AN OVERVIEW OF ELECTRONIC FUEL INJECTION SYSTEM

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ABSTRACT

This paper gives an overview of electronic fuel injection systems for small automobiles currently available on the market. Electronic fuel injection (EFI) is a technology that monitors and controls engine functions using electrical and electronic devices. Electrical signals in the form of current or voltage received by an electronic control unit (ECU) or a computer from numerous sensors. An electric motor drives the fuel injection pump, the pressure control valve keeps the pressure at 100 bar, and the calibration fluid has injected into the measurement cylinder through the nozzle. Fuel is delivered into a simulated conical jar at the bottom of the injector to conduct the analysis. It is also illustrated that the system saves a large amount of fuel compared to similarly equivalent, carburetted automobiles. This paper provides a review of the system's advancement over the last two decades and explains the need for a more advanced fuel injection system for improved fuel efficiency, fuel management, and lower carbon emissions.

Keyword: *Injection system, Electronic Control Unit (ECU), Fuel consumption, Engine Efficiency, Fuel injector.*

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1. INTRODUCTION:

Electronic fuel injection operates on a relatively simple principle. The following section gives a better overview of how our Conventional Electronic Fuel Injection (EFI) system works. The Electronic Fuel Injection system has divided into three parts: the basic includes, the fuel delivery system, the air induction system, and the electronic control system [1].

- EFI is a highly accurate, dependable, and cost-effective solution.
- Strict emission regulations required precise fuel delivery.
- For whatever load, speed, or temperature range, EFI provides the correct A/F ratio.
- Computers were utilized to calculate fuel requirements.

In an internal combustion engine, a fuel injection system is a mechanism that allows fuel to inject. Carburettors used to accomplish this duty in the past. In an internal combustion engine, a carburettor is a system that mixes air with fuel. Bernoulli's Principle governs the operation of a carburettor. The throttle (accelerator) linkage does not directly control the flow of liquid fuel its static pressure drops and its dynamic pressure rises [2].

The vehicle industry needs to achieve and accomplish reductions in tailpipe exhaust emissions of more than 90% over the previous 30 years or so. EFI has provided other benefits, such as lower brake specific fuel usage, higher full-load output, and better driveability, in addition to lower exhaust emissions [3].

2. AIR INTAKE SYSTEM:

The amount of air taken into the system is influenced by air pressure and density, throttle valve position, engine speed, and the air cleaner element. The Manifold Absolute Pressure (MAP) sensor, Air Charge Temperature (ACT) sensor, Throttle Position Sensor (TPS), and control of the engine idle speed via the Idle Speed Control Valve (ISCV) are all used by the electronic engine control (EEC) IV module to evaluate and control these variables [4].

3. FUEL DELIVERY SYSTEM:

The Fuel Delivery System (FDS) consists of the fuel pump, fuel filter, fuel tank, fuel delivery pipe (fuel rail), fuel return pipe, fuel injector and fuel pressure regulator. FDS has a charge forming mechanism that feeds a tailored injector tube rich fuel. Induced air has first precisely measured with an airflow meter, and then fuel has injected into the manifold in proportion to the air entered [5].

An electric fuel pump used to transfer fuel from the tank to the injector and located next to the fuel tank. A high-capacity in-line fuel filter filters out contaminants. A fuel pressure regulator ensures that the fuel is kept at a constant pressure. Any fuel that the injector does not deliver to the intake manifold is returned to the tank through a fuel return pipe [6].

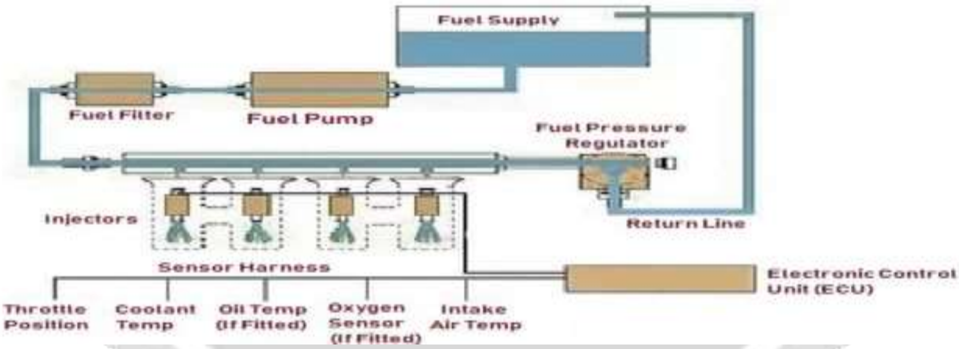

Fig 1: Fuel delivery system

4. AIR INDUCTION SYSTEM:

When air and fuel enter a combustion chamber, an air induction system is present to control and maintain the mixture balanced. This process is important in determining an engine's performance by improving gas mileage, increasing power, making it easier to start, and lowering emissions [7]. It's also necessary because fuel deposits in the system can cause the engine to run poorly, eventually leading to a complete failure. Installing an air induction system will help your engine last longer [8]. Compressors, gas engines, and turbines that require a supply of clean air can benefit from an air induction system. This induction system provides an air intake system that enables the balance of air and fuel in an engine's combustion chamber [9].

