MODULE 1

SYLLABUS:

CO1: Identify fuel systems employed in petrol vehicles.

Different fuel feed system components - fuel feed pump, Petrol fuel filters, and air cleaners. Working of simple carburettor, Air fuel ratios, stoichiometric air - fuel ratio, Introduction to Electronic Fuel Injection (EFI) systems - basic working, Types of petrol injection - indirect injection methods-single point injection, multi point injection, direct injection, components - fuel tank, fuel supply pump, fuel lines, fuel filters, fuel pressure regulator, fuel injectors - operation, EFI subsystems - air intake system, fuel delivery system, electronic control system, sensors and actuators - different types, idle air control, on board diagnostics of EFI.

FUEL SUPPLY SYSTEM:

The basic fuel supply system in an automobile with petrol engine consists of a fuel tank, fuel lines, fuel pump, fuel filter, air cleaner, carburettor, inlet manifold and supply & return pipelines.

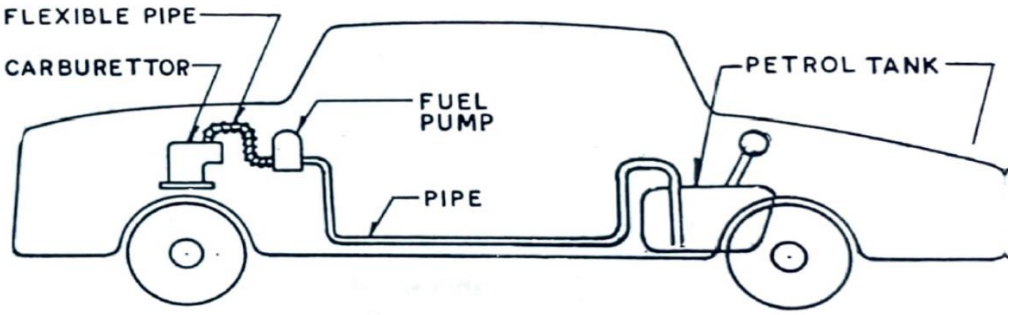


Fig. 9.1. Pump system of fuel supply.

FUEL FEED PUMP:

- The fuel pump is used to pump the petrol into the float chamber of the carburettor through flexible pipe.
- Two main types of pumps most generally used are:
  1. **A.C. Mechanical Pump**
  2. **S.U. Electrical Pump**
- If the fuel pump is mechanical, it has to be driven from the engine camshaft and hence placed on the engine itself.
- However, electrically operated fuel pump can be placed anywhere, the real location is away from the hot engine to reduce the tendency of forming vapour lock. This system is used most commonly in the present-day cars.

1. A.C. MECHANICAL PUMP:

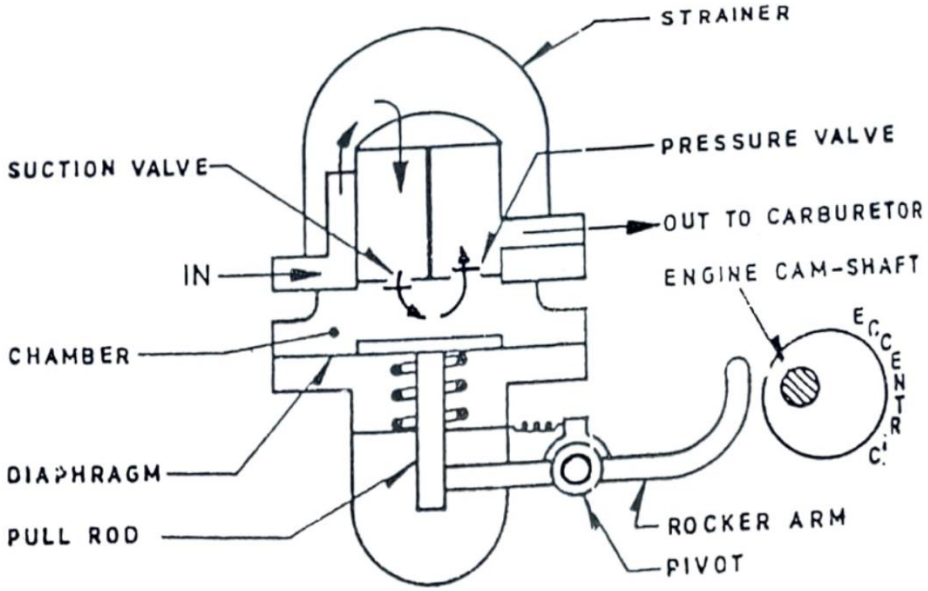


Fig. 9.2. A.C. Mechanical pump

- The drive for the pump is taken from camshaft by means of an eccentric or cam.
- The eccentric operates the rocker arm which in conjunction with the diaphragm return spring pushes the diaphragm up and down.
- Downward movement of the diaphragm causes vacuum in the chamber which causes the inlet valve to open and the fuel then goes through the strainer to the chamber.
- The next upward movement of the diaphragm causes the inlet valve to close while the outlet valve opens and the fuel goes out to carburettor float chamber.

