2 POWER SYSTEM

2.1 INTRODUCTION

All the automobiles use power system to propel the vehicle. The power generating unit for most of the automobiles are Internal Combustion engines. These engines burn their fuel inside the engine cylinder. The heat energy thus generated is converted into mechanical energy by expansion of gases against the piston inside the cylinder. The movement of piston is further transmitted to wheels through many mechanical and hydraulic linkages.

2.2 FUEL SYSTEM FOR PETROL ENGINE

The fuel system for petrol engine consists of following components :

1. Fuel tank,
2. Fuel pump,
3. Fuel lines,
4. Fuel filter,
5. Carburettor,
6. Air cleaner,
7. Inlet manifold,
8. Supply and return pipes.

The various functions of fuel system are as follow :

1. To store fuel in fuel tank.
2. To supply fuel to the engine in required amount.
3. To show the fuel level in tank to the driver.

Different types of systems used for the supply of fuel from the fuel tank to the engine cylinder are as follows :

1. Pressure system
2. Gravity system
3. Pump system
4. Vacuum system
5. Fuel injection system (MPFI).

First four systems make use of carburettor while in fuel injection system, carburettor is not used.

1. **Pressure System :** In this system, a sealed fuel tank is used. The pressure is created in the tank by means of separate air pump. For starting, pump is primed by cam to produce pressure in the tank. It is due to the pressure thus produced that the fuel flows to the carburettor. This system is almost obsolete now.

2. **Gravity System :** In this, fuel tank is mounted at a higher position from where the fuel drops into the carburettor float chamber by gravity. It is very simple and cheap system. It is used in two wheelers.

3. **Pump System :** In this system, fuel pump fuel pumps into the float chamber of the carburettor through a flexible pipe.

There are two type of pump used for this purpose

1. Mechanical fuel pump
2. Electrical fuel pump

Mechanical fuel pump is driven from the engine camshaft and hence placed near the engine itself. This system is used most commonly in the present day cars.

The electrical fuel pump has an the impeller which pushes the fuel into the carburator, impeller is driven by electric motor.

4. **Vacuum System :** The vaccum created at engine suction line is used for sucking fuel from the main tank to the auxillary fuel tank from where it flows by gravity to the carburettor float chamber. This system is also obsolete now.

5. **Fuel Injection System :** It is used successfully in some modern vehicles. It uses a fuel injection pump instead of carburettor. The fuel is atomised by means of an injector nozzle and then delivered into an air stream. Separate fuel injectors are used for each cylinder while the mixture under different load and speed conditions is controlled either mechanically electronically. It is most accurate fuel supply system.

2.3 FUEL SYSTEM FOR DIESEL ENGINE

The system used to supply of fuel in diesel engine consists of the following components :

1. **Fuel Tank :** To store diesel in fuel tank.
2. **Fuel Lines :** Used for supply of diesel to engine.
3. **Fuel Filter :** Used for filtering diesel.
4. **Fuel Feed Pump :** Used for delivering of diesel from tank to fuel injection pump.
5. **Air Cleaner :** Used for cleaning the air.

6. Fuel Injection Pump : Exact amount of fuel is metered, atomized to each cylinder in proper sequence and at the proper moment as the engine requires.

7. Governor : To control the quantity of fuel according to load variation.

2.4 MULTI POINT FUEL INJECTION SYSTEM (MPFI)

The function of multi point fuel injection system is to supply the proper ratio of petrol and air to the cylinder.

Fig. 2.1 shows the multiprint fuel injection system (MPFI)

The fuel supply system, of MPFI is shown in fig. 2.1. In this system the fuel is supplied by the fuel pump. At the time of starting, the cold start injector is operated by the cold start injector timing switch. The cold start injector injects fuel into the air intake chamber, thus enriching the air fuel mixture. The pressure regulator checks the pressure of the fuel. The injector receives signal from the ECU and injects the fuel into the intake manifold.

