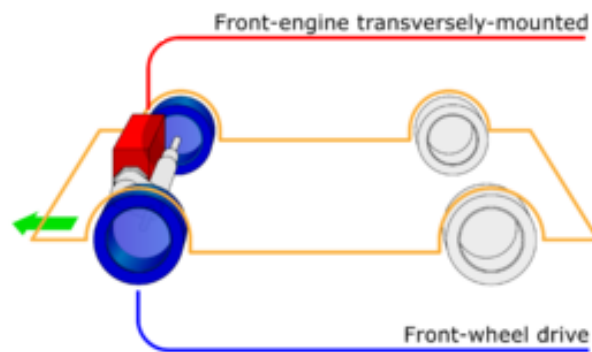


Fig: Front Wheel Drive Line

(c) Constructional details, Working Principles and Operation of Differentials, Drive Axles and Four Wheel Drive Line:

In four wheel drive line vehicles, differentials are fitted to both front and rear axle assemblies. When a two-wheel drive range is selected, the drive is transferred through the rear final drive and the differential gears to the rear axle shafts and road wheels. The differential gears allow the rear wheels to rotate at different speeds when the vehicle is turning, while continuing to transmit an equal turning effort to each wheel. When four-wheel drive is engaged, the drive is transmitted through both front and rear axle assemblies, and differential action occurs in both. However, in a turn, side-swiveling of the front wheels for steering makes the front wheels travel a greater distance than the rear wheels. This causes a difference in the rotational speeds of the front and rear wheels. Since there is also a difference between inner and outer wheels, each axle shaft now turns at a different speed. Differences in speed can also arise from differences in tread wear between front and rear, or in tire inflation pressures. Since front and rear propeller shafts are

locked together at the transfer case, the difference in speed cannot be absorbed in the transmission, and the transmission drive line can be subjected to torsional stress.

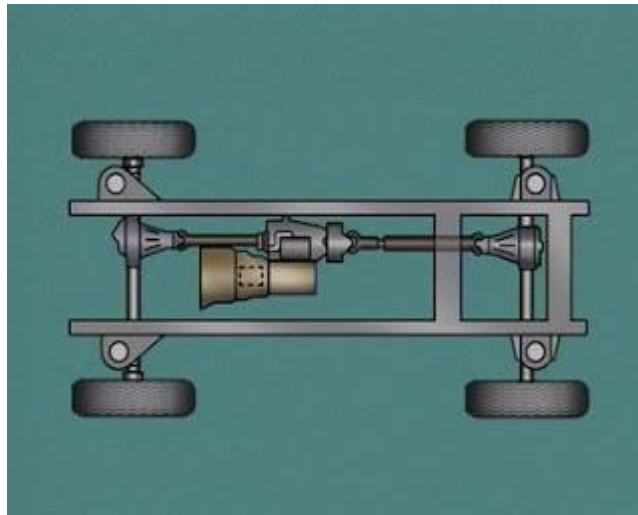


Fig: 4 Wheel Drive Differential Axle Line



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Experiment No: 4

Objective: To study and prepare report on the constructional details, working principles and operation of the **Automotive Engine Systems & Sub Systems**.

Apparatus: Models of Multi-cylinder: Diesel and Petrol Engines.

Theory:

Multi-cylinder: Diesel and Petrol Engines.

Both are internal combustion engines. The difference is that Diesel engine is CI (compression Ignition) and petrol is SI (Spark Ignition). In a petrol engine spark is used to initiate the ignition of the petrol air mixture. In a diesel engine the Air is compressed to 21 times its normal volume (Approx) and then fuel is injected into the Cylinder head/ or piston, due to the high compression the temperature rises and as fuel is injected it ignites.

Both diesel and petrol engines may be 2 stroke or 4 stroke engines. In 2 stroke cycle engine: The engine revolves once (two strokes of the piston, one down, one up) for a complete cycle of the engine. Whereas in 4-stroke cycle engine: Each complete cycle of the engine involves four strokes of the piston, a down, an up, a down, and an up stroke for each complete cycle of the engine (which is two revolutions of the engine).

A single cylinder four-stroke piston engine spends three quarters of its running time exhausting burned gas, drawing in fresh mixture and compressing it. On only one of the four strokes the power stroke is any energy produced and this makes the output of a single cylinder four stroke engine very uneven. This can be smoothed out if more cylinders, with their pistons driving a common crank shaft, are used. A twin-cylinder four stroke, for instance, will produce one power stroke for each revolution of the crank shaft, instead of every other revolution as on a single cylinder engine. If the engine has four cylinders it produces one power stroke for each half-turn of the crankshaft and at no time is the crankshaft freewheeling' on one of the three passive strokes. Even better results can be

obtained using six cylinders, as the power strokes can be made to overlap, so that the crankshaft receives a fresh impulse before the previous power stroke has died away on an in-line six-cylinder engine the crankshaft receives three power impulses each revolution. In theory, the more cylinders you can use to drive the crank- shaft, the smoother the power output, and 8 and 12 cylinder engines are used on some of the more expensive cars. A large number of cylinders can pose practical problems. An engine with eight cylinders in a straight line for instance would have a very long crank- shaft which would tend to twist and be more likely to break at higher engine speeds. The car would also need a long bonnet to enclose the engine. So in the interests of crank- shaft rigidity and compactness, 8 and 12 cylinder engines have their cylinders arranged in a V, with two cylinder heads and a common crankshaft. There are also V-6 and V-4 cylinder engines.

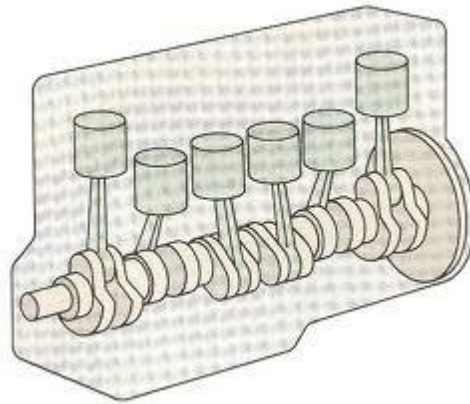


Fig: In line engine or 6 cylinder engine

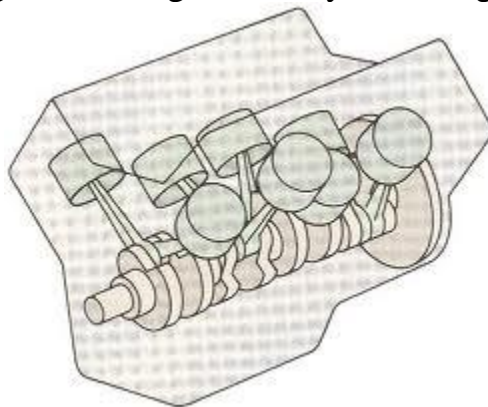


Fig: V8 Engine

The construction, working principle and operation of multi cylinder engines is same as single cylinder diesel and petrol engines.

Experiment No: 5

Objective: To study and prepare report on the constructional details, working principles and operation of the **Automotive Engine Systems & Sub Systems**.

Apparatus: Models of

(a) Engine starting Systems.

(b) Contact Point & Electronic Ignition Systems.

Theory:

(a) Engine starting Systems: The "starting system", the heart of the electrical system in the engine. The starting system converts electrical energy from the batteries into mechanical energy to turn the engine over.

Construction, Working Principle and Operation of Engine starting System: Engine starting system, begins with the Battery. The key is inserted into the Ignition Switch and then turned to the start position. A small amount of current then passes through the Neutral Safety Switch to a Starter Relay or Starter Solenoid which allows high current to flow through the Battery Cables to the Starter Motor. The starter motor then cranks the engine so that the piston, moving downward, can create a suction that will draw a Fuel/Air mixture into the cylinder, where a spark created by the Ignition System will ignite this mixture. If the Compression in the engine is high enough and all this happens at the right Time, the engine will start.

The starting system has five main components: the ignition switches or start button, a neutral safety switch (an option on some vehicles), the starter solenoid, the starter motor, and the batteries.

When the key is turned in the ignition switch to the start position, or the start button is pushed, electricity flows from the batteries to the starter solenoid. Some vehicles are equipped with a neutral safety switch. If the vehicle is in gear when the key is turned, the neutral safety switch blocks the signal to the batteries, so the engine doesn't start cranking. Otherwise, the vehicle could jump forward or backward when the key is turned. The starter solenoid is an electromagnetic switch mounted on the starter motor. When coils inside the solenoid are energized by

electricity, they create a magnetic field which attracts and pulls a plunger. Attached to one end of this plunger is a shift lever. The lever is connected to the drive pinion and clutch assembly of the starter motor. The starter motor is a small but powerful electric motor that delivers a high degree of power for a short period of time. When the starter motor is energized it engages the flywheel ring gear and produces torque, which turns the flywheel and cranks the engine. When the driver releases the ignition switch from the start position to the run position, the solenoid is deactivated. Its internal return springs cause the drive pinion to be pulled out of mesh with the flywheel, and the starter motor stops.

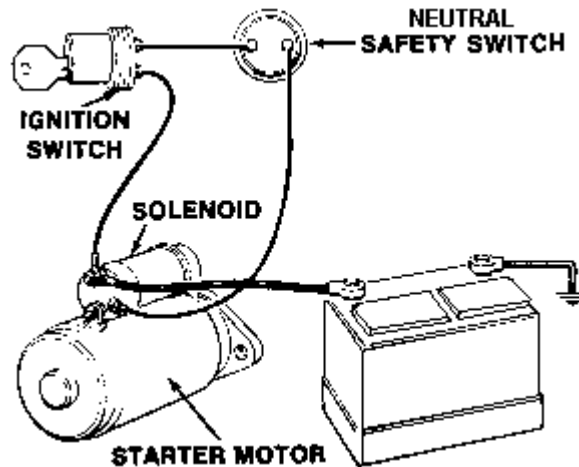


Fig: Engine Starting System

(b) Contact Point & Electronic Ignition Systems: An ignition system is a system for igniting a fuel-air mixture. There are two common ignition types associated with automotive engines, they are contact points and fully electronic. For many years, the contact point ignition was the favored system to control the timing of the ignition spark. However, as electronics in general became more reliable and less costly to produce, manufacturers turned to full electronic systems cutting out the mechanical contact points.