2. S.U. ELECTRIC PUMP:

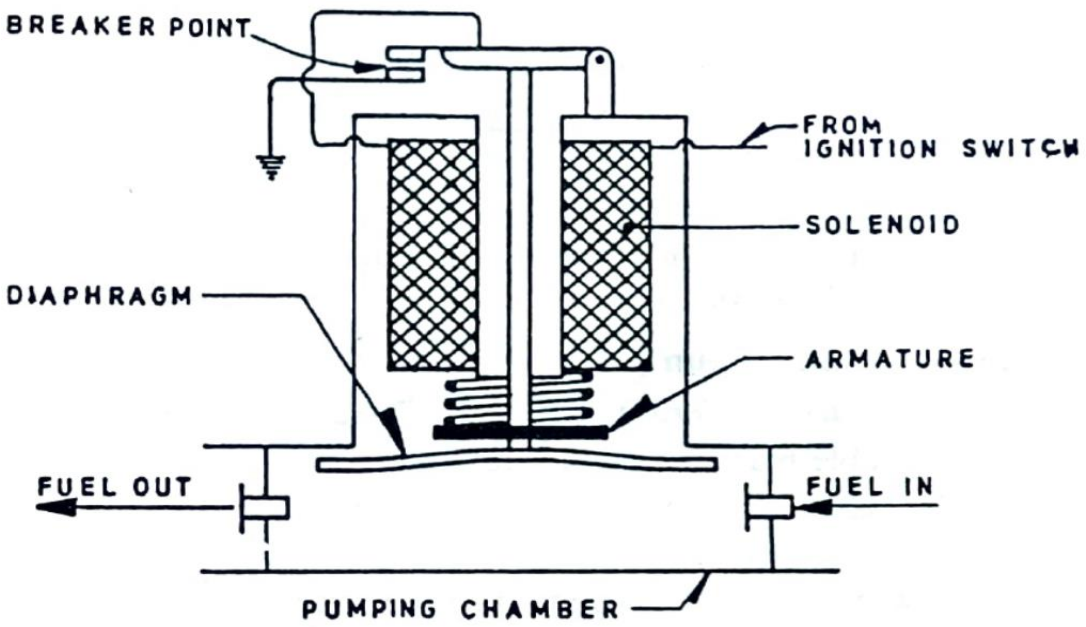


Fig. 9.5. S.U. Electrical Pump

- Here, alternate vacuum and pressure are produced due to the movement of the diaphragm which is caused electrically.
- Closing the ignition switch energises the solenoid winding, magnetic flux is generated which pulls the armature to which the diaphragm is attached.
- Thus, the diaphragm moves to cause suction in the chamber and the fuel is drawn into the chamber.
- But as soon as the armature moves, it interrupts the electric supply by disconnecting the breaker points, the solenoid is de-energised and the armature falls back, causing the diaphragm to move to create pressure in the pump chamber which opens the outlet valve and the fuel goes out to the carburettor float chamber.
- This movement of the armature, however, completes the circuit again and the solenoid again gets energized.
- The whole cycle is again repeated in this way and the fuel continues to be pumped.

AIR CLEANERS (AIR FILTERS):

- As hundreds of cubic metres of air per hour are used by the engine of an automobile, it is very important that this air should be very clean.
- Impurities like dust in the air cause a very rapid wear of the engine, particularly of the cylinders, pistons, rings, valves and guides.
- Apart from filtering the air, air cleaner also performs other functions: It acts as a silencer for the carburation system i.e., it reduces the engine induction noise to an acceptable level.
- The air cleaners generally used are of two types:
  1. **Heavy duly type**
  2. **Light duty type**