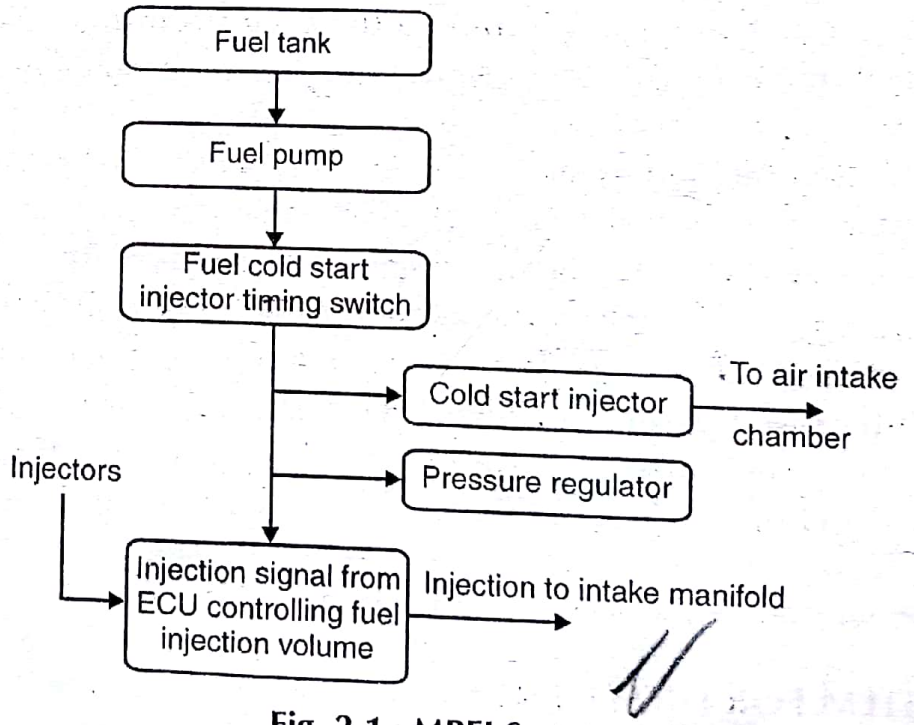

Fig. 2.1 : MPFI System

There are two types of fuel injection in MPFI system :

A. Port injection,

B. Throttle body injection.

(A) Port Injection : In this arrangement, the injector is placed on the side of the intake manifold near the intake port. The injector sprays petrol into the air inside the intake manifold.

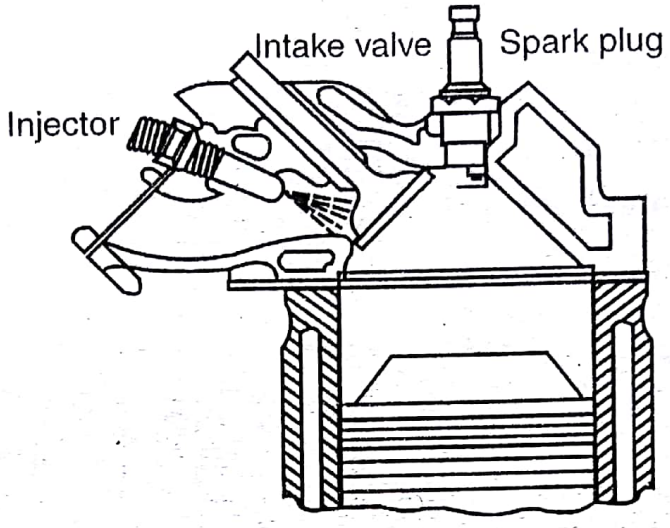

Fig. 2.2 : Port Injection

The petrol mixes with the air and passes through the intake valve and enters the cylinder. Each cylinder is provided with an injector in its intake manifold. Fig. 2.3 shows this arrangement.