Construction, Working Principle and Operation of Contact Point Ignition System:

The contact point ignition system consists of:

1. A battery or magneto to supply low voltage current for the spark
2. Mechanical contact points to control the point of ignition
3. A rotating cam to operate the contact points
4. A condenser to reduce arcing across the contact point surfaces
5. An ignition coil
6. A spark plug

The job of the ignition system is to supply a spark at the correct time within the cylinder. The distributor cam is a part of, or is attached to, the distributor shaft and has one lobe for each cylinder. As the cam rotates with the shaft at one half of engine speed, the lobes cause the contact points to open and close the primary circuit. The contact points, also called breaker points, act like spring-loaded electrical switches in the distributor. Its function is to cause intermittent current flow in the primary circuit, thus causing the magnetic field in the coil to build up and collapse when it reaches maximum strength. Wires from the condenser and ignition coil primary circuit connect to the points. The condenser, also known as a capacitor, is wired in parallel with the contact points and grounded through the distributor housing. The condenser prevents arcing or burning at the distributor contact points when the points are first open. The condenser provides a place where current can flow until the contact points are fully open. With the engine running, the distributor shaft and distributor cam rotate. This action causes the distributor cam to open and close the contact points. With the contact points wired to the primary windings of the ignition coil, the contact points make and break the ignition coil primary circuit. With the contact points closed, the magnetic field builds up in the coil. As the points open, the magnetic field collapses and voltage is sent to the spark plugs. With the distributor operating at one half of engine speed and with only one cam for each engine cylinder, each spark plug only fires once during a complete revolution of the distributor cam. To ensure that the contact points are closed for a set time, point dwell, also known as cam angle, is set by using a dwell meter. Point dwell is the amount of time given in degrees of distributor rotation that the points remain closed between each opening.

A dwell period is required to assure that the coil has enough time to build up a strong magnetic field. If the point dwell is too small, the current will have insufficient time to pass through the primary windings of the ignition coil, resulting in a weak spark. However, if the point dwell is too great, the contact points will not open far enough, resulting in arcing or burning of the points.

The spark must be sufficiently strong enough to jump a gap at the spark plug electrodes. To achieve this, the voltage must be increased considerably from the motorcycle's electrical system (6 or 12 volts) to around 25,000 volts at the plug. To achieve this increase in voltage, the system has two circuits: the primary and the secondary. In the primary circuit, the 6 or 12 volt power supply charges the ignition coil. During this phase the contact points are closed. When the contact points open, the sudden drop in power supply causes the ignition coil to release stored energy in the form of the increased high voltage. The high voltage current travels along a lead (HT lead) to a plug cap before entering the spark plug via the

central electrode. A spark is created as the high voltage jumps from the central electrode to the ground electrode.

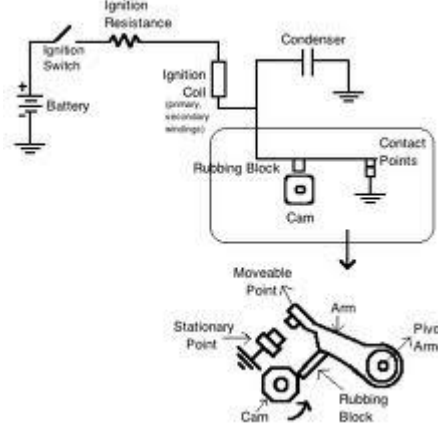


Fig: Contact Point Ignition System

Construction, Working Principle and Operation of Electronic Ignition System:

The basic difference between the contact point and the electronic ignition system is in the primary circuit. The primary circuit in a contact point ignition system is open and closed by contact points. In the electronic system, the primary circuit is open and closed by the electronic control unit (ECU). The secondary circuits are practically the same for the two systems. The difference is that the distributor, ignition coil, and wiring are altered to handle the high voltage produced by the electronic ignition system. One advantage of this higher voltage (up to 60,000volts) is that spark plugs with wider gaps can be used. This results in a longer spark, which can ignite leaner air-fuel mixtures. As a result engines can run on leaner mixtures for better fuel economy and lower emissions.

The basic components of an electronic ignition system are as follows: The trigger wheel, also known as a reluctor, pole piece, or armature, is connected to the upper end of the distributor shaft. The trigger wheel replaces the distributor cam. Like the distributor cam lobes, the teeth on the trigger wheel equal the number of engine cylinders. The pickup coil, also known as a sensor assembly, sensor coil, or magnetic pickup assembly, produces tiny voltage surges for the ignition systems electronic control unit. The pickup coil is a small set of windings forming a coil. The ignition system electronic control unit amplifier or control module is an "electronic switch" that turns the ignition coil primary current ON and OFF. The ECU performs the same function as the contact points. The ignition ECU is a network of transistors, capacitors, resistors, and other electronic components sealed in a metal or plastic housing. The ECU can be located (1) in the engine compartment, (2) on the side of the

distributor, (3) inside the distributor, or (4) under the vehicle dash. ECU dwell time (number of degrees the circuit conducts current to the ignition coil) is designed into the electronic circuit of the ECU and is NOT adjustable. Electronic Ignition System Operation With the engine running, the trigger wheel rotates inside the distributor. As a tooth of the trigger wheel passes the pickup coil, the magnetic field strengthens around the pickup coil. This action changes the output voltage or current flow through the coil. As a result, an electrical surge is sent to the electronic control unit, as the trigger wheel teeth pass the pickup coil. The electronic control unit increases the electrical surges into ON/OFF cycles for the ignition coil. When the ECU is ON, current passes through the primary windings of the ignition coil, thereby developing a magnetic field. Then, when the trigger wheel and pickup coil turn OFF the ECU, the magnetic field inside the ignition coil collapses and fires a sparkplug. Hall-Effect Sensor Some electronic distributors have a magnetic sensor using the Hall effect. When a steel shutter moves between the two poles of a magnet, it cuts off the magnetism between the two poles. The Hall-effect distributor has a rotor with curved plates, called shutters. These shutters are curved so they can pass through the air gap between the two poles of the magnetic sensor, as the rotor turns. Like the trigger wheel, there is the same number of shutters as there are engine cylinders. Each time a shutter moves through the air gap between the two poles of the magnetic sensor, it cuts off the magnetic field between the poles. This action provides a signal to the ECU. When a shutter is not in the way, the magnetic sensor is producing voltage. This voltage is signaling the ECU to allow current to flow through the ignition coils primary winding. However, when the shutter moves to cut off the magnetic field, the signal voltage drops to zero. The ECU then cuts off the current to the ignition coils primary winding. The magnetic field collapses, causing the coil secondary winding to produce a high voltage surge. This high voltage surge is sent by the rotor to the proper spark plug.

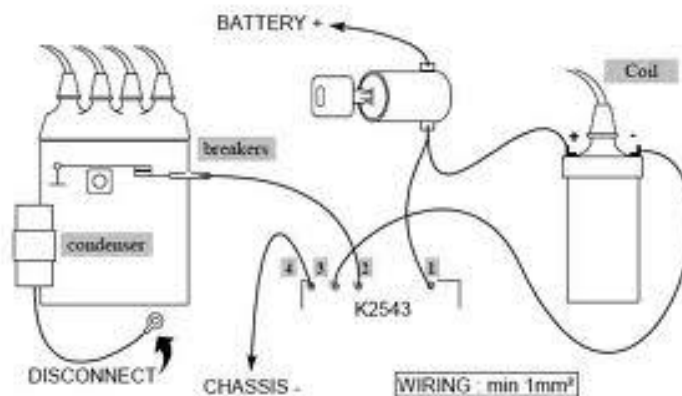


Fig: Electronic Ignition System



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Experiment No: 6

Objective: To study and prepare report on the constructional details, working principles and operation of the **Fuels supply systems**.

Apparatus: Models of

- (a) Carburetors
- (b) Diesel Fuel Injection Systems
- (c) Gasoline Fuel Injection Systems.

Theory:

(a) Carburetors: A carburetor is a mechanical device on an internal combustion engine, for the purpose of mixing air and gasoline into a combustible fine vapor, in automatically changing proportions, depending on the operating conditions of the engine. As an example, an engine that runs continually at one speed, day in and day out has need only for a carburetor of the simplest construction. One that has only to mix air and gasoline in one fixed ratio. However, when the demands of the engine are changed and it is desirable to run it at variable speeds, the carburetor must mix air and gasoline in different proportions and therefore, its construction must be more complex.

Construction, Working Principle and Operation of Carburetors:

In the part of the carburetor known as the body is located the float bowl or chamber. This chamber is used for the storage of a certain quantity of gasoline. It serves two purposes, namely, to keep all the other circuits of the carburetor supplied with the amount of fuel they need and to absorb the pulsation of the fuel pump, as it delivers the gasoline to the carburetor. Though its construction is simple, it plays a very important part in the proper functioning of the engine. The float system consists of the following: float chamber or bowl, fuel inlet, needle valve and seat, float, float pin and on some carburetors a float pin retainer, and the float chamber or bowl cover which contains the float chamber vent. The pump system consists of pump cylinder, pump plunger, plunger operating rod, plunger spring, intake check valve, outlet check valve and pump jet. It also contains the throttle system and choke system.

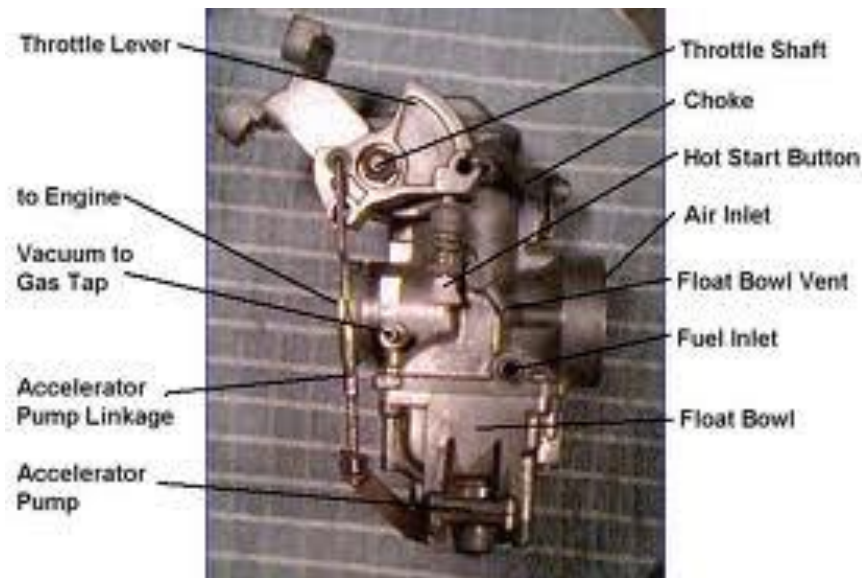


Fig: Carburetor parts

A carburetor is a tube attached to the intake port of the engine and open to the atmosphere. On the intake stroke a volume with little to no pressure develops in the combustion chamber. As a result air flows from outside to inside the engine. As the air flows through the carburetor, the fuel is metered, atomized and vaporized. To have available fuel, the carburetor must have a source of fuel. In the float type carburetor this source is the fuel bowl. A pressure difference is also needed to cause the fuel to flow from the fuel bowl into the air stream. This is accomplished using a venturi, Bernoulli's principle and a tube connecting the mouth of the venturi to the fuel bowl.

