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Multipoint Fuel Injection System

Ishant Gupta, Shweta Kandari, Arvind Rajput, Mohd Asif, Anand Singh
DEPARTMENT OF MECHANICAL ENGINEEERING
DRONACHARYA COLLEGE OF ENGINEERING
MAHAMAYA TECHNICAL UNIVERSITY, Noida

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ABSTRACT

In the Multipoint Injection System, we have one injector per cylinder; the injector injects the fuel into the admission valve which admits the fuel and air into the cylinder. This gives an individual control on this cylinder, improving the fuel consumption in relation of the Single point injection. In The first Multipoint injection system, the injection was done at the same time in all injectors. The improvement in relation of the single point is the same amount of Fuel is delivering to all cylinders. This system only solved one problem, because the problem of lag was still existent, like in the single point injection. So if the injection occur, the fuel and air are in the admission valve, and if driver make a sudden change it only change the fuel in the next admission, so it would be a waste of fuel or insufficient fuel. To solve this problem it was develop one new system of Multipoint Injection. This system is sequential Multipoint injection system; the layout is the same that the original Multipoint injection system, the difference is that the injection is done individually, in each cylinder. In this system because we have injection individually and sequential, we don't have the lag problem. Let's suppose that the injection occurs in cylinder 1, then cylinder 3, and suddenly the driver makes a change, in the injection in the cylinder 4 will be done whit the new value. This was the improvement in relation of the first Multipoint injection system.

1. INTRODUCTION

Petrol vehicles uses device called carburetor for supplying the air fuel mixture in correct ratio to cylinders in all rpm ranges. However in response to recent demands for cleaner exhaust emission, more economical fuel consumption, improved drivability, etc., carburettor should now be equipped with various devices that make it more complex system. Therefore, the MPFI (multi point fuel injection) system is used, assuring proper air fuel ratio to the engine by electrically injecting fuel in accordance with various driving conditions. The primary difference between carburetors and fuel injection is that fuel injection atomizes the fuel by forcibly pumping it through a small nozzle under high pressure, while a carburetor relies on suction created by intake air accelerated through a Venturi tube to draw the fuel into the airstream.

MPFI system injects fuel into individual cylinders, based on commands from the 'on board engine management system computer' – popularly known as the Engine Control Unit/ECU. These techniques result not only in better 'power balance' amongst the cylinders but also in higher output from each one of them, along with faster throttle response. Optimized ratio of air-fuel mixture is supplied to the combustion chamber in varying driving conditions with the help of electronic fuel injection system. The Multipoint Fuel Injection System consists of sensors which detect the engine conditions, the ENGINE- ECU which controls the system based on signals from these sensors, and actuators which operate under the control of the ENGINE-ECU. The ENGINE-ECU carries out activities such as fuel injection control, idle air control, and ignition timing control. In addition, the ENGINE-ECU is equipped with a number of diagnostic test modes which simplify troubleshooting when a problem develops.

The functional objectives for fuel injection systems can vary. All share the central task of supplying fuel to the combustion process, but it is a design decision how a particular system is optimized. There are several competing objectives such as:

- Power output
- Fuel efficiency
- Emissions performance
- Ability to accommodate alternative fuels
- Reliability
- Drivability and smooth operation
- Initial cost
- Maintenance cost

- Diagnostic capability
- Range of environmental operation
- Engine tuning

2. COMPONENTS OF MPFI SYSTEM

The system has four major components. These four components are

1. Air intake system
2. Fuel delivery system
3. Electronic control system
4. Emission control system

1. Air intake system

The function of the air intake system is to allow air to reach your car engine. Oxygen in the air is one of the necessary ingredients for the engine combustion process. A good air intake system allows for clean and continuous air into the engine, thereby achieving more power and better mileage for your car. A modern automobile air intake system has three main parts: air filter, mass flow sensor and throttle body.

a. Air Filter

An air filter is an important part of a car's intake system, because it is through the air filter that the engine "breathes". It is usually a plastic or metal box in which the air filter sits. The air filter's job is to filter out dirt and other foreign particles in the air, preventing them from entering the system and possibly damaging the engine.

b. Mass flow sensor

A mass air flow sensor is used to find out the mass of air entering a fuel-injected internal combustion engine. From mass flow sensor, then, does it goes to the throttle body. There are two common types of mass airflow sensors in use on automotive engines. They are the vane meter and the hot wire. The vane type has a flap that is pushed by the incoming air. The more air coming in, the more the flap is pushed backed. The hot wire uses a series of wires strung in the air stream. The electrical resistance of the wire increases as the wire's temperature increases, which limits electrical current flowing through the circuit.

c. Throttle Body

The throttle body is the part of the air intake system that controls the amount of air flowing into an engine's combustion chamber. It consists of a bored housing that contains a throttle plate that rotates on a shaft. When the accelerator is depressed, the throttle plate opens and allows air into the engine. Throttle plate gets closed when the accelerator paddle is released and thus effectively chokes-off air flow in the combustion chamber. This process effectively controls the rate of combustion and ultimately the speed of the vehicle.