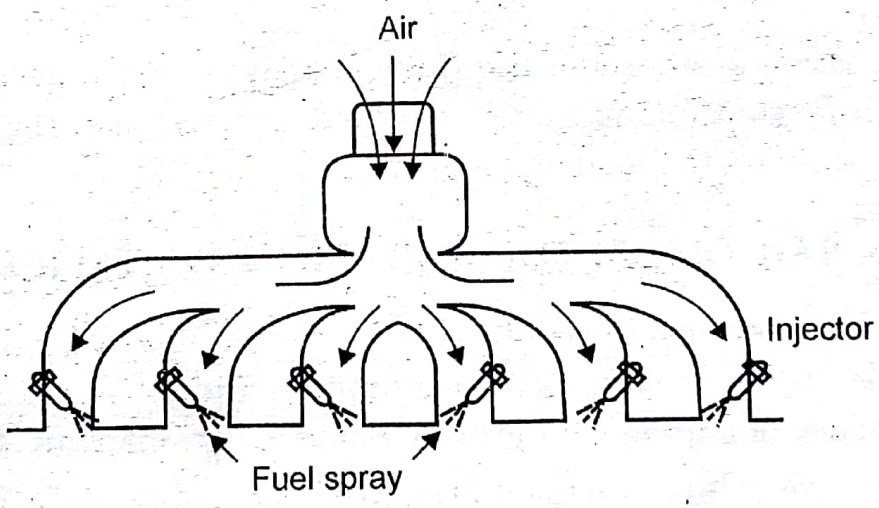

Fig. 2.3 : Multi-Point Fuel Injection (MPFI) Near Intake Port

(B) Throttle Body Injection : It is also known as single point injection. Its throttle body is similar to the carburettor throttle body, with the throttle valve controlling the amount of air entering the intake manifold.

An injector is placed slightly above the throat of the throttle body. The injector sprays fuel into the air in the intake manifold where the fuel mixes with air. This mixture then passes through the throttle valve and enters into the intake manifold. Fig. 2.4 shows this arrangement.

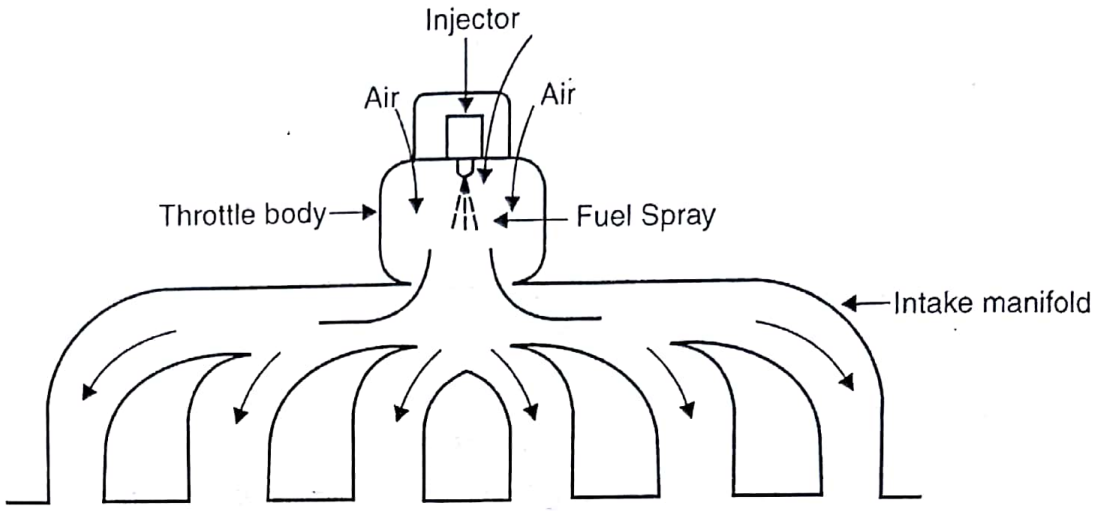

Fig. 2.4 : Throttle Body Injection (Single Port)

The fuel injection system is of two types :

1. In the timed injection system, petrol is sprayed from the injector in pulses.
2. In continuous injection system, petrol is sprayed continuously from the injector.

The port injection system and the throttle body injection system may be timed or pulsed system or continuous system. In both the systems, the amount of petrol injected depends fully on the load on engine.