1. HEAVY DUTY TYPE AIR CLEANER:

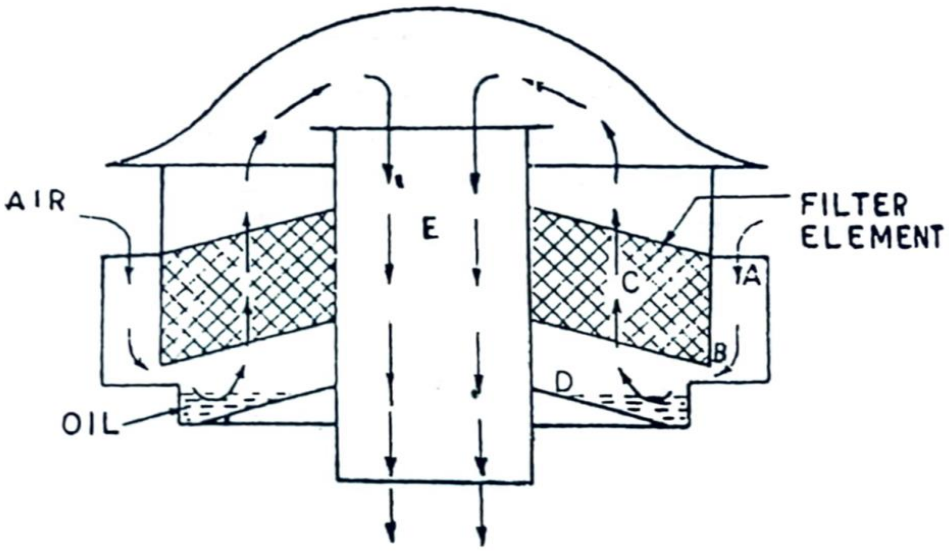
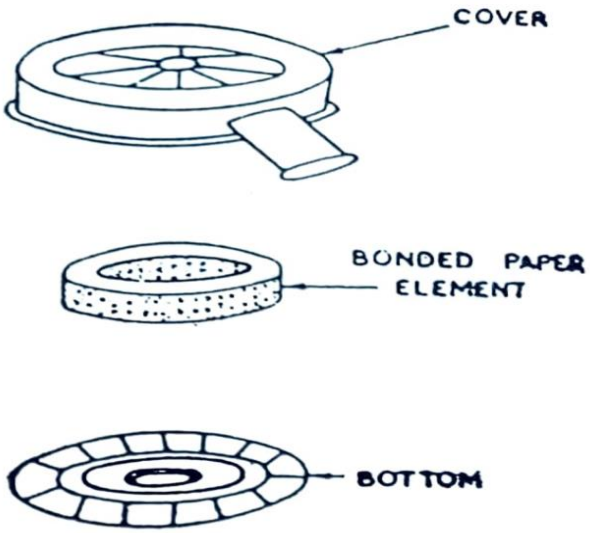


Fig. 9.6. Heavy duty air cleaner.

- It contains a filter element C saturated with oil.
- At the bottom There is separate oil pan D. The air from the atmosphere enters through circumferential gap A.
- At the corner B when the air takes a turn, it leaves large particle impurities there.
- Next, impinging on the surface of the oil relieves the air further of impurities.
- Final cleaning is done by means of filter C and the clean air passes through passage E as shown.

2. <u>LIGHT DUTY TYPE AIR CLEANER:</u>



- It consists of a cleaning element only. The element consists of a cylindrical cellulose fiber material, over which is put a fine mesh screen to provide strength.
- The element is corrugated to increase the surface area exposed to the incoming air so that the resistance offered by the air cleaner is reduced to minimum.
- Sides of the element are sealed against dust. The air passes through the element and any dust contained is left outside.

<u>CARBURETTORS:</u>

- A carburetor is a device which produces air–fuel mixture for facilitating combustion inside an internal combustion engine.

  functions of a carburettor:
  - To vaporize the fuel to prepare a homogeneous air fuel mixture.
  - To supply correct amount of the air fuel mixture at the correct strength under all conditions of load and speed.
  - To keep a small reserve of fuel at a constant head.

STOICHIOMETRIC AIR FUEL RATIO:

- The stoichiometric air fuel ratio is the ratio that gives the amount of air required for the complete combustion of the unit amount of fuel.
- The amount of air which is required for the complete combustion of fuel is known as stoichiometric air.
- For petrol engines, the stoichiometric air–fuel ratio is about 14.7:1. In order to completely burn 1 kg of gasoline fuel, the combustion process needs 14.7 kg of air.
- ***Rich mixture:*** When the air fuel ratio is lower than the stoichiometric ratio (i.e., amount of fuel higher than stoichiometric ratio), the air fuel mixture is called rich. For example, 13:1, 10:1, 9:1 etc.
- ***Lean mixture:*** When the air fuel ratio is higher than the stoichiometric ratio (i.e., amount of fuel lower than stoichiometric ratio), the air fuel mixture is called lean. For example, 16:1, 19:1, 20:1 etc.

MIXTURE STRENGTH REQUIREMENT:

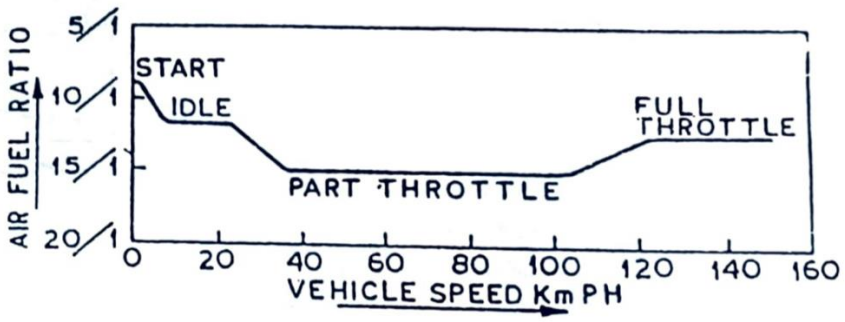
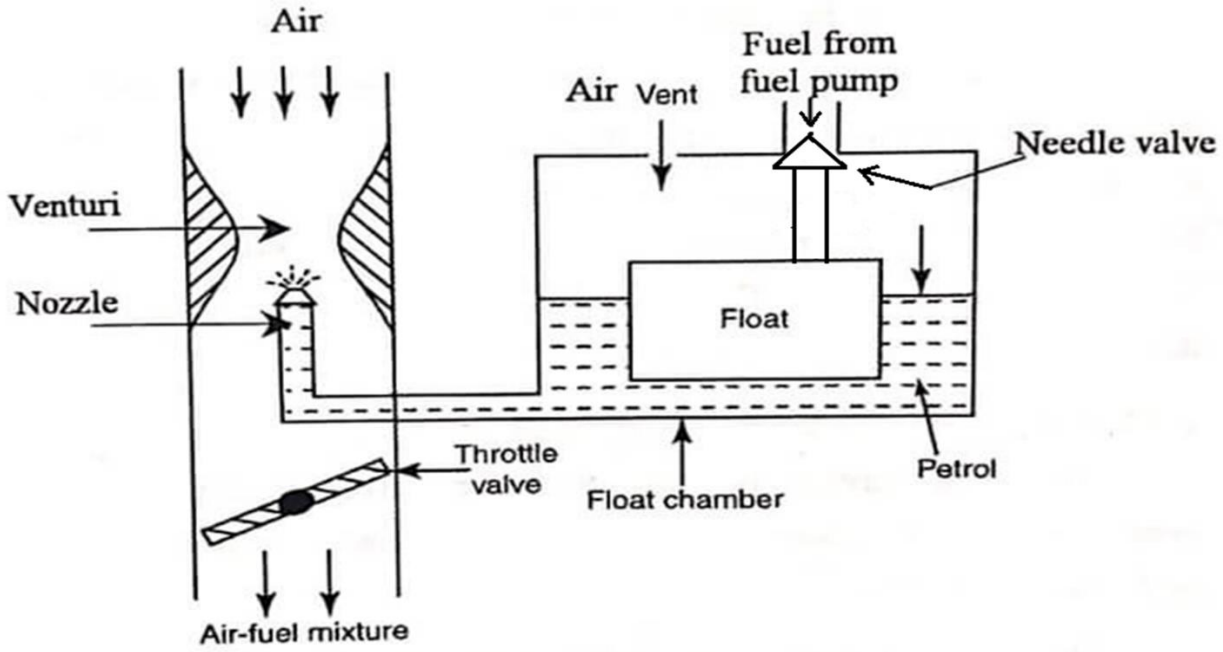


Fig. 9.8. Mixture strength requirement

- Fig. shows the air fuel ratio required at different engine speeds.
- For starting, the mixture required is very rich, because the engine is cold at that time due to which the fuel does not vaporize properly. Thus, to get enough volatile fuel while starting a cold engine, more fuel is required.
- While idling there is no external load on the engine, However, since the engine is still not turning hot at normal temperatures, and the airflow through the carburetor is slow, some liquid fuel drops out of the air-fuel mixture onto the manifold walls and condenses there. To compensate for this, a rich mixture is required, though not as rich as required for starting.
- For normal part throttle operation at cruising speeds a comparatively lean mixture, about 15:1 air fuel ratio, will suffice.
- Apart from this, a rich mixture is required during the acceleration period to provide the necessary power for increasing the vehicle speed.

SIMPLE CARBURETTOR:



- The main parts are a float chamber, fuel jet, venturi, nozzle and a throttle valve.
- The needle valve attached to the float lever serves to close or open the fuel inlet to the float chamber depending upon the requirements. The needle valve consists of a cylindrical stem with a conical tip.
- When the fuel level falls below a definite predetermined value, the float also falls along with fuel level, thus opening the passage for the fuel supply. The fuel starts flowing in and the float rises gradually till the fuel level reaches the desired value. At this time, the float needle closes the fuel inlet passage. Thus, a constant head of fuel is maintained in the float.
- A small vent in the float chamber keeps the pressure inside atmospheric.
- The venturi is simply a restriction in the air passage. Here the passage area is minimum. Thus, due to less area, the air velocity increases and because of this increase in velocity, decrease in pressure is caused at the nozzle which is located in venturi itself.
- Due to this drop in pressure at the nozzle, the fuel comes out and is vaporized by the coming air stream. The mixture then goes through the inlet manifold, to the engine cylinders.
- The purpose of a throttle valve is to control the quantity of air fuel mixture.