2. Fuel delivery system

The fuel in the fuel tank is pumped up by the fuel pump, filtered by fuel filter and fed under pressure to each injector through the delivery pipe. As the fuel pressure applied to the injector is always kept a certain amount higher than the pressure in the intake manifold by the fuel pressure regulator, the fuel is injected into the intake port of the cylinder head when the injector opens according to the injection signal form ECM. The fuel relieved by the fuel pressure regulator return through the fuel return to the fuel tank.

a. Fuel pump

The electrical fuel pump located on the fuel tank consists *of* armature, magnet, impeller, brush, check valve etc...The ECM controls its operation. When the power is supplied to the fuel pump, the motor in the pump runs and so does the impeller. This causes a pressure difference to occur between both sides of the impeller, as there are many grooves around it. Then the fuel is drawn through the inlet port, and with its pressure increases, It is discharged through the outlet port, the fuel pump also has a check valve to keep some pressure in the fuel feed line even when the fuel pump is stopped.

b. Pressure regulator system

The fuel pressure regulator is a pressure relief valve that consist of a spring, diaphragm and a valve . It keeps the fuel pressure applied to the injector *2.9Kglcm^2 higher* than intake manifold at all times, The pressure applied to the upper chamber of the fuel pressure regulator intake manifold pressure and that to the lower chamber is fuel pressure. When the fuel pressure rises more than *2,9Kg/cm2* higher than the intake manifold pressure, the fuel pushes the valve in the regulator open and excess fuel return to the fuel tank through return line.

c. Injector

Each cylinder has one injector for its work, which is installed between the intake manifold delivery pipes. Injector is a electromagnetic type injection nozzle that perform its works according to the signal from ECM

and injects fuel in the intake port of cylinder. When the solenoid coil of the injector is energized by ECM, it becomes an Electro magnet and attracts the plunger. At the same time, the ball valve which is incorporated with the plunger opens and the injector which is under the *fuel* pressure injects fuel. As the lift stroke of the ball valve of the injector is set constant, the amount of fuel injected at one time is determined by the length of the time during which the solenoid is being energized.

3. Electronic control system

The electronic control system consist of various sensors which detect the state of engine and driving conditions, ECM is a device which controls various devices according to the signals from the sensors and Various controlled devices.
The systems are:

a. Fuel injection control system
b. Idle speed control system
c. Fuel pump control system
d. Ignition control system
e. Radiator fan control system

a. Fuel injection control system:

The work of electronic fuel injection system is to supply air-fuel mixture of optimize ratio to the combustion chambers under different driving conditions. It uses the sequential multi-port fuel injection system, which injects fuel into each intake port of the cylinder head. In this system ECM controls the time and timing of the fuel injection from the fuel injector into the cylinder head intake port according to the signals from the various sensors so that suitable air/fuel mixture is supplied to the engine in each driving condition.

b. Idle speed control system

This system controls the bypass airflow by means of ECM & lAC valve for the following purposes. To keep the engine idle speed as specified at all times. The engine idle speed can vary due to load applied to engine, to improve starting performance of the engine to compensate air fuel mixture ratio when -decelerating, to improve drivability while engine is warmed up. lAC valve operates according to duty signal sent from ECM. ECM detects the engine condition by using the signals from various signals and switches and controls the bypass airflow by changing lAC valve opening.

c. Fuel pump control system

ECM controls ON/OFF operation of the fuel pump by turning it ON, the fuel pump relay under any of the conditions. While crankshaft position sensor or camshaft - position sensor signal is inputted to ECM.

d. Ignition control system

Ignition control system electrically controls the time of flow of electric current in primary ignition coil and ignition timing. ECM judges the engine and vehicle conditions by using signals from various sensors, selects the most suitable electric current flow time and ignition timing for that engine and vehicle conditions from among those Restored in its memory and sends an ignition signal to the igniter in ignition coil assembly.

e. Radiator fan control system

This system controls operation (ON/OFF) of the radiator fan motor. Radiator fan motor is turned ON and OFF by its relay when ECM controls. Radiator fan motor turned ON at below 98°C and OFF at below 93°C

4. EMISSION CONTROL SYSTEM

The need for controlling the emissions in automobiles is the root cause for the development of computerization of automobile. Hydrocarbons, carbon monoxide and oxides of nitrogen are created during the combustion process and are emitted into the atmosphere from the tail pipe.