2.5 COMMON RAIL DIRECT FUEL INJECTION SYSTEM (CRDI) OR (CRDE)

This system is now coming into use in recent diesel engine as it has the potential to reduce the emission, fuel consumption and to increase the power. With this system efficiency of engine is improved. Some of its important features are :

1. It can give very high injection pressure in the order of 1500 bar.
2. Starting is much improved.
3. Full control at the end of injection.
4. Pressure of injection is independent of the engine speed.
5. It provides variable injection pressure.
6. It can be used from heavy duty engine to light duty engine.

In CRDI, a single injection pump with injector called as unit injector is employed on each cylinder.

A layout of common rail fuel injection system is shown in fig. 2.5.

The unit injectors are operated by rocker arms and springs similar to the engine valves.

A linkage connects the control racks of all the unit injectors, so that fuel injection in all the cylinders may be equal and simultaneously controlled.

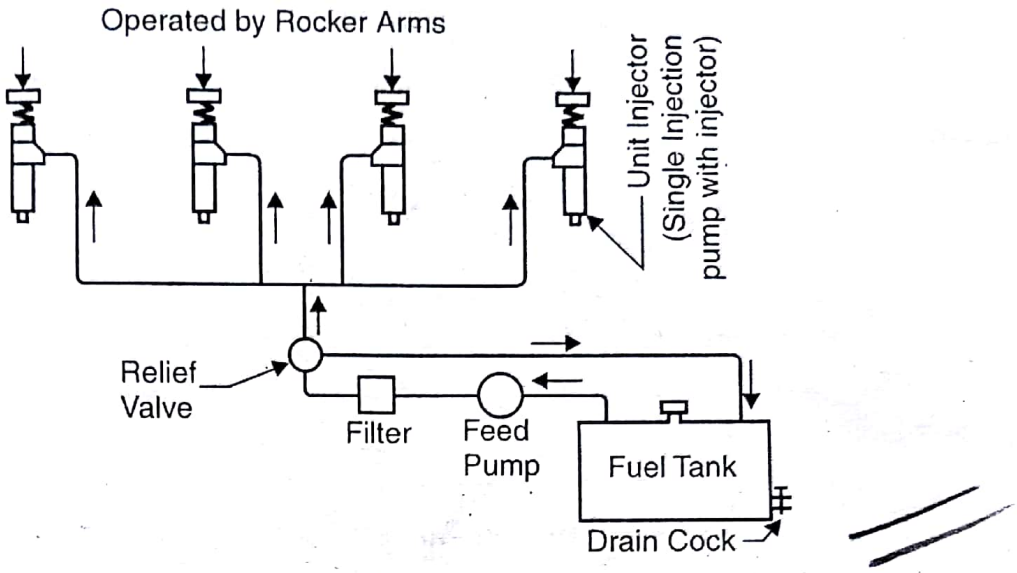

Fig. 2.5 : Layout of common rail direct fuel injection system

The fuel is sucked from the fuel tank by the feed pump and is supplied at low pressure through a filter, to all the unit injectors.

This avoids the high pressure fuel lines necessary in the individual pump system.

Any excess fuel from the relief valve is returned to the fuel tank.

Due to very high pressure in cycle operation the CI engine has to be more robust than an SI Engine for the same output. Moreover it has got higher thermal efficiency on account of high compression ratio of about 18-20 as compared to 8-10 in SI Engines.

2.6 FUEL INJECTOR OR ATOMISER

A nozzle mounted on the combustion chamber which supplies the fuel to the engine cylinder in the form of a fine spray is known as fuel injector or atomiser or fuel valve or nozzle or sprayer. By atomizing the fuel into very fine droplets, it increases the surface area of the fuel droplets resulting in better mixing with air and subsequent combustion. Atomisation is done by forcing the fuel through a small orifice under high pressure.

The fuel injector consists of the following components :

(*i*) A needle valve,

(*ii*) A compression spring,

(*iii*) A nozzle,

(*iv*) An injector body.

Fig. 2.6 shows a Bosch fuel injector.