This is a functioning carburetor and it will operate an engine as long as it has a constant load and constant speed. Very few engines operate at a constant load and constant speed. To adjust the rate of fuel flow a throttle is used. When the throttle is in the closed position there is minimum air flow through the carburetor. When the throttle is in the wide open position, there is maximum air flow through the carburetor. To provide a means to adjust maximum fuel flow, a needle valve was added to the orifice in the emulsion tube. A carburetor with this design would function well under varying loads and speeds. Starting is a different condition; an engine needs a richer fuel-air mixture. This was accomplished by adding a choke. Closing the choke increases the pressure difference between the fuel bowl and the venturi. Once engine starts the choke must be opened to prevent the engine from running too rich. The addition of a choke/primer improved engine starting, but this carburetor still has a problem if the engine needs to idle. When the throttle is in the idle position, almost closed, the area with greatest restriction, and greatest pressure difference, moves from the venturi to the area between the throttle plate and the wall of the tube. This problem was solved with the addition of an idle circuit and idle needle valve. To have constant fuel flow with constant pressure difference the

lift, distance from the top of the fuel to the top of the main nozzle, must remain constant. A constant level of fuel is maintained in the fuel bowl by the float, float needle valve and float needle valve seat.

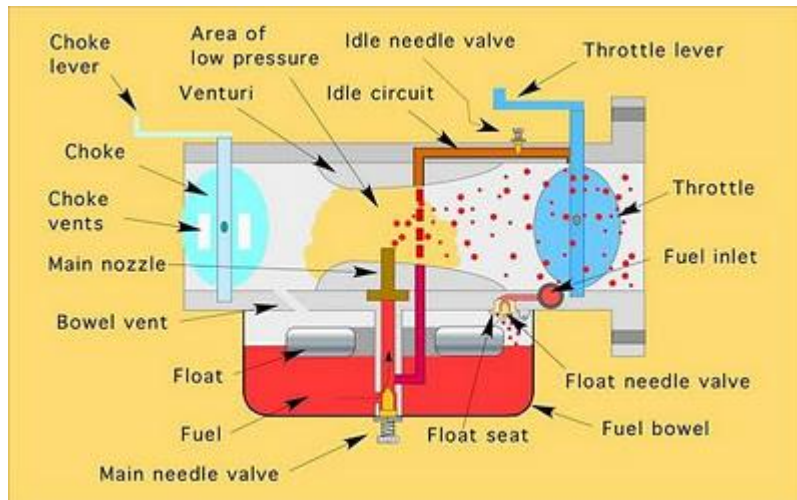


Fig: Carburetor Operation

(b) Diesel Fuel Injection Systems: The injection system in diesel engines can be of two types as air injection and airless injection. In air injection system the diesel is injected along with the compressed air whereas in airless injection system only the liquid diesel is injected into the cylinder.

Construction, Working Principle and Operation of Diesel Fuel Injection Systems:

The construction details of diesel fuel injection system are fuel tank, fuel filter, fuel pump, fuel injector, and nozzle.

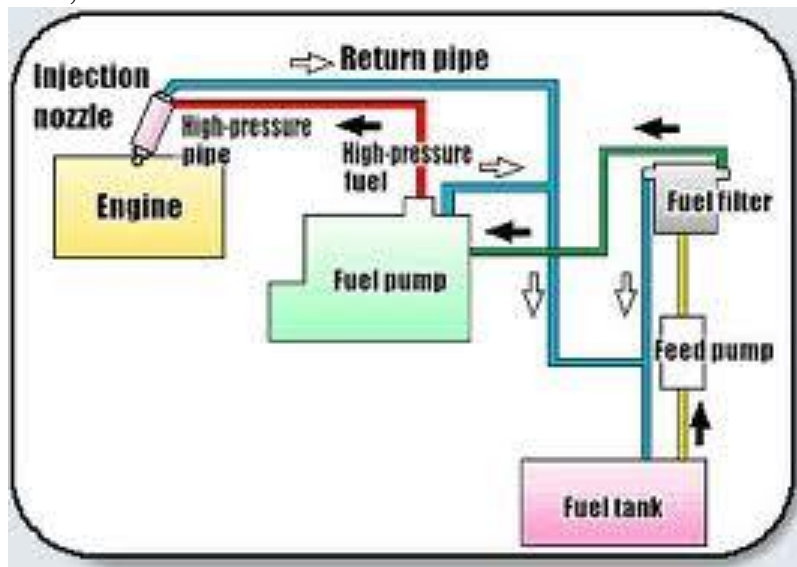


Fig: Diesel Fuel Injection System

A fuel tank is used for storage. The feed pump is used to feed the fuel to filter where fuel can be filtered. A fuel injection pump is used to supply precisely metered quantity of diesel under high pressure to the injectors at well timed instants. A fuel injector is used to inject the fuel in the cylinder in atomized form and in proper quantity. Main components of fuel injectors are nozzle, valve, body and spring. The nozzle is its main part which is attached to the nozzle holder. Entry of fuel in the injector is from the fuel injection pump. Diesel injector nozzles are spring-loaded closed valves that spray fuel directly into the combustion chamber. Injector nozzles are threaded into the cylinder head, one for each cylinder. The top of the injector nozzle has many holes to deliver an atomized spray of diesel fuel into the cylinder.

(c) Gasoline Fuel Injection Systems: A modern gasoline injection system uses pressure from an electric fuel pump to spray fuel into the engine intake manifold. Like a carburetor, it must provide the engine with the correct air-fuel mixture for specific operating conditions. Unlike a carburetor, however, pressure, not engine vacuum, is used to feed fuel into the engine. This makes the gasoline injection system very efficient.

A gasoline injection system has several possible advantages over a carburetor type of fuel system. Some advantages are as follows:

1. Improved atomization: Fuel is forced into the intake manifold under pressure that helps break fuel droplets into a fine mist.
2. Better fuel distribution: Equal flow of fuel vapors into each cylinder.
3. Smoother idle: Lean fuel mixture can be used without rough idle because of better fuel distribution and low-speed atomization.
4. Lower emissions: Lean efficient air-fuel mixture reduces exhaust pollution.
5. Better old weather drivability: Injection provides better control of mixture enrichment than a carburetor.
6. Increased engine power: Precise metering of fuel to each cylinder and increased air flow can result in more horsepower output.
7. Fewer parts: Simpler, late model, electronic fuel injection system has fewer parts than modern computer-controlled carburetors.

There are many types of gasoline injection systems. Before studying the most common ones, you should have a basic knowledge of the different classifications:

1. Single- or Multi-Point Injection
2. Indirect or Direct Injection

The point or location of fuel injection is one way to classify a gasoline injection system. A single-point injection system, also called throttle body injection (TBI), has the injector nozzles in a throttle body assembly on top of the engine. Fuel is sprayed into the top center of the intake manifold.

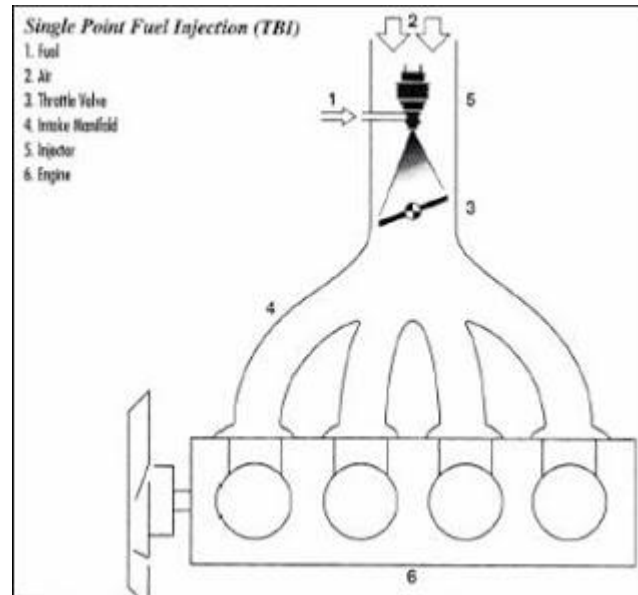


Fig: Single Point Gasoline Fuel Injection System

A multi-point injection system, also called port injection, has an injector in the port (air-fuel passage) going to each cylinder. Gasoline is sprayed into each intake port and toward each intake valve. Thereby, the term multipoint (more than one location) fuel injection is used.

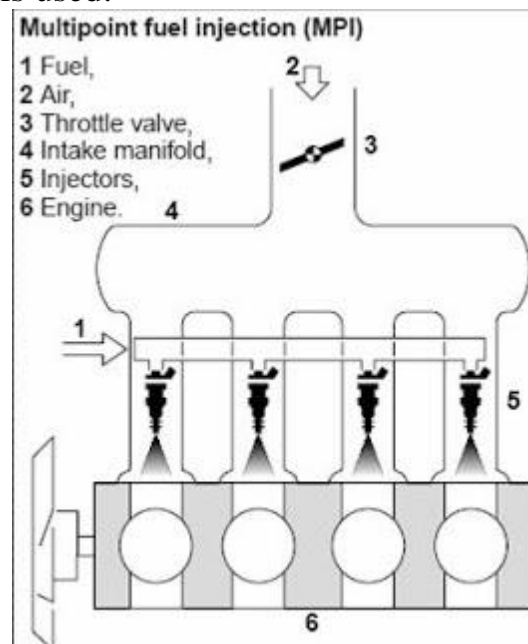


Fig: Multi-point Gasoline Fuel Injection System

An indirect injection system sprays fuel into the engine intake manifold. Most gasoline injection systems are of this type.

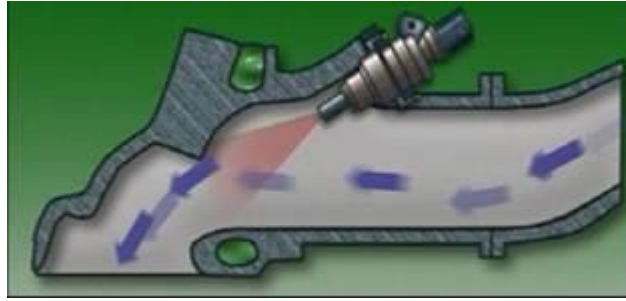


Fig: Indirect Injection Gasoline Fuel System

Direct injection forces fuel into the engine combustion chambers. Diesel injection systems are direct type. So, Gasoline electronic Direct Injection System is classified as multi-point and direct injection systems.



Fig: Direct Injection Gasoline Fuel System

Construction, Working Principle and Operation of Gasoline Fuel Injection Systems:

Its construction details consists of parts as fuel tank, electric fuel pump, fuel filter, electronic control unit, common rail and pressure sensor, electronic injectors and fuel line.