a. Air injection

Secondary air injection is the first developed exhaust emission control system. Originally, this system was used to inject air into the engine's exhaust ports to provide oxygen so unburned and partially burned hydrocarbons in the exhaust would finish burning.

b. Exhaust gas recirculation

Many engines have a system that routes a metered amount of exhaust into the intake tract under particular operating conditions. Exhaust neither burns nor supports combustion, so it dilutes the air/fuel charge to reduce peak combustion chamber temperatures. This, in turn, reduces the formation of NO_x

c. Catalytic converter

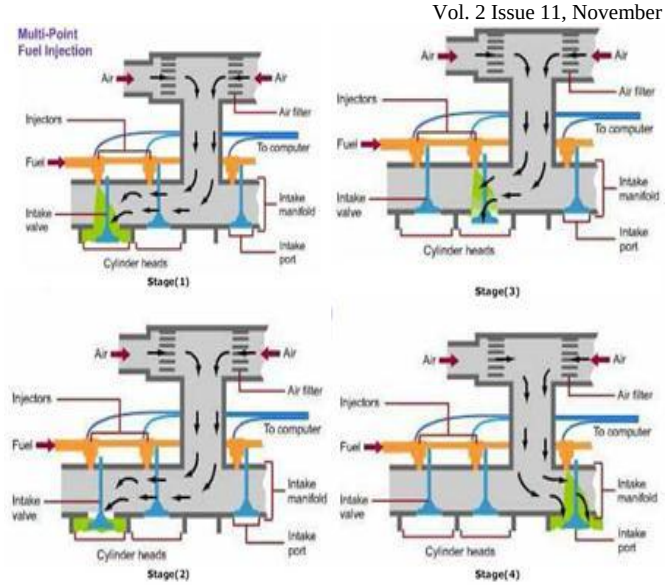
The catalytic converter is a device placed in the exhaust pipe, which converts hydrocarbons, carbon monoxide, and NO_x into less harmful gases by using a combination of platinum, palladium and rhodium as catalysts. There are two types of catalytic converter, a two-way and a three-way converter.

3. Working of mpfi system

The working of MPFI engine is somewhat similar to the carburetor engine, each cylinder is treated individually. An input is fed to the computerized system in order to calculate the amount of air and fuel is to be mixed and send to the combustion chamber. A several stages of calculations are to be made in order to judge the right amount of fuel to be mixed. After this calculation, the proper fuel is delivered at the proper instance. There are a number of sensors used in the MPFI engine. At the time when the inputs are given to the car's computer, it begins to read the given sensors. The things which can be known from the sensors are listed below:

- The engine temperature of the vehicle.
- The speed at which the engine is running.
- The engine load.
- The position of the accelerator.
- The cylinder's air-fuel pressure.
- The rate of exhaust.

The amount of fuel to be injected into the combustion chamber is decided by analyzing the inputs given to the computerized system of the MPFI engine.



4. SENSORS USED IN MULTIPOINT FUEL SYSTEM

Typical sensors for multi-point FUEL system include:

a. An exhaust gas or oxygen sensor (Lambda sensor).

Oxygen sensor measure the oxygen level in engine as a means of checking combustion efficiency. Oxygen sensor voltage output vary with change in the content of the exhaust. Increase in oxygen makes the sensor output voltage to decrease and a decrease oxygen content causes increased sensor output. Sensor then sends data to the computer. The computer then alters the opening and closing of injector to maintain a correct air-fuel ratio for maximum efficiency.

b. Intake manifold pressure sensor.

This sensor measures the pressure inside the engine intake manifold. High pressure indicates a high load that requires a rich mixture and low manifold pressure indicates small load requiring a leaner mixture. The manifold pressure sensor changes resistance with change in engine load and thus computer alter the fuel mixture.

c. A throttle position sensor.

In throttle position sensor a variable resistor is connected to the throttle plate shaft. When the throttle wings is opened for more power or closes for less power, the sensor changes the resistance and sends the signals the

computer. Computer then makes the mixture richer or leaner as required.

d. An engine coolant temperature sensor.

Engine coolant temperature sensor monitors the operating temperature of the engine. This sensor is kept so that it is exposed to the engine coolant. When the engine is cold, the sensor might provide a high current flow. The computer would enrich the air-fuel mixture for cold operation. When the engine warms, the sensor would supply information so that the computer could make the leaner mixture.

e. An airflow sensor.

Airflow sensor is used to measure the amount of air entering the engine. This helps the computer to determine the amount of fuel required in combustion. Air flow through the sensor causes an air flap to swing to one side. The air flap is connected to a variable resistor, the amount of air flow into the engine is converted into an electrical signal for the computer. Computer then make the mixture richer or leaner as required.

f. An inlet air temperature sensor.