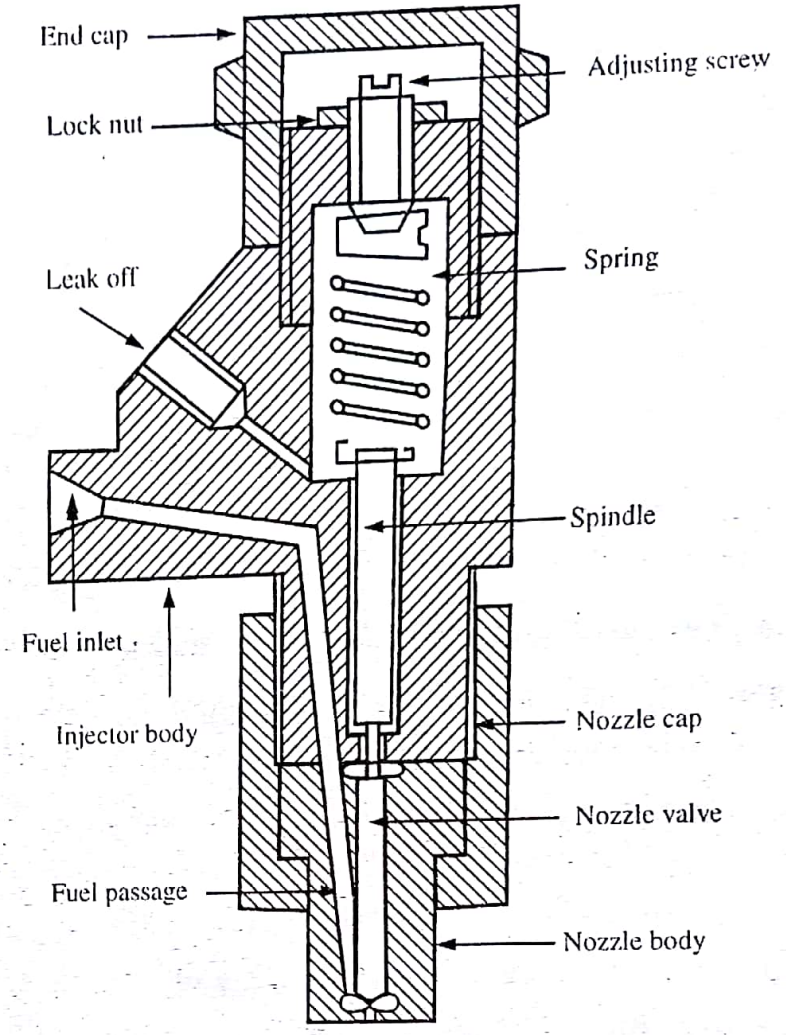

Fig. 2.6 : Bosch Fuel Injector

The high pressure fuel coming out of fuel pump enters the injector. The nozzle valve is lifted up due to high pressure fuel entering at the bottom of the valve and the fuel is sprayed into the combustion chamber in finely atomised droplets. The pressure of the fuel falls as it is injected into the cylinder and the nozzle valve moves down under the spring force and disconnects the nozzle inlet to the inlet fuel passage. Thus the fuel supply to the engine is cut-off. For proper lubrication between nozzle valve and its guide, a small quantity of fuel is allowed to leak through the clearance between these and then drained back to fuel tank through leak off connection. The adjusting screw helps to adjust the tension in the spring and hence the valve opening pressure.

2.7 NOZZLE AND TYPES OF NOZZLE

Nozzle is that part of an injector through which the liquid fuel is sprayed into the combustion chamber.

The main requirements of the an injector nozzle are :

(*i*) To inject the fuel at a sufficiently high pressure in the engine cylinder in the form of very fine droplets.

(*ii*) Penetration should be such that the fuel should not impinge on cylinder walls, otherwise, this may result in poor starting.

(*iii*) Fuel supply and cut-off should be rapid and there should be no dribbling.

There are various types of injection nozzles generally employed in diesel engines. The type of nozzle used is greatly dependent on the types of combustion chamber as open type or pre-combustion chamber. The nozzles are classified as per the types of orifice and its number used for injecting the fuel in the combustion chamber. The usual types of the injection nozzles are discussed below :

(*a*) Single hole nozzle,

(*b*) Pintle nozzle,

(*c*) Multi-hole nozzle,

(*d*) Circumferential orifice nozzle,

(*e*) Pintaux nozzle.