1. Fuel tank is safe container for flammable liquids and typically part of an engine system in which the fuel is stored and propelled (fuel pump) or released (pressurized gas) into an engine.
2. An electric fuel pump is used on engines with fuel injection to pump fuel from the tank to the injectors. The pump must deliver the fuel under high pressure (typically 30 to 85 psi depending on the application) so the injectors can spray the fuel into the engine. Electric fuel pumps are usually mounted inside the fuel tank.
3. The fuel filter is the fuel system's primary line of defense against dirt, debris and small particles of rust that flake off the inside of the fuel tank. Many filters for fuel

injected engines trap particles as small as 10 to 40 microns in size. Fuel filter normally made into cartridges containing a filter paper.

4. In automotive electronics, electronic control unit (ECU) is a generic term for any embedded system that controls one or more of the electrical systems or subsystems in a motor vehicle.

An engine control unit (ECU), also known as power-train control module (PCM), or engine control module (ECM) is a type of electronic control unit that determines the amount of fuel, ignition timing and other parameters an internal combustion engine needs to keep running. It does this by reading values from multidimensional maps which contain values calculated by sensor devices monitoring the engine. Control of fuel injection: ECU will determine the quantity of fuel to inject based on a number of parameters. If the throttle pedal is pressed further down, this will open the throttle body and allow more air to be pulled into the engine. The ECU will inject more fuel according to how much air is passing into the engine. If the engine has not warmed up yet, more fuel will be injected. Control of ignition timing: A spark ignition engine requires a spark to initiate combustion in the combustion chamber. An ECU can adjust the exact timing of the spark (called ignition timing) to provide better power and economy. Control of idle speed: Most engine systems have idle speed control built into the ECU. The engine RPM is monitored by the crankshaft position sensor which plays a primary role in the engine timing functions for fuel injection, spark events, and valve timing. Idle speed is controlled by a programmable throttle stop or an idle air bypass control stepper motor.

5. The term "common rail" refers to the fact that all of the fuel injectors are supplied by a common fuel rail which is nothing more than a pressure accumulator where the fuel is stored at high pressure. This accumulator supplies multiple fuel injectors with high pressure fuel.

6. The fuel injectors are typically ECU-controlled. When the fuel injectors are electrically activated a hydraulic valve (consisting of a nozzle and plunger) is mechanically or hydraulically opened and fuel is sprayed into the cylinders at the desired pressure. Since the fuel pressure energy is stored remotely and the injectors are electrically actuated the injection pressure at the start and end of injection is very near the pressure in the accumulator (rail), thus producing a square injection rate. If the accumulator, pump, and plumbing are sized properly, the injection pressure and rate will be the same for each of the multiple injection events. The injectors can survive the excessive temperature and pressure of combustion by using the fuel that passes through it as a coolant. The electronic fuel injector is normally closed, and opens to inject pressurized fuel as long as electricity is applied to the injector's solenoid coil. When the injector is turned on, it opens,

spraying atomized fuel at the combustion chamber. Depending on engine operating condition, injection quantity will vary.

7. Fuel line hoses carry gasoline from the tank to the fuel pump, to the fuel filter, and to the fuel injection system. While much of the fuel lines are rigid tube, sections of it are made of rubber hose, which absorb engine and road vibrations.

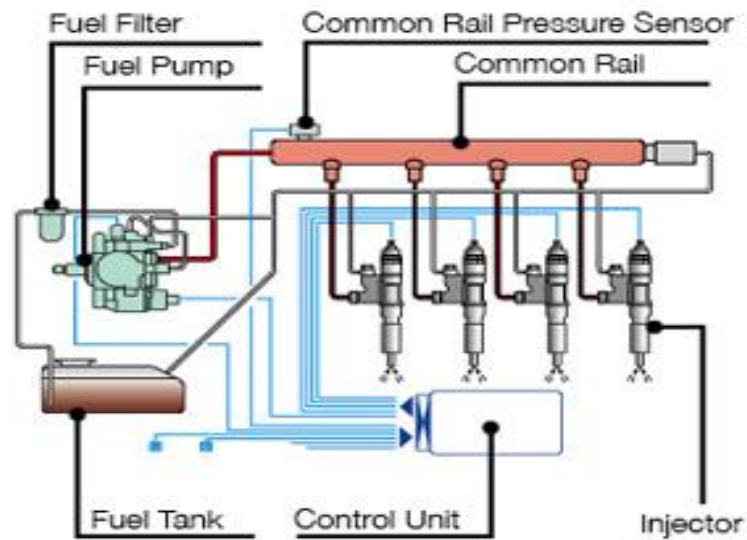


Fig: Electronic Gasoline Fuel Injection System

Experiment No: 7

Objective: To study and prepare report on the constructional details, working principles and operation of the **Automotive Engine Systems & Sub Systems**.

Apparatus: Models of Engine cooling & lubricating Systems.

Theory:

Engine cooling & lubricating Systems:

Engine Cooling Systems: The cooling system removes excess heat to keep the inside of the engine at an efficient temperature, about 200°F (94°C). There are two types of cooling systems found on automobiles, they are liquid cooling system and air cooling system.

Construction, Working Principle and Operation of Air Cooling System:

The air cooling system will have metal **FINS** on the outer perimeter of the engine. The heat is transferred from the engine, through these fins, into the atmosphere.



Fig: Air Cooling System

Construction, Working Principle and Operation of Liquid Cooling System:

The cooling system is made up of the passages inside the engine block and heads, a water pump to circulate the coolant, a thermostat to control the temperature of the coolant, a radiator to cool the coolant, a radiator cap to control the pressure in the system, and some plumbing consisting of interconnecting hoses to transfer the

coolant from the engine to radiator and also to the car's heater system where hot coolant is used to warm up the vehicle's interior on a cold day.

A cooling system works by sending a liquid coolant through passages in the engine block and heads. As the coolant flows through these passages, it picks up heat from the engine. The heated fluid then makes its way through a rubber hose to the radiator in the front of the car. As it flows through the thin tubes in the radiator, the hot liquid is cooled by the air stream entering the engine compartment from the grill in front of the car. Once the fluid is cooled, it returns to the engine to absorb more heat. The water pump has the job of keeping the fluid moving through this system of plumbing and hidden passages. A thermostat is placed between the engine and the radiator to make sure that the coolant stays above a certain preset temperature. If the coolant temperature falls below this temperature, the thermostat blocks the coolant flow to the radiator, forcing the fluid instead through a bypass directly back to the engine. The coolant will continue to circulate like this until it reaches the design temperature, at which point, the thermostat will open a valve and allow the coolant back through the radiator. In order to prevent the coolant from boiling, the cooling system is designed to be pressurized. Under pressure, the boiling point of the coolant is raised considerably. However, too much pressure will cause hoses and other parts to burst, so a system is needed to relieve pressure if it exceeds a certain point. The job of maintaining the pressure in the cooling system belongs to the radiator cap. The cap is designed to release pressure if it reaches the specified upper limit that the system was designed to handle. Prior to the '70s, the cap would release this extra pressure to the pavement. Since then, a system was added to capture any released fluid and store it temporarily in a reserve tank. This fluid would then return to the cooling system after the engine cooled down. This is what is called a closed cooling system.

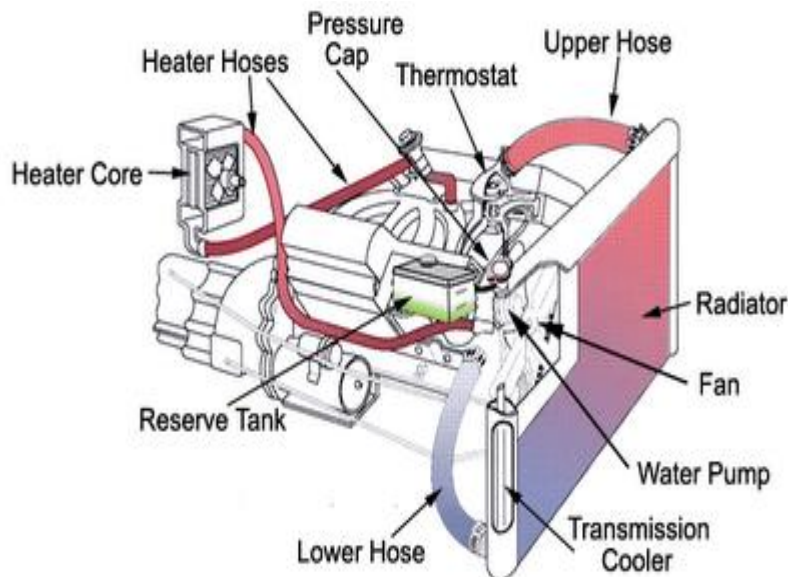


Fig: Liquid Cooling System

Engine Lubricating Systems: The engine lubrication system includes the lubricating oil, oil pump, oil filter and the oil passages. Oil lubrication provides a barrier between rotating engine parts to prevent damage by friction. The engine oil provides a method of cooling engine parts that are not cooled by the engine cooling system. Engine oil helps to protect engine components from corrosion by neutralizing harmful chemicals that are the by-product of combustion.

Construction, Working Principle and Operation of Lubricating System:

To protect moving parts and reduce friction, automotive engine oil provides a barrier between the rotating or moving engine components. Ideally, a film of oil should exist between moving components. This is called full film lubrication. In order to achieve full film lubrication, a constant supply of clean oil is required. The engine oil system constantly filters and circulates engine oil to ensure that all components are protected. The engine oil is stored in the crankcase. Most engines hold between 4 to 6 quarts of oil. The engine oil pump pressurizes and circulates the engine oil. The oil will flow from the pump to the oil filter, where it is cleaned. The cleaned engine oil then moves through passages, into the crankshaft where it circulates through the engine bearings. The crankshaft has passages bored into it that allows oil to travel to all the bearing surfaces. The cylinder walls and pistons are lubricated by the oil that is thrown from the crankshaft as it rotates. This is sometimes referred to as splash lubrication. Engine oil will leave the crankshaft, usually at a passage in one of the main bearings and is fed to the camshaft and lifters. On some overhead valve engines, oil will travel through the pushrods up to the valve train to lubricate the rocker arms. Other designs use a passage to feed oil through a rocker arm shaft to achieve the same purpose. The oil then returns to the crankcase by return holes in the cylinder heads. It is then picked up by the oil pump to be circulated again.