ELECTRONIC FUEL INJECTION:

- The petrol is injected by an electronically controlled valve, called injector, which is supplied with the petrol under high pressure by the fuel pump.
- When the injector is energized, an electromagnet actuates a plunger, opening the valve, allowing the pressurized fuel to flow through a tiny nozzle; which is designed to atomize the fuel.
- The amount of time the injector stays open determines the amount of fuel supplied to the engine and is called the pulse width, which is controlled by ECU.

TYPES OF FUEL INJECTION SYSTEM:

1. Throttle body injection
2. Port injection
3. Direct injection

1. THROTTLE BODY INJECTION: (TBI)

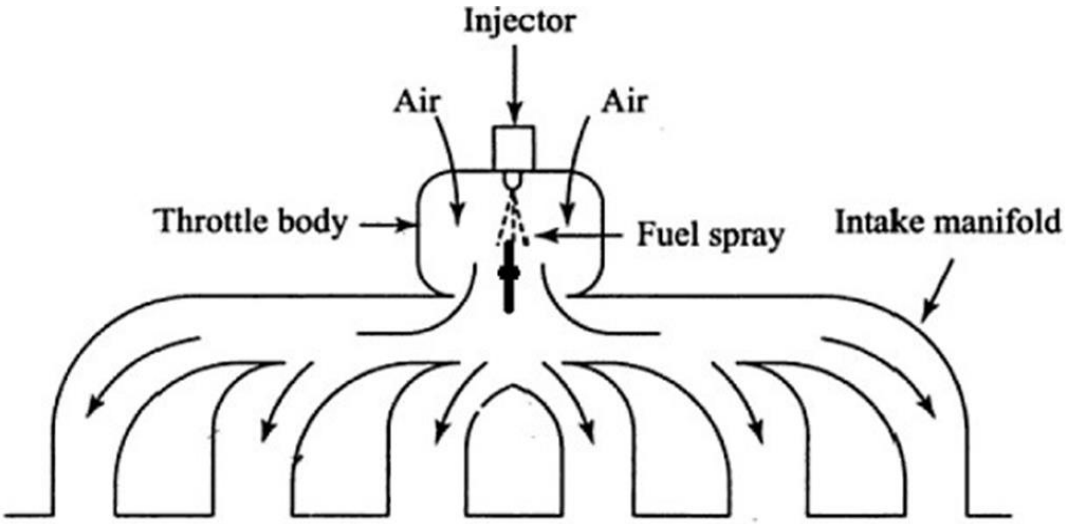
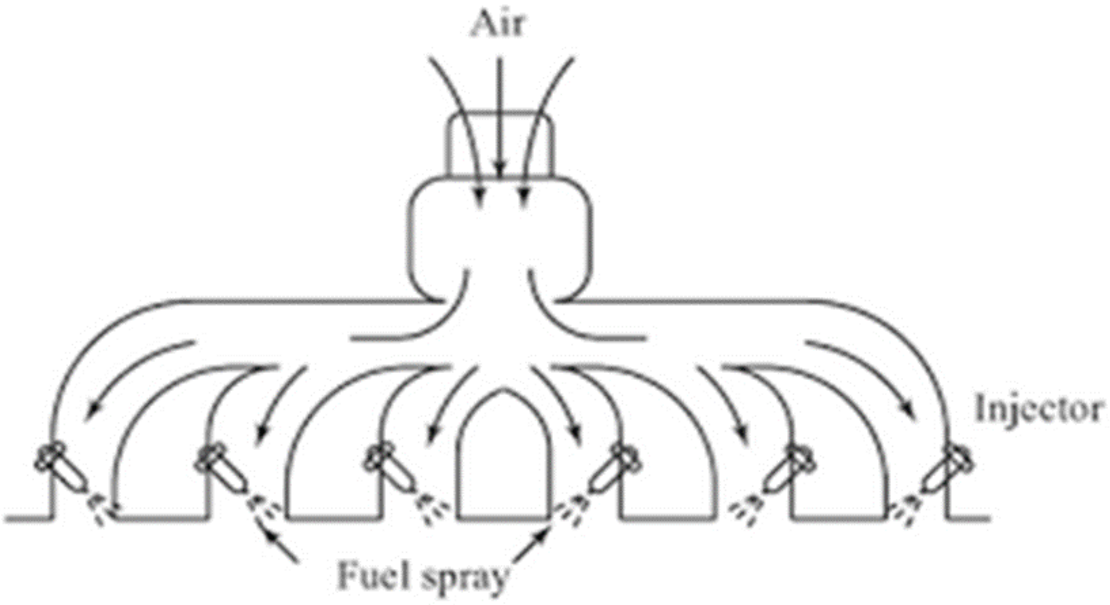


Fig. Throttle body injection (Single point)