(*a*) Single Hole Nozzle : This is the simplest type of the nozzle shown in Fig. (2.7), It consists of a single hole bored centrally through the nozzle body and closed by the needle valve. The size of hole is usually 0.2 mm. The spray cone angle of this nozzle varies from 5° to 15° and injection pressure is of the order of 8 – 10 MPa. In some cases, a cone is given a series of spiral grooves in order to impart a rotational motion to the fuel for mixing with the air. This is used in open combustion chambers.

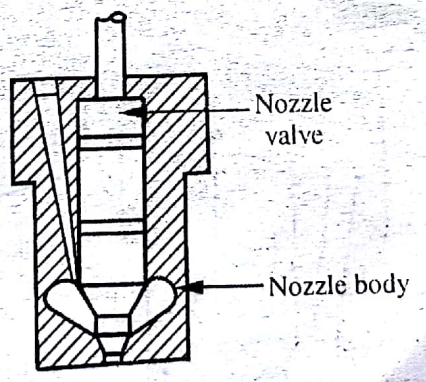

Fig. 2.7 : Single Hole Nuzzle

Advantages :

(*i*) It is simple in construction.

Disadvantages :

(*i*) Very high injection pressure is required.

(*ii*) As the spray angle is very small, this does not facilitate good mixing unless higher air velocity is provided.

(b) Pintle Nozzle : The stem of nozzle valve is extended to form a pin or pintle which extends through the mouth of the nozzle. The size and shape of the pintle can be varied according to requirement. The spray cone angle is generally 60° and spray injection pressure is about 8 – 10 MPa. Fig. 2.8 shows a pintle nozzle.

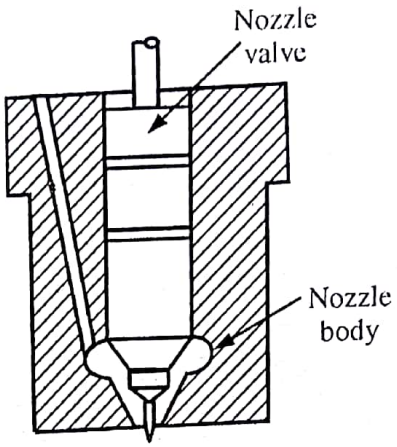

Fig. 2.8 : Printle Nozzle

Advantages :

(*i*) It prevents the deposition of carbon on the nozzle hole.

(*ii*) It avoids weak injection and dribbling.

(c) Multi-Hole Nozzle : In consists of a number of holes bored in the tip of the nozzle. This type of nozzle finds extensive use in automobile engines having open combustion chambers. The number of holes varies from 4 to 18 and the hole diameter varies between 0.25 to 0.35 mm. The hole angle may be from 20°upwards. Fig. 2.9 shows a mutli-hole nozzle.

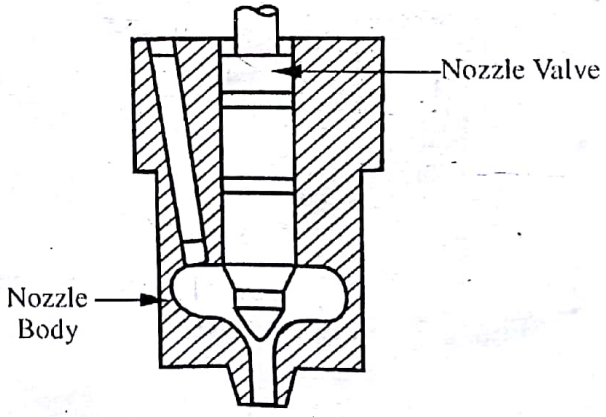

Fig. 2.9 : Multi-Hole Nozzle

Advantages :

(*i*) It distributes fuel properly even at lower air motion.

(*ii*) It gives good automisation.

Disadvantages :

(*i*) Holes are small and liable to clogging.