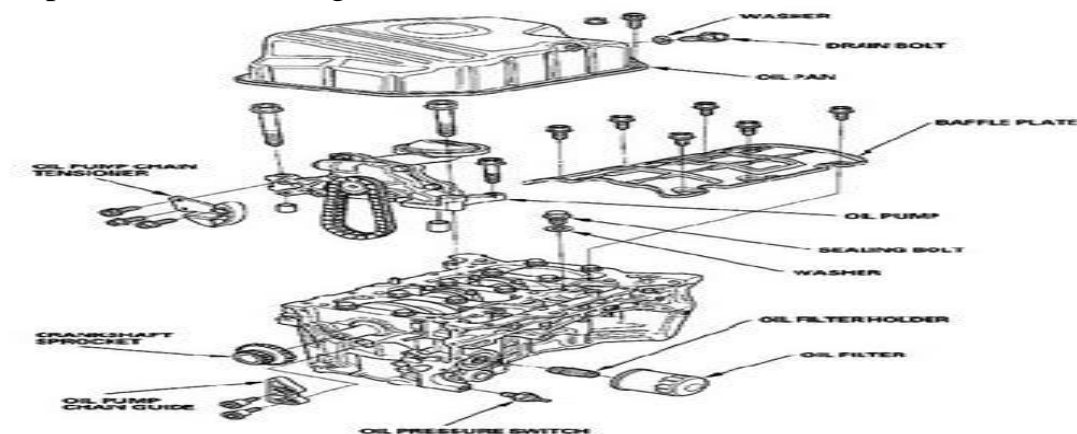


Fig: Engine Lubrication System

Experiment No: 8

Objective: To study and prepare report on the constructional details, working principles and operation of the **Automotive Suspension Systems**.

Apparatus: Models of

(a) Front Suspension System.

(b) Rear Suspension System.

Theory:

(a) **Constructional details, working principles and operation of the Front Suspension System:** The shock absorber is contained inside the strut, and is a direct acting telescopic type shock absorber. The coil spring is mounted over the strut, inside the suspension tower. The strut has an upper mounting point in the suspension tower. For the front steerable suspension, the strut's upper mounting is bushed, or bearing-mounted, to allow for the steering movement. The control arm mount is fixed (or 'held in place') in the vehicle configuration, by bushes. The lower control arm is attached to the vehicle body and holds in place the strut, brake assembly, and drive shafts.



Fig: Front Suspension System

Another Example: This non-driven or 'dead' axle front suspension arrangement consists of: coil springs; lower wishbone and upper wishbone as shown below.

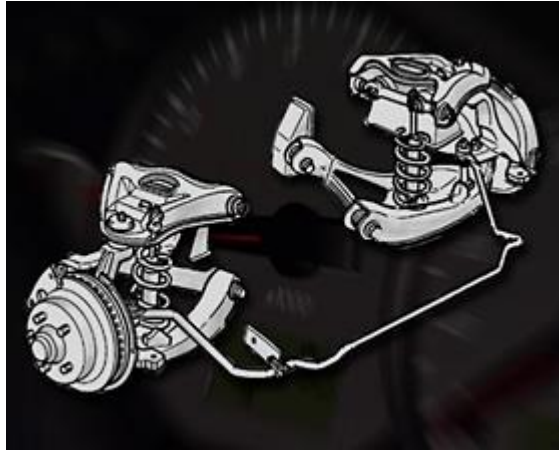


Fig: Front Suspension System Layout

(b) Constructional details, working principles and operation of the Rear Suspension System: The front of the leaf spring is attached to the chassis at the rigid spring hanger. This spring eye is bushed with either rubber bushes or, in the case of heavy vehicles, steel bushes. The axle housing is rigid between each road wheel. This means that any deflection to one side is transmitted to the other side. The swinging shackle allows for suspension movement by allowing the spring to extend or reduce in length, as the vehicle moves over uneven ground. The top of the shock absorber is attached to the chassis, and to the spring pad at the bottom. It is a direct-acting shock absorber. The U-bolts attach the axle housing to the leaf spring. They have a clamping force that helps to keep the leaf spring together. Leaf springs are usually made of tempered steel. They hold the axle in position, both laterally and longitudinally. The leaf spring is usually made up of a number of leaves of different length. The top, or longest leaf, is normally referred to as the main leaf.



Fig: Rear Suspension System

Another example: This driven or 'live' rear axle arrangement consists of: shock absorbers; u-bolts; fixed shackle; rebound clips and swinging shackles as shown below.

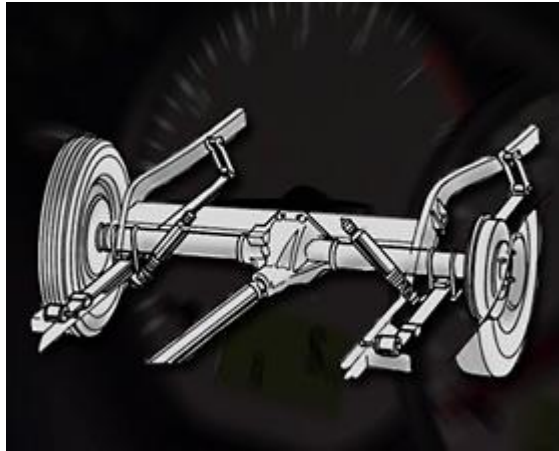


Fig: Rear Suspension System Layout

Experiment No: 9

Objective: To study and prepare report on the constructional details, working principles and operation of the **Automotive Steering Systems**.

Apparatus: Models of

- (a) Manual Steering Systems, e.g. Pitman –arm steering, Rack & Pinion steering.
- (b) Power steering Systems, e.g. Rack and Pinion Power Steering System.

Theory:

(a) **Constructional details, working principles and operation of the Manual Steering Systems, e.g. Pitman –arm steering, Rack & Pinion steering:**

The **Pitman arm** is a steering component in an automobile or truck. The pitman arm shaft is attached to the steering box by a spline and nut. As the driver turns the steering wheel, the steering box mechanism moves the steering linkages via the pitman arm shaft either left or right, depending on the direction in which the steering wheel is turned. The steering box provides the change of angle at 90° to the steering linkage. The idler arm is attached to the chassis and is positioned parallel to the pitman arm. The track rod connects the pitman arm shaft to the idler arm shaft. In this way any movement in the pitman arm shaft is directly applied to the idler arm shaft.

The tie rods connect the track rod to the steering arms that are located on the steering knuckles. Thus all movement from the pitman arm shaft is relayed directly to the front wheels, which steer the vehicle. Tie rod ends are attached to the tie-rod shaft. These pivot as the rack is extended or retracted when the vehicle is negotiating turns. Tie-rods and tie-rod ends are left or right hand threaded. The adjustment sleeve connects the tie-rod to the tie-rod end.



Fig: Pitman Arm Steering

The primary components of the **rack and pinion steering system** are: rubber bellows, pinion, rack, inner ball joint or socket and tie-rod. This rubber bellows is attached to the Rack and Pinion housing. It protects the inner joints from dirt and contaminants. In addition, it retains the grease lubricant inside the rack and pinion housing. There is an identical bellows on the other end of the rack for the opposite side connection. The pinion is connected to the steering column. As the driver turns the steering wheel, the forces are transferred to the pinion and it then causes the rack to move in either direction. This is achieved by having the pinion in constant mesh with the rack.

The rack slides in the housing and is moved by the action of the meshed pinion into the teeth of the rack. It normally has an adjustable bush opposite the pinion to control their meshing, and a nylon bush at the other end. The inner ball joint is attached to the tie-rod, to allow for suspension movement and slight changes in steering angles. A tie rod end is attached to the tie-rod shaft. These pivot as the rack is extended or retracted when the vehicle is negotiating turns. Some tie-rods and tie-rod ends are left or right hand threaded.

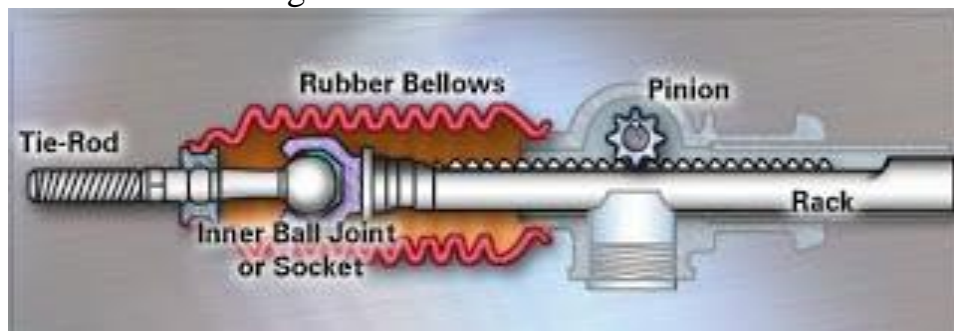


Fig: Rack & Pinion Steering

(b) Constructional details, working principles and operation of the Power steering Systems, e.g. Rack and Pinion Power Steering System:

The use of electronics into automotive steering systems enables much more sophisticated control to be achieved. Electric steering is more economical to run, and easier to package and install than conventional hydraulic power steering systems. Electrically Powered Hydraulic Steering, or EPHS, replaces the customary drive belts and pulleys with a brushless motor that drives a high efficiency hydraulic power steering pump in a conventional rack and pinion steering system. Pump speed is regulated by an electric controller to vary pump pressure and flow. This provides steering efforts tailored for different driving situations. The pump can be run at low speed or shut off to provide energy savings during straight ahead driving. An EPHS system is able to deliver an 80 percent

improvement in fuel economy when compared to standard hydraulic steering systems. Electrically assisted steering or EAS is a power-assist system that eliminates the connection between the engine and steering system. EAS or direct electric power steering takes the technology a step further by completely eliminating hydraulic fluid and the accompanying hardware from the system, becoming a full “electronic power steering system” or EPS. An EPS Direct electric steering system uses an electric motor attached to the steering rack via a gear mechanism and torque sensor. A microprocessor or electronic control unit, and diagnostic software control steering dynamics and driver effort. Inputs include vehicle speed and steering, wheel torque, angular position and turning rate.

There are four primary types of electric power assist steering systems:

1. Column-assist type. In this system the power assist unit, controller and torque sensor are attached to the steering column.
2. Pinion-assist type. In this system the power assist unit is attached to the steering gear pinion shaft. The unit sits outside the vehicle passenger compartment, allowing assist torque to be increased greatly without raising interior compartment noise.
3. Rack-assist type. In this system the power assist unit is attached to the steering gear rack. It is located on the rack to allow for greater flexibility in the layout design.
4. Direct-drive type. In this system the steering gear rack and power assist unit form a single unit. The steering system is compact and fits easily into the engine compartment layout. The direct assistance to the rack enables low friction and inertia, which in turn gives an ideal steering feel.