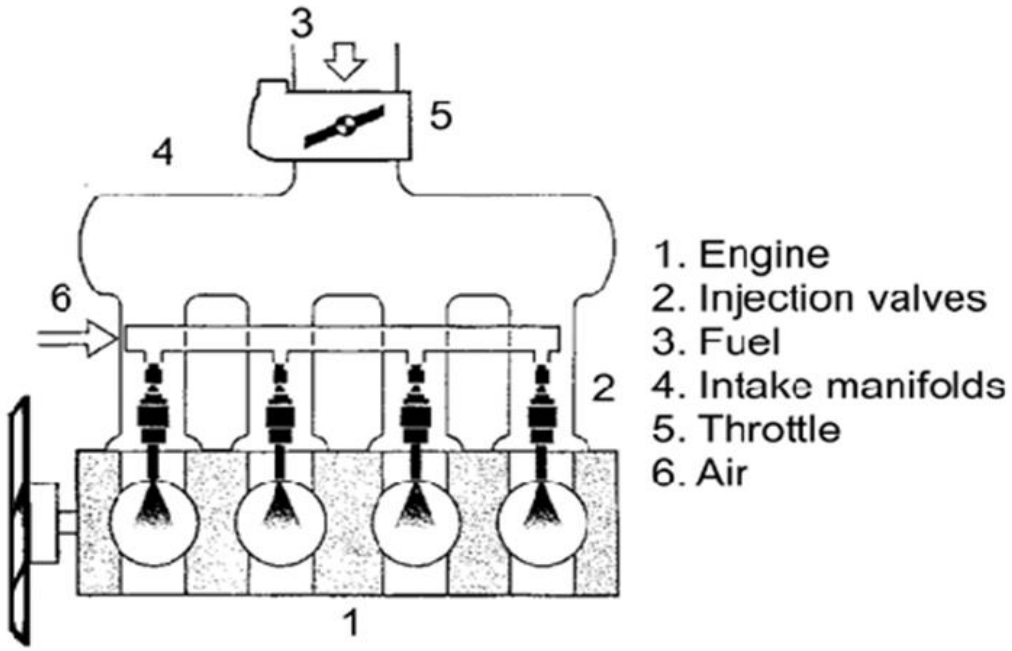
- TBI is a type of fuel injection system that has one fuel injector mounted in a throttle body.
- This injector- throttle body assembly is installed on the intake manifold in place of a carburettor.
- The injectors deliver fuel into the air above the throttle plates. From there, the air-fuel mixture enters the intake manifold, where it is distributed to the engine's individual cylinders.
- It requires only one injector circuit in the computer to control injection. Thus, this is less costly but less precise system.

2. <u>PORT INJECTION:</u>



- This is also called multi-port fuel injection (MPFI) system.
- The throttle body fuel injection has only one centrally located fuel injector which supplies fuel to all cylinders, but in a multi-point fuel injection system, each cylinder has a separate fuel injector that supplies fuel from the fuel tank to the cylinders.
- In this the injector sprays the fuel into each intake port on the manifold side of the inlet valve. This system has the advantage that it allows more time for the mixing of air and petrol.
- Moreover, the system is more precise than throttle body type since in this the fuel delivery does not depend upon air to carry the fuel through the intake manifold.

3. <u>DIRECT INJECTION:</u>



- In this the fuel injector is placed directly into the cylinder.
- This system is similar to the direct injection system used in diesel engines. Mainly, the intake valve allows only the air into the combustion chamber and the fuel is sprayed- in directly through an injector.
- The fuel and air mix inside the combustion chamber itself.
- ECU controls the amount of fuel injected based upon the airflow into the engine and demand.
- This is the most precise and efficient fuel injection system.

ELECTRONIC FUEL INJECTION SYSTEM / MULTI-POINT FUEL INJECTION SYSTEM: (MPFI)