(d) Circumferential Nozzle : The injected fuel particles tend to project in the form of plane with wide angle cone. The purpose of this is to obtain maximum possible area of fuel spray which comes into contact with the air in the combustion chamber.

Fig. 2.10 shows a circumferential nozzle.

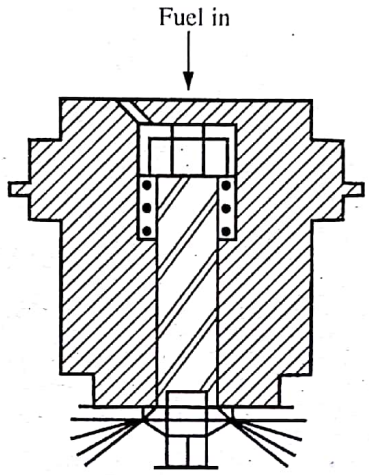

Fig. 2.10 : Circumferential Nozzle

(e) Pintaux Nozzle : When an auxiliary hole is provided at the nose of a pintle nozzle, it is called pintaux nozzle. The auxiliary hole supplies fuel in the upstream direction during the idling or at the starting of the engine. This helps in easy starting of the engine. During the normal running of the engine, the fuel is sprayed through the pintle nozzle. Fig. 2.11 shows a pintaux nozzle.

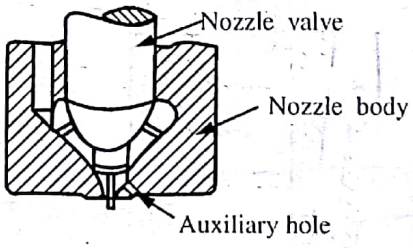

Fig. 2.11 : Pintaux Nozzle

Advantages :

(*i*) Better cold starting performance.

Disadvantages :

(*i*) There is a tendency of the auxiliary hole to choke.

(*ii*) Injection characteristics are poorer than the multihole nozzle.

2.8 COMPARISON BETWEEN MPFI WITH CARBURETTOR SYSTEM

	MPFI	Carburettor system
1.	As fuel is atomised, the mixing of fuel and air is better giving homogeneous mixture for better combustion.	Air and fuel mixture is less homogeneous as compared to MPFI system
2.	Higher volumetric efficiency.	Less volumetric efficiency.
3.	Consumption of fuel is lower.	More fuel consumption.
4.	High faster engine response.	As comparison lower engine response.
5.	Compression ratio is high.	low compression ratio
6.	More complicated system is required.	The system is simplified.
7.	Initial cast is high.	Low initial cast.

2.9 CAMSHAFT

A cam is mounted on a cam shaft and *it is a device which changes rotary motion of camshaft into linear motion of the follower*. The function of camshaft is to operate the valve (opened or closed). A number of cams are mounted on the cam shaft and one cylinder has two cams, one to operate the inlet valve and other for the exhaust valve. Each cam has lobe which controls the operation of valves.

Cam shaft is older type of engine may be equipped with eccentric to operate the fuel pump and a gear to drive the distributor and oil pump.

2.9.1 Working of Camshaft

It is located in either the cylinder block or in the cylinder head. If the cam shaft is located in the cylinder block and is placed above the crank shaft, the valves are to be opened through lifters, push rod and rocker arm. As the cam rotates, it pushes up the lifter, which lifts up the push rod, moving one of the rocker arm up while the other pushes the valve down to open it. As the cam rotates, the valve spring forces the valve to close and maintain the contact between the valve and the rocker arm, there by keeping the push rod and the lifter in contact with the rotating arm.

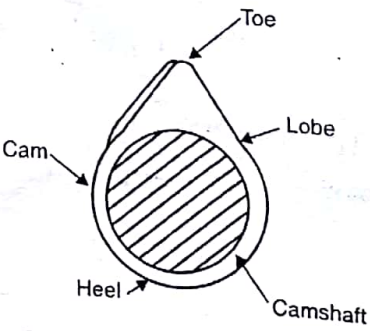

Fig. 2.12 : Cam on a camshaft