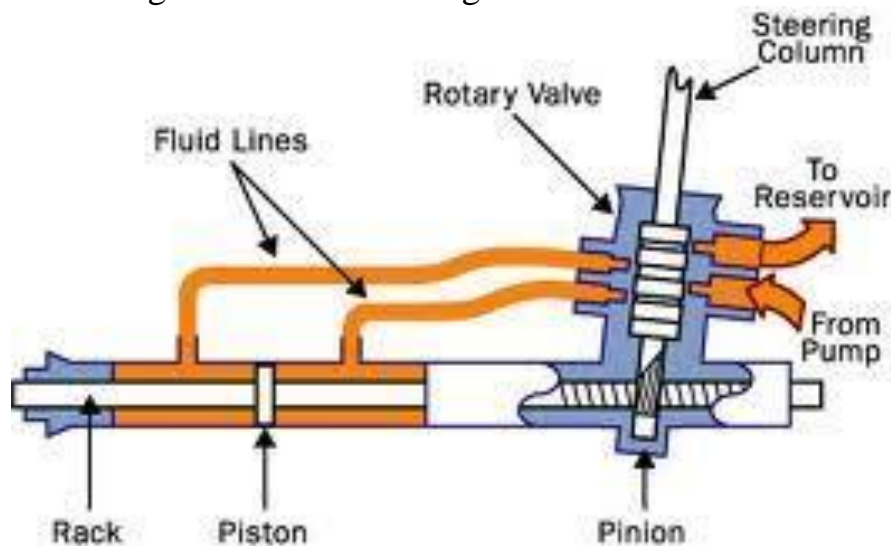


Fig: Power Steering

Experiment No: 10

Objective: To study and prepare report on the constructional details, working principles and operation of the **Automotive Brake systems**.

Apparatus: Models of

- (a) Hydraulic & Pneumatic Brake systems.
- (b) Drum Brake System.
- (c) Disk Brake System.
- (d) Antilock Brake System.

Theory:

(a) Constructional details, working principles and operation of the Hydraulic & Pneumatic Brake systems:

The **Hydraulic brake system** is a braking system which uses brake fluid usually includes ethylene glycol, to transmit pressure from the controlling unit, which is usually near the driver, to the actual brake mechanism, which is near the wheel of the vehicle. The most common arrangement of hydraulic brakes for passenger vehicles, motorcycles, scooters, and mopeds, consists of the following:

Brake pedal or Brake lever

Pushrod, also called an actuating rod

Reinforced hydraulic lines

Rotor or a brake disc or a drum attached to a wheel

Master cylinder assembly includes: Piston assembly is made up of one or two pistons, a return spring, a series of gaskets or O-rings and fluid reservoir.

Brake caliper assembly usually includes: One or two hollow aluminum or chrome-plated steel pistons called caliper pistons and set of thermally conductive brake pads.

A glycol-ether based brake fluid regularly loads the system or some other fluids are also used to control the transfer of force or power between the brake lever and the wheel. The automobiles generally use disc brakes on the front wheels and drum brakes on the rear wheels. The disc brakes have good stopping performance and

are usually safer and more efficient than drum brakes. Many two wheel automobiles design uses a drum brake for the rear wheel.

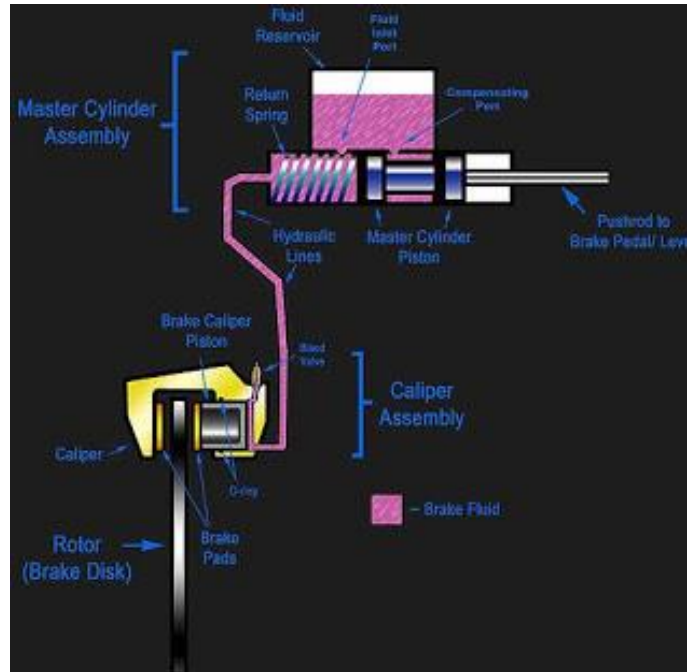


Fig: Hydraulic-Brake

In Hydraulic brake system when the brake pedal or brake lever is pressed, a pushrod applies force on the piston in the master cylinder causing fluid from the brake fluid tank to run into a pressure chamber through a balancing port which results in increase in the pressure of whole hydraulic system. This forces fluid through the hydraulic lines to one or more calipers where it works upon one or two extra caliper pistons protected by one or more seated O-rings which prevent the escape of any fluid from around the piston. The brake caliper piston then applies force to the brake pads. This causes them to be pushed against the rotating rotor, and the friction between pads and rotor causes a braking torque to be generated, slowing the vehicle. Heat created from this friction is dispersed through vents and channels in rotor and through the pads themselves which are made of particular heat-tolerant materials like kevlar, sintered glass. The consequent discharge of the brake pedal or brake lever lets the spring(s) within the master cylinder assembly to return that assembly piston(s) back into position. This reduces the hydraulic pressure on the caliper lets the brake piston in the caliper assembly to slide back into its lodging and the brake pads to discharge the rotor. If there is any leak in the system, at no point does any of the brake fluid enter or leave.

In hydraulic brake the brake pedal is called as brake pedal or brake lever. One end of the hydraulic brake is connected to the frame of the vehicle, the other end is connected to the foot pad of the lever and a pushrod extends from a point along its

length. The rod either widens to the master cylinder brakes or to the power brakes. The master cylinder is separated as two parts in cars, each of which force a separate hydraulic circuit. Every part provides force to one circuit. A front/rear split brake system utilizes one master cylinder part to pressure the front caliper pistons and the other part to pressure the rear caliper pistons.

Pneumatic or Air Brake System is the brake system used in automobiles such as buses, trailers, trucks, and semi-trailers. The Compressed Air Brake System is a different air brake used in trucks which contains a standard disc or drum brake using compressed air instead of hydraulic fluid. The compressed air brake system works by drawing clean air from the environment, compressing it, and hold it in high pressure tanks at around 120 PSI. Whenever the air is needed for braking, this air is directed to the functioning cylinders on brakes to activate the braking hardware and slow the vehicle. Air brakes use compressed air to increase braking forces. Design and Function: The Compressed air brake system is separated into control system and supply system. The supply system compresses, stores and provides high pressure air to the control system and also to other air operated secondary truck systems such as gearbox shift control, clutch pedal air assistance servo, etc., Control system: The control system is separated into two service brake circuits. They are the parking brake circuit and the trailer brake circuit. This two brake circuits is again separated into front and rear wheel circuits which gets compressed air from their individual tanks for more protection in case of air leak. The service brakes are applied by brake pedal air valve which controls both circuits. The parking brake is the air controlled spring brake which is applied by spring force in the spring brake cylinder and released by compressed air through the hand control valve. The trailer brake consists of a direct two line system the supply line which is marked red and the separate control or service line which is marked blue. The supply line gets air from the main mover park brake air tank through a park brake relay valve and the control line is regulated through the trailer brake relay valve. The working signals for the relay are offered by the prime mover brake pedal air valve, trailer service brake hand control and Prime Mover Park brake hand control. Supply system: The air compressor is driven off of the automobile engine by crankshaft pulley through a belt or straightly off of the engine timing gears. It is lubricated and cooled by the engine lubrication and cooling systems. The Compressed air is initially directed through a cooling coil and into an air dryer which eliminates moisture and oil impurities and also contains a pressure regulator, safety valve and a little purge reservoir. The supply system is outfitted with an anti freeze device and oil separator which is an alternative to the air dryer. The compressed air is then stored in a tank and then it is issued through a

4 - way protection valve into the front and rear brake circuit air reservoir, a parking brake reservoir and an auxiliary air supply distribution point. The Supply system also contains many check, pressure limiting, drain and safety valves.



Fig: Air Break

(b) Constructional details, working principles and operation of the Drum Brake System:

Drum brakes consist of a backing plate, brake shoes, brake drum, wheel cylinder, return springs and an automatic or self-adjusting system. When you apply the brakes, brake fluid is forced under pressure into the wheel cylinder, which in turn pushes the brake shoes into contact with the machined surface on the inside of the drum. When the pressure is released, return springs pull the shoes back to their rest position. As the brake linings wear, the shoes must travel a greater distance to reach the drum. When the distance reaches a certain point, a self-adjusting mechanism automatically reacts by adjusting the rest position of the shoes so that they are closer to the drum.

Brake Shoes: Like the disk pads, brake shoes consist of a steel shoe with the friction material or lining riveted or bonded to it.

Backing Plate: The backing plate is that holds everything together. It attaches to the axle and forms a solid surface for the wheel cylinder, brake shoes and assorted hardware.

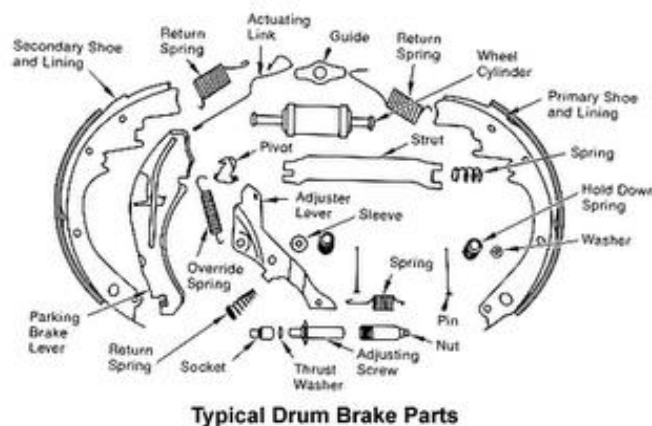
Brake Drum: Brake drums are made of iron and have a machined surface on the inside where the shoes make contact. Just as with disk rotors, brake drums will show signs of wear as the brake linings seat themselves against the machined surface of the drum.

Wheel Cylinder: The wheel cylinder consists of a cylinder that has two pistons, one on each side. Each piston has a rubber seal and a shaft that connects the piston with a brake shoe. When brake pressure is applied, the pistons are forced out

pushing the shoes into contact with the drum. Wheel cylinders must be rebuilt or replaced if they show signs of leaking.

Return Springs: Return springs pull the brake shoes back to their rest position after the pressure is released from the wheel cylinder. If the springs are weak and do not return the shoes all the way, it will cause premature lining wear because the linings will remain in contact with the drum.

Self Adjusting System: The parts of a self adjusting system should be clean and move freely to insure that the brakes maintain their adjustment over the life of the linings. If the self adjusters stop working, you will notice that you will have to step down further and further on the brake pedal before you feel the brakes begin to engage. Disk brakes are self adjusting by nature and do not require any type of mechanism.