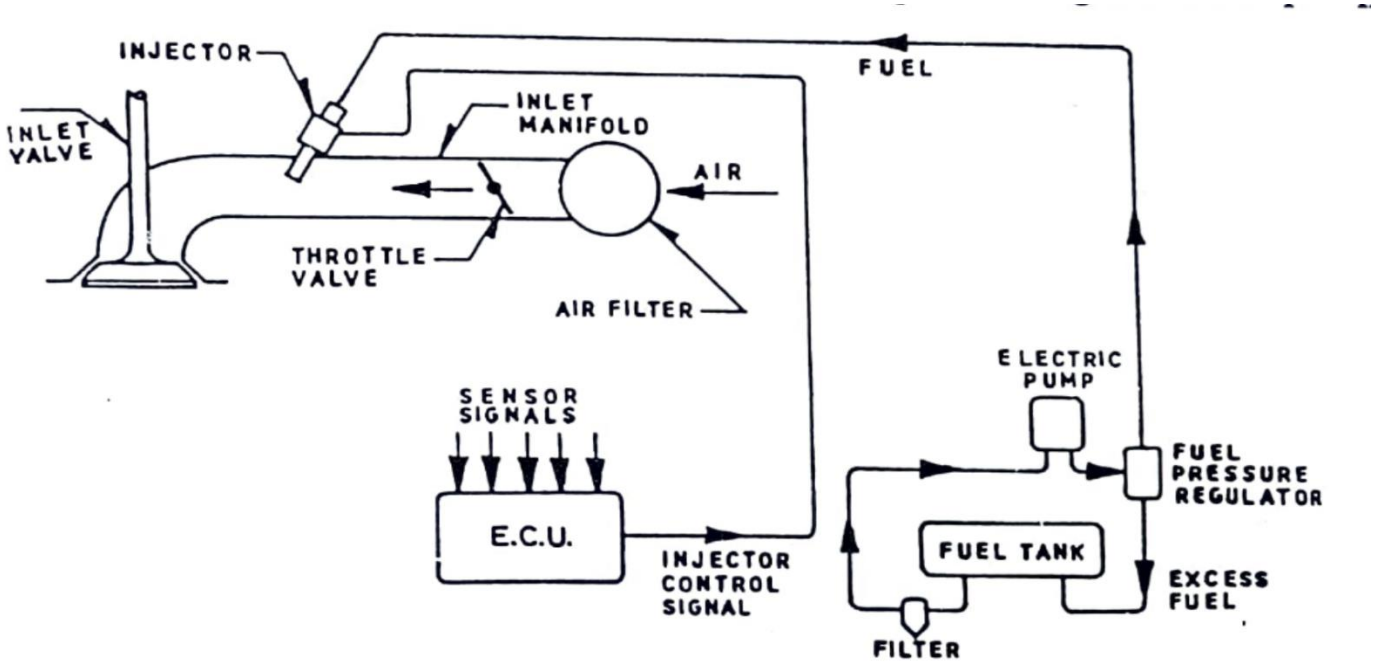


Fig. 9.58. Schematic diagram of electronic petrol injection system.

- An electrically driven pump draws the fuel from the tank through a filter and supplies the same to the injectors at a pressure which is held constant by means of a fuel-pressure regulator.
- The pump draws more fuel than the required and the excess fuel is returned to the tank by the fuel pressure regulator.
- The injectors are held closed by means of spring and are opened by means of solenoids energized by the control signal from the electronic control unit (ECU), which translates sensor signals into command signals.
- The strength of the ECU control signal, which determines the open time of the injector to control the amount of fuel injected, depends upon the engine requirements which are determined by the ECU from the sensor signals from critical locations.
- The common sensors employed are:
  - ***Crankshaft speed sensor:*** This registers the speed and angle of crankshaft without contact.

- ***Camshaft speed sensor:*** It measures the speed and position of the camshaft without contact.
- ***Knock sensor:*** detects ping or preignition noise so that the ignition timing can be retarded.
- ***Mass Air flow sensor:*** To measure quantity of air drawn into the engine.
- ***Manifold absolute pressure (MAP) sensor:*** monitors vacuum in the engine intake manifold so that the mixture strength can be adjusted with changes in engine. load.
- ***Throttle position sensor (TPS):*** senses the movement of the throttle plate so that the mixture flow can be adjusted for engine speed and acceleration.
- ***Coolant temperature sensor (CTS):*** senses the temperature of the engine coolant, and from this data the computer adjusts the mixture strength.
- ***Manifold air temperature (MAT) sensor:*** checks the temperature of the ambient air entering the engine for fine tuning the mixture strength.
- ***Exhaust oxygen sensor:*** senses the amount of oxygen in the engine exhaust and calculates air-fuel ratio.
- ***Vehicle speed sensor (VSS).***

ADVANTAGES OF EFI SYSTEM:

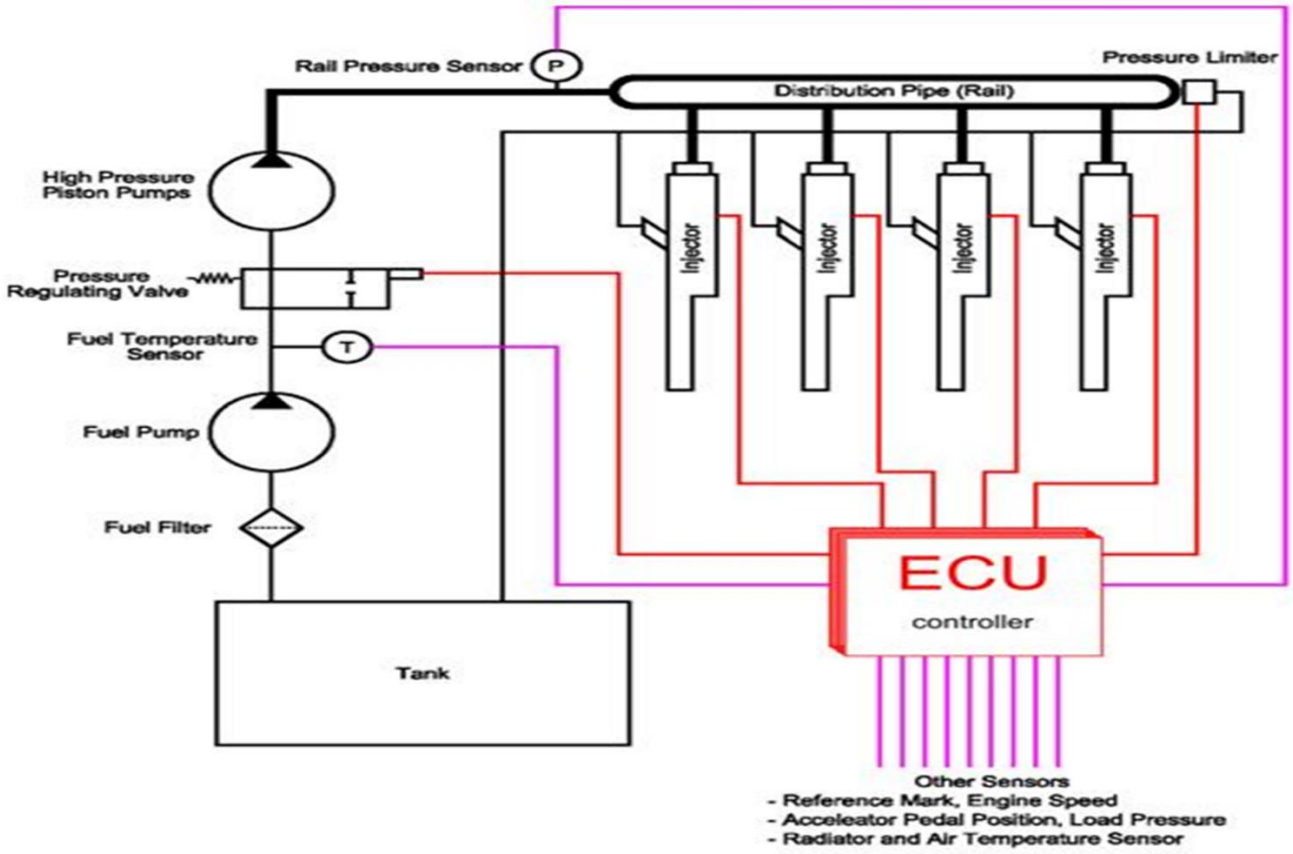
- It increases fuel efficiency of the engine
- With MPFI system vehicle have less emissions
- Better atomization of fuel
- Less wastage of fuel
- Smooth operation of engine
- It reduces the difference in power, produced by each cylinder
- Better acceleration and deacceleration of engine
- In improves durability and functionality of engine
- It improves cold start characteristics of the engine
- It reduces vibrations in the engine

DISADVANTAGES OF EFI SYSTEM:

- High initial and maintenance cost.
- Difficulty in servicing.
- Possibility of malfunction of some sensors.

GASOLINE DIRECT INJECTION SYSTEM: (GDI)

- In Gasoline direct injection (GDI), the fuel is injected into the combustion chamber. This is distinct from manifold fuel injection systems, which inject fuel into the intake manifold.



- The GDI system has a high-pressure pump which operates continuously and charges a high-pressure rail or reservoir or accumulator.
- Fuel is then flow from this rail to the injector mounted on the cylinder head through fuel lines. The injector is solenoid operated.
- Fuel from the tank is lifted by a low-pressure pump and passed through a filter to high pressure pump. The low-pressure pump is generally run by an electric motor.
- The pressure pump used to increase the pressure of the fuel and supplied to the fuel rail.
- In fuel rail section the pressurized fuel is supplied into the injectors with same quantity and same pressure in all injectors and further the fuel in the injectors is supplied into the cylinders for combustion process.
- The common sensors employed are:
  - ***Crankshaft speed sensor:*** This registers the speed and angle of crankshaft without contact.
  - ***Camshaft speed sensor:*** It measures the speed and position of the camshaft without contact.
  - ***Knock sensor:*** detects ping or preignition noise so that the ignition timing can be retarded.

- ***Mass Air flow sensor:*** To measure quantity of air drawn into the engine.
- ***Manifold absolute pressure (MAP) sensor:*** monitors vacuum in the engine intake manifold so that the mixture strength can be adjusted with changes in engine. load.
- ***Throttle position sensor (TPS):*** senses the movement of the throttle plate so that the mixture flow can be adjusted for engine speed and acceleration.
- ***Coolant temperature sensor (CTS):*** senses the temperature of the engine coolant, and from this data the computer adjusts the mixture strength.
- ***Manifold air temperature (MAT) sensor:*** checks the temperature of the ambient air entering the engine for fine tuning the mixture strength.
- ***Exhaust oxygen sensor:*** senses the amount of oxygen in the engine exhaust and calculates air-fuel ratio.
- ***Vehicle speed sensor (VSS).***