Inlet air temperature sensor measure the temperature of the air that enters the engine. Cold air being denser than warm air requires a little more fuel as compared to warm air. Air temperature sensor helps the computer compensate for the changes in outside air temperature and maintain an almost perfect air-fuel ratio.

g. A crankshaft position sensor and distributor rpm sensor.

Crankshaft position sensor or distribution rpm sensor is used to detect the engine speed and cylinder identification. The sensor consists of magnet and coil. It is mounted on oil pan with specified air gap between the sensor core end and crankshaft timing belt pulley tooth. This sensor allows the computer to change injector opening with changes in engine rpm. Higher engine speeds generally require more fuel. Lower engine speeds require less fuel. This data is used by the computer to alter the fuel mixture.

h. Vehicle speed sensor

The vehicle speed sensor, located on the transmission gearbox or speedometer, Generates a signal in proportion to the vehicle speed. Receiving this signal, the speedometer uses it for operation of its indicator and also converts it into to the ON/OFF signal by doubling the cycle. This signal is sent to ECM where it is used as one of the signals to control various devices.

5. ADVANTAGES OF MULTIPOINT FUEL INJECTION SYSTEM

1. Improved Fuel Consumption

Vehicles with dual point fuel injection or carburetors do not get nearly the fuel economy of those with multi-point fuel injection. The underlying reason is that fuel delivery systems of these older vehicles are less precise. A multi-point fuel injection system, which uses one fuel injector for each cylinder of the engine, delivers just the right amount of gas to each cylinder. Thus, gas is not wasted in the process. Over time, the gas saved with a multi-point fuel injection system saves the vehicle owner loads of money.

2. Emissions

Emissions test results are an important factor today. A car from this century emits a small fraction of what a vehicle emitted even a few decades ago. Multi-point fuel injection system proves to be better for the environment as the emission of hazardous chemicals; made when fuel is being burned, are minimized. As mentioned above, the more precise delivery of fuel to the engine means that fewer noxious byproducts are released when the fuel combusts within the engine. The implements within the engine meant to clean the exhaust have been fine-tuned in a multi-point system to work more efficiently. Therefore, the engine--and the air--is cleaner as a result of multi-point systems.

3. Better Performance

The performance of an engine suffers with the use of a carburetor, but multi-point fuel injection allows for far better engine performance. This is due to a few factors. Multi-point injectors atomize the air taken through a small tube in place of allowing additional air intake. Multi-point injectors are controlled by computers, therefore different system component perform each function of a carburetor. These systems provide improved distribution of fuel in cylinder-to-cylinder of an engine due to which energy is conserved.

6. PROBLEMS IN MULTIPOINT FUEL IGNITION SYSTEM

1. The problem with this system is that because the injection is done into the admission valve, and when the admission valve open some fuel will not enter the combusting chamber, so there will be some fuel waste, and the timing is still done

mechanically by the camshaft. This problem not only exists in this system but also in every single one system that was analyzed before. This is because all of them are systems with indirect injection.

2. Indirect injection has also other problems, like spontaneous ignition that is a very common problem in Electronic injection systems with indirect injection. So to overcame this problems, it was develop the Multipoint injection system with direct injection.

3. Complexity and cost are the main disadvantages of direct injection engine. Direct injection systems are more expensive to build because their components must be more rugged -- they handle fuel at significantly higher pressures than indirect injection systems and the injectors themselves must be able to withstand the heat and pressure of combustion inside the cylinder.

7. CONCLUSION

The carburetor and fuel injection performance is mainly due to the amount of air and gasoline that can enter into the engine cylinders. The cylinders contain the pistons and combustion chambers where energy is released from the combustion of gasoline. The carburetor and fuel injection system will both feed fuel and air into the engine. It is fairly obvious that most automobiles will be changing to fuel injection systems due to the lower emissions. Almost all vehicles in India are changing to the mpfi because of law emissions, improved mileage and drivability since the engine is controlled by micro computer more accurate amount of a/f mixture will be supplied and as a result complete combustion will take place. This leads to effective utilization of fuel supplied and hence low emission level. It reduces wastage of fuel by the use of sensors and other control systems. The fuel injection systems are the best as they will decrease vibration and help to overcome steep grades that are traditional terrain for off-roading. One of the main issues is that these systems are sophisticated and will cost much more than a carburetor. The use of electrical component and custom cylinder head configuration makes the installation of multi-point injection system very complicated. Modern fuel injectors can instantly detect things like temperature changes and how the car is traveling in order to get the correct mixture of oxygen and fuel. These systems can also deliver the fuel directly to each cylinder, increasing power and performance. Overall, this system ensures that fuel is not wasted, which helped automakers increase the fuel economy of their vehicles. It also cuts down on the amount of emissions that a car generates, which became especially important as the government began cracking down.

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