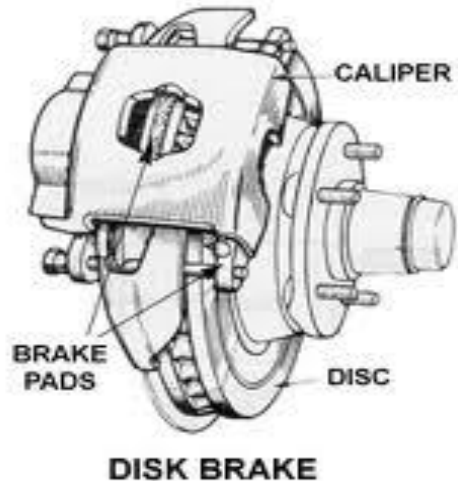
(c) Constructional details, working principles and operation of the Disk Brake System:

The disk brake is the best brake we have found so far. Disk brakes are used to stop everything from cars to locomotives and jumbo jets. Disk brakes wear longer, are less affected by water, are self adjusting, self cleaning, less prone to grabbing or pulling and stop better than any other system around. The main components of a disk brake are the Brake Pads, Rotor, Caliper and Caliper Support.

Brake Pads: There are two brake pads on each caliper. They are constructed of a metal "shoe" with the lining riveted or bonded to it. The pads are mounted in the caliper, one on each side of the rotor. Brake linings used to be made primarily of asbestos because of its heat absorbing properties and quiet operation; however, due to health risks, asbestos has been outlawed, so new materials are now being used.

Rotor: The disk rotor is made of iron with highly machined surfaces where the brake pads contact it. Just as the brake pads wear out over time, the rotor also undergoes some wear, usually in the form of ridges and groves where the brake pad rubs against it.

Caliper & Support: There are two main types of calipers: Floating calipers and fixed calipers. A floating caliper "floats" or moves in a track in its support so that it can center itself over the rotor. As you apply brake pressure, the hydraulic fluid pushes in two directions. It forces the piston against the inner pad, which in turn pushes against the rotor. It also pushes the caliper in the opposite direction against the outer pad, pressing it against the other side of the rotor. Four Piston Fixed Calipers are mounted rigidly to the support and are not allowed to move. Instead, there are two pistons on each side that press the pads against the rotor.



(d) Constructional details, working principles and operation of the Antilock Brake System:

An **anti-lock braking system** abbreviated as **ABS** is a braking system or security system which prevents the wheels on an automobile from locking up while braking. The wheels revolving on the road let the driver to maintain steering control under heavy braking by preventing a skid and allowing the wheel to continue interacting tractively with the road surface as directed by driver steering inputs. The ABS offers better vehicle control, and may reduce ending distances on dry and especially slippery surfaces. It can also boost braking distance on loose surfaces such as snow and gravel.

The Anti-lock Brake System is composed of a central electronic control unit (ECU), four wheel speed sensors one for each wheel and two or more hydraulic valves inside the brake hydraulics. The ECU continuously observes the revolving speed of every wheel, and when it senses a wheel rotating significantly slower than the other wheels a condition indicative of approaching wheel lock it trigger the valves to decrease hydraulic pressure to the brake at the affected wheel, thus dropping the braking power on that wheel. Then the wheel turns quicker when the ECU senses it is rotating significantly faster than the others, brake hydraulic pressure to the wheel is improved so the braking force is reapplied and the wheel

slows. This process is repeated always, and it is perceived by the driver via brake pedal pulsation. A typical anti-lock system can apply and discharge braking pressure up to 20 times a second.

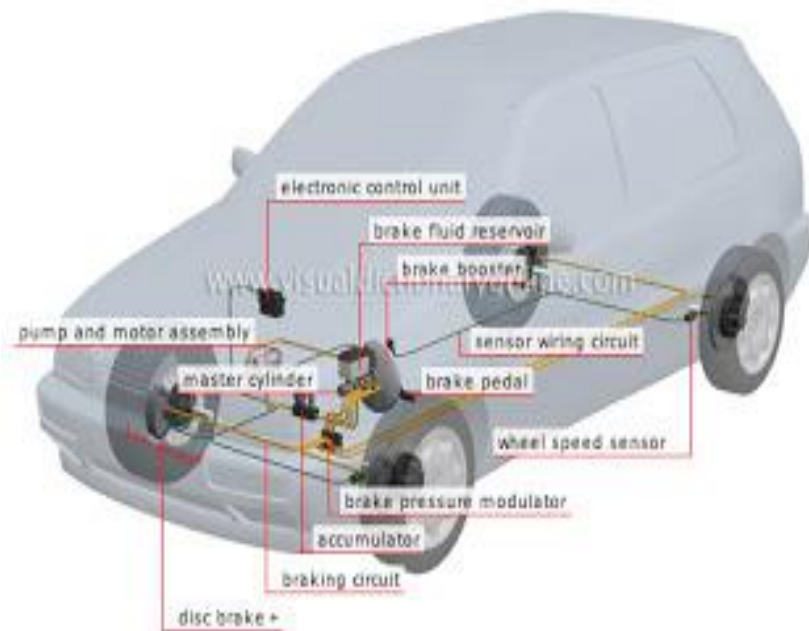


Fig: Antilock-Braking-System-(ABS)

Experiment No: 11

Objective: To study and prepare report on the constructional details, working principles and operation of the **Automotive Tyres & wheels**.

Apparatus: Models of

- (a) Various Types of Bias & Radial Tyres.
- (b) Various Types of wheels.

Theory:

(a) Constructional details, working principles and operation of the Various Types of Bias & Radial Tyres:

- 1. Bias:** Bias tire (or cross ply) construction utilizes body ply cords that extend diagonally from bead to bead, usually at angles in the range of 30 to 40 degrees, with successive plies laid at opposing angles forming a crisscross pattern to which the tread is applied. The design allows the entire tire body to flex easily, providing the main advantage of this construction, a smooth ride on rough surfaces. This cushioning characteristic also causes the major disadvantages of a bias tire: increased rolling resistance and less control and traction at higher speeds.
- 2. Belted bias:** A belted bias tire starts with two or more bias-ply cords to which stabilizer belts are bonded directly beneath the tread. This construction provides smoother ride that is similar to the bias tire, while lessening rolling resistance because the belts increase tread stiffness. The plies and belts are at different angles, which improve performance compared to non-belted bias tires. The belts may be cord or steel.
- 3. Radial tyres:** Radial tyre construction utilizes body ply cords extending from the beads and across the tread so that the cords are laid at approximately right angles to the centerline of the tread, and parallel to each other, as well as stabilizer belts directly beneath the tread. The belts may be cord or steel. The advantages of this construction include longer tread life, better steering control, and lower rolling resistance. Disadvantages of the radial tire include a harder ride at low speeds on rough roads and in the

context of off-roading, decreased "self-cleaning" ability and lower grip ability at low speeds.

4. Solid: Many tires used in industrial and commercial applications are non-pneumatic, and are manufactured from solid rubber and plastic compounds via molding operations. Solid tires include those used for lawn mowers, skateboards, golf carts, scooters, and many types of light industrial vehicles, carts, and trailers. One of the most common applications for solid tires is for material handling equipment (forklifts). Such tires are installed by means of a hydraulic tire press.

5. Semi-pneumatic: Semi-pneumatic tires have a hollow center, but they are not pressurized. They are light-weight, low-cost, puncture proof, and provide cushioning. These tires often come as a complete assembly with the wheel and even integral ball bearings. They are used on lawn mowers, wheelchairs, and wheelbarrows. They can also be rugged, typically used in industrial applications, and are designed to not pull off their rim under use.

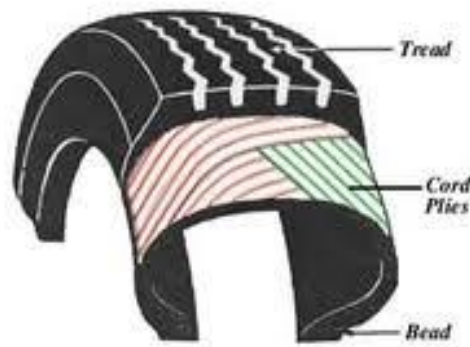


Fig: Bias Tyre



Fig: Radial Tyre

(b) Constructional details, working principles and operation of the Various Types of wheels:

Wheels must be strong enough to carry the mass of the vehicle, and withstand the forces that are generated during use. Some are made from steel. They are pressed in 2 sections - the wheel center, with a flange or disc that is drilled for the wheel fasteners, and the rim. They are then welded together. Others are made from cast aluminum alloy. Alloy wheels are lighter than similar steel wheels, and since aluminum is a better heat conductor than steel, alloy wheels dissipate heat from brakes and tires more quickly than steel wheels. The wheel center must accurately locate the wheel rim centrally on the axle. It must also provide the required distance from the centerline of the wheel, to the face of the mounting flange. This is called offset. Offset is important because it brings the tire centerline into close alignment with the larger inner hub bearing, and reduces load on the stub axle. This allows the inside of the wheel center to be shaped to provide space for the brake assembly, usually located inside the wheel. Ventilation slots allow air to circulate around the brakes. In some cases wheels are directional to assist the airflow. The rim must be accurately shaped, and dimensioned, and strong enough to support the tire under the load of the vehicle and the forces generated by the motion of the vehicle. Passenger cars normally use rims which are of well based, or drop-center design. The drop-center is used for mounting and demounting the tire onto the rim. When inflated, the tire is locked to the rim by tapering the bead seat towards the flange, or by safety ridges or humps, close to the flange. In the event of sudden deflation, or blowout, safety ridges prevent the tire moving down into the well. This helps maintain control of the vehicle while it is being braked. Well-based rims can also be used on heavy commercial vehicles for tubeless tires. The rims are referred to as 15-degree drop-center rims, because the bead seats are inclined at 15 degrees towards the flange. The taper gives a good grip, and an airtight seal between the tire beads, and the rim. The low flanges and drop-center allow the special size, flexible, tubeless truck tires to be mounted and demounted in a similar manner to that used on smaller passenger car tires. The stiff sidewalls of larger cross-ply tires mean they cannot be mounted and demounted in this way, and many 4-wheel-drive and commercial vehicles use a flat-base, demountable flange rim. When all of the air is removed from the tire, one flange can be removed so the tire can be demounted. Wheels are fastened to the hubs by wheel studs and nuts. They are highly stressed by loads from the weight of the vehicles, and the forces generated by its motion, and they're made from heat-treated, high-grade alloy-steel. The threads between the studs and nuts are close fitting and accurately-sized. All wheel nuts must be tightened to the correct torque; otherwise the wheel could break free from the hub.



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Experiment No: 12

Objective: To study and prepare report on the constructional details, working principles and operation of **Automotive Emission / Pollution control systems**.

Apparatus: Model of Automotive Emission / Pollution control systems.

Theory: The need to control the emissions from automobiles gave rise to the computerization of the automobile. Hydrocarbons, carbon monoxide and oxides of nitrogen and particulates are created during the combustion process and are emitted into the atmosphere from the tail pipe. There are also hydrocarbons emitted as a result of vaporization of gasoline and from the crankcase of the automobile. Some of the more popular emission control systems installed on the automobile are: EGR valve, catalytic converter, EVAP system, air injection system, PCV valve, charcoal canister.

Sources of vehicle emissions are Engine Crankcase Blow-by Fumes (20%) – heating oil and burning of fuel that blows past piston rings and into the crankcase. Fuel Vapour (20%) – chemicals that enter the air as fuel evaporates. Engine Exhaust (60%) - blown out the tailpipe when engine burns a hydrocarbon based fuel.

Constructional details, working principles and operation of Automotive Emission / Pollution control systems:

PCV Valve: The purpose of the **positive crankcase ventilation** (PCV) system is to take the vapors produced in the crankcase during the normal combustion process, and redirecting them into the air/fuel intake system to be burned during combustion. These vapors dilute the air/fuel mixture so they have to be carefully controlled and metered in order to not affect the performance of the engine. This is the job of the positive crankcase ventilation (PCV) valve. At idle, when the air/fuel mixture is very critical, just a little of the vapors are allowed in to the intake system. At high speed when the mixture is less critical and the pressures in the engine are greater, more of the vapors are allowed in to the intake system. When the valve or the system is clogged, vapors will back up into the air filter housing or at worst; the excess pressure will push past seals and create engine oil leaks. If the

wrong valve is used or the system has air leaks, the engine will idle rough, or at worst, engine oil will be sucked out of the engine.

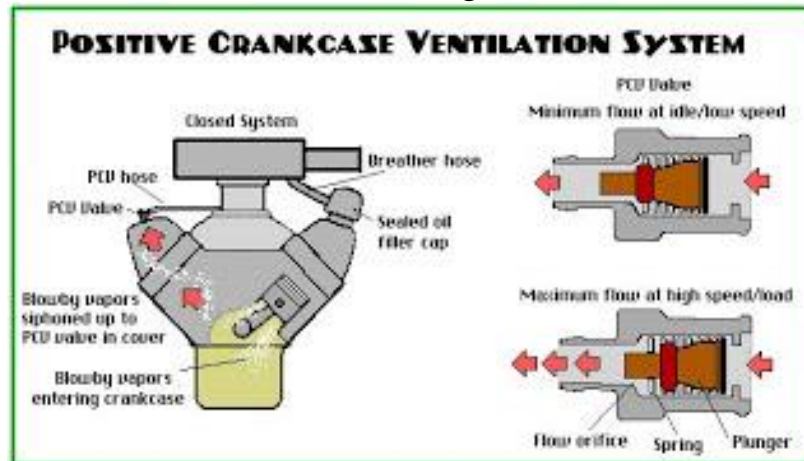


Fig: PCV System

Evaporative Emission Control Systems (EVAP): It prevents toxic fuel system vapours from entering the atmosphere. It consists of parts non-vented fuel tank cap which prevents fuel vapours from entering the atmosphere, air dome is hump formed at the top of the tank for fuel expansion, charcoal canister which stores vapours when the engine is not running, purge line/valve which controls the flow of vapours from the canister to the intake manifold that allows flow when engine reaches operating temperature and is operating above idle speed.

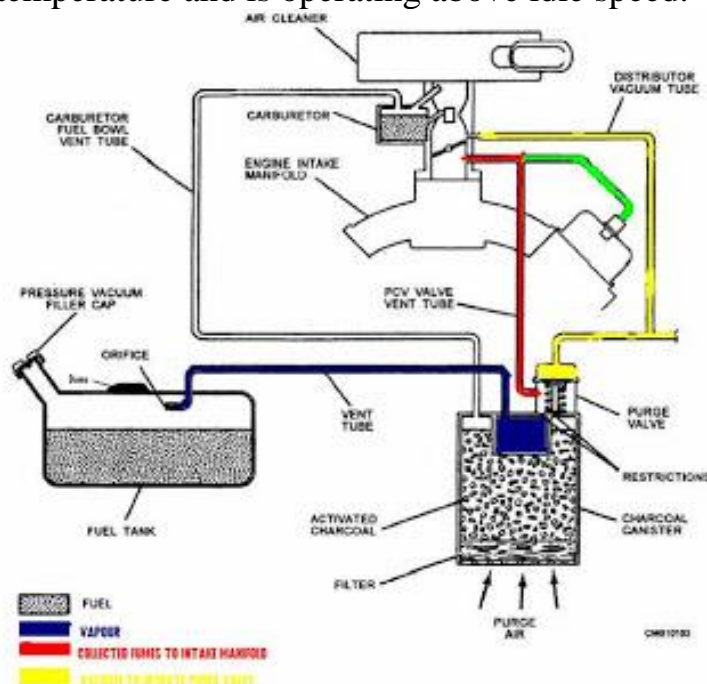


Fig: EVAP System

Exhaust Gas Recirculation (EGR): The purpose of the exhaust gas recirculation valve (EGR) valve is to meter a small amount of exhaust gas into the intake

system; this dilutes the air/fuel mixture so as to lower the combustion chamber temperature. Excessive combustion chamber temperature creates oxides of nitrogen, which is a major pollutant. While the EGR valve is the most effective method of controlling oxides of nitrogen, in its very design it adversely affects engine performance. The engine was not designed to run on exhaust gas. For this reason the amount of exhaust entering the intake system has to be carefully monitored and controlled. This is accomplished through a series of electrical and vacuum switches and the vehicle computer. Since EGR action reduces performance by diluting the air /fuel mixture, the system does not allow EGR action when the engine is cold or when the engine needs full power.

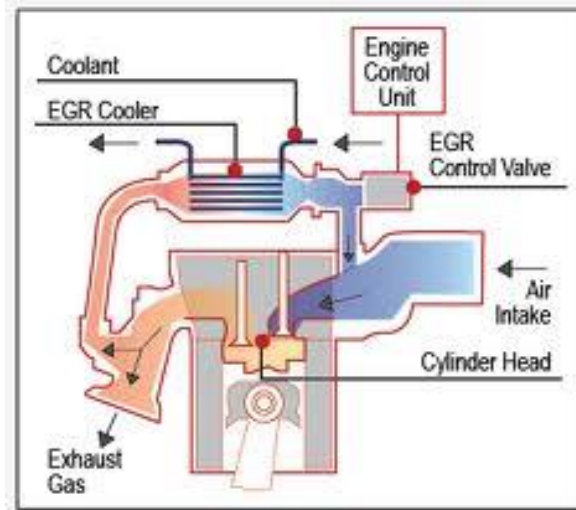


Fig: EGR System

Air Injection System: Since no internal combustion engine is 100% efficient, there will always be some unburned fuel in the exhaust. This increases hydrocarbon emissions. To eliminate this source of emissions an air injection system was created. Combustion requires fuel, oxygen and heat. Without any one of the three, combustion cannot occur. Inside the exhaust manifold there is sufficient heat to support combustion, if we introduce some oxygen than any unburned fuel will ignite. This combustion will not produce any power, but it will reduce excessive hydrocarbon emissions. Unlike in the combustion chamber, this combustion is uncontrolled, so if the fuel content of the exhaust is excessive, explosions that sound like popping will occur. There are times when under normal conditions, such as deceleration, when the fuel content is excessive. Under these conditions we would want to shut off the air injection system. This is accomplished through the use of a diverter valve, which instead of shutting the air pump off, diverts the air away from the exhaust manifold. Since all of this is done after the combustion process is complete, this is one emission control that has no effect on

engine performance. The only maintenance that is required is a careful inspection of the air pump drive belt.

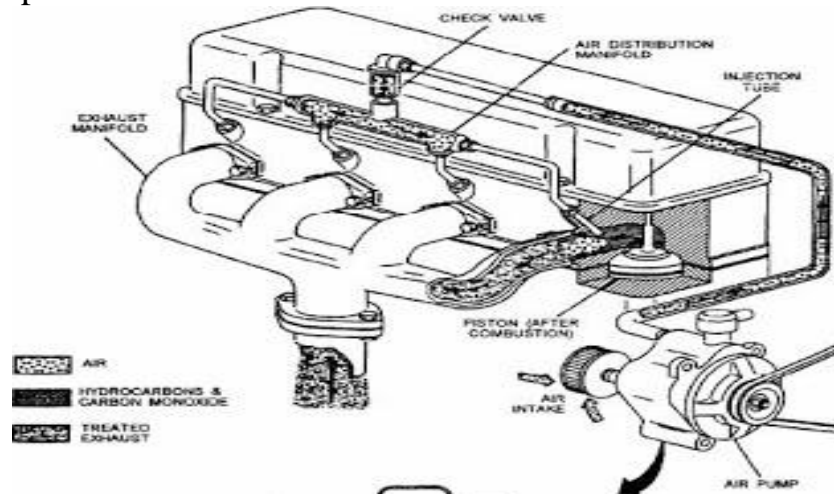


Fig: Air Injection System

Catalytic Converter System: Automotive emissions are controlled in three ways; one is to promote more complete combustion so that there is less by products. The second is to reintroduce excessive hydrocarbons back into the engine for combustion and the third is to provide an additional area for oxidation or combustion to occur. This additional area is called a catalytic converter. The catalytic converter looks like a muffler. It is located in the exhaust system ahead of the muffler. Inside the converter are pellets or a honeycomb made of platinum or palladium. The platinum or palladium is used as a catalyst (a catalyst is a substance used to speed up a chemical process). As hydrocarbons or carbon monoxide in the exhaust are passed over the catalyst, it is chemically oxidized or converted to carbon dioxide and water. As the converter works to clean the exhaust, it develops heat. The dirtier the exhaust, the harder the converter works and the more heat that is developed. In some cases the converter can be seen to glow from excessive heat. If the converter works this hard to clean a dirty exhaust it will destroy itself. Also leaded fuel will put a coating on the platinum or palladium and render the converter ineffective.

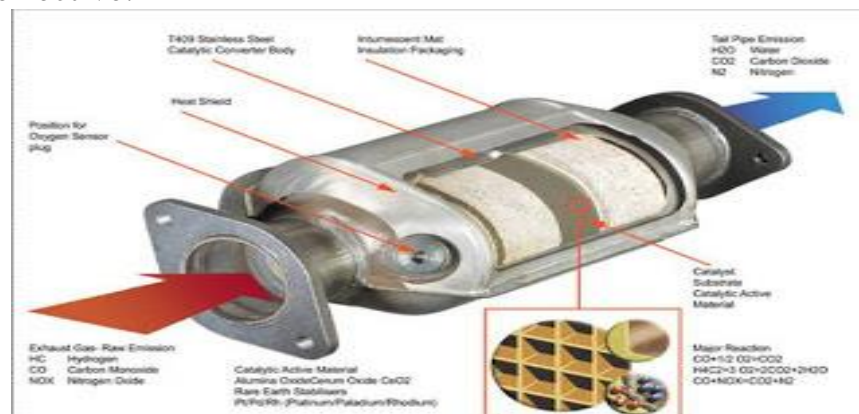


Fig: Catalytic Converter System