When the throttle valve is opened, air passes through the air cleaner, the airflow meter, the throttle valve, and into the intake via a finely tuned intake manifold runner. The amount of air supplied to the engine cylinders is a function of the driver's demand. As the throttle valve is opened further, more air is allowed to enter the cylinders [10].

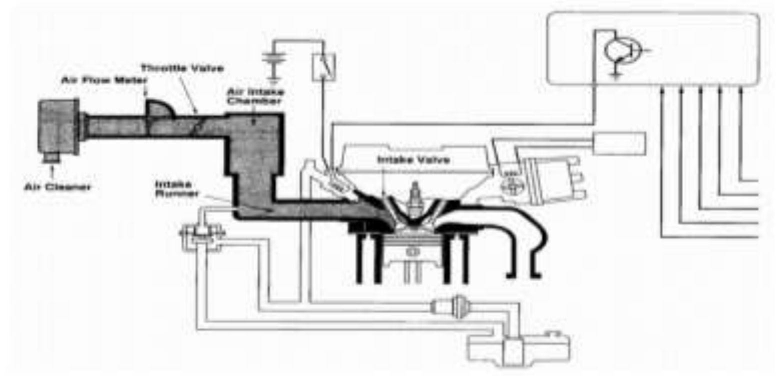

Fig 2: Air Induction System

5. ELECTRONIC CONTROL SYSTEM:

The engine ECU is responsible for monitoring the fuel injection as well as the timing of the spark in the ignition of fuel in petrol engines. It uses a Crankshaft location Sensor to determine the position of the engine's internals, allowing the injectors and ignition system to fire at precisely the right time [11].

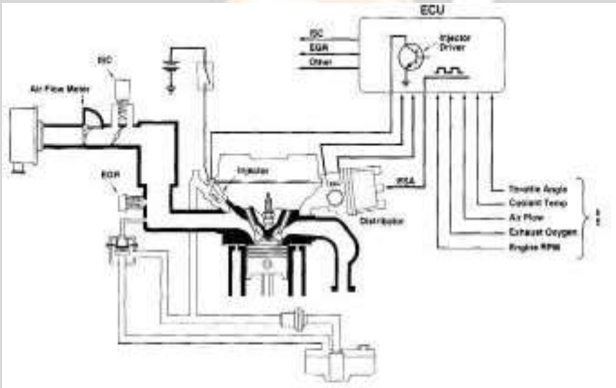

Fig 3: Electronic Control System

Various engine sensors, electronic control units (ECUs), fuel injector assemblies, and related wiring make up the electronics control system. ECS receives data from sensors on engine speed, throttle position, intake air volume, pressure and temperature, and oxygen content continually [12]. The ECS then decides when and how long the fuel injectors should be opened. The duration of the pulse opens the injection valve for the appropriate time [13]. The engine control unit (ECU) monitors the vast number of input sensors to give the correct amount of fuel for each operating condition.

5.1 MANAGEMENT OF THE IGNITION SPARK:

By determining the optimal spark timing, the EFI system regulates the spark advance angle.

5.2 IDLE SPEED CONTROL (ISC):

The EFI system regulates engine speed using a variety of ECU-controlled components.

5.3 EXHAUST GAS RECIRCULATION (EGR):

EGR is a nitrogen oxide (NO x) emissions reduction technology that involves returning a part of an engine's exhaust gas to the cylinders.

6. INJECTOR AND PATTERN OF SPRAY:

Fuel injector uses electrically controlled valves that may open and close multiple times per second to spray fuel into a car's engine. They have an atomizing nozzle that properly distributes the gasoline or fuel for efficient burning [14].

The fuel injection pressure, density, viscosity, ambient pressure, and temperature have an impact on the spray properties of the fuel. The spray structure is substantially influenced by the fuel injection pressure, which is one of these parameters [15].

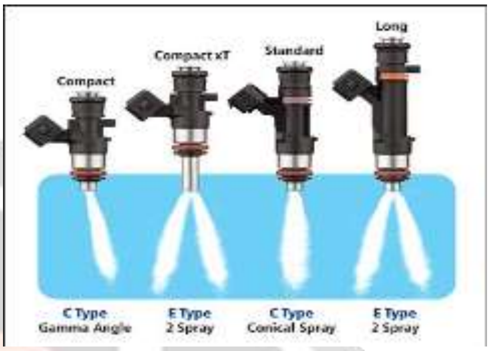

Fig 4: Fuel Injector

Fig 5: Spray pattern

7. SYSTEM BASIC OPERATION:

- The air induction system feeds air into the cylinder via an airflow meter. Fuel injectors are arranged behind each intake valve in the intake manifold. The ECU controls the injectors, which are electrical solenoids [16].
- The ECU pulses the injector by turning on and off the injector ground circuit. When the injector is turned on, it opens and sprays atomized fuel on the intake valve's backside [17].
- Due to the low pressure in the intake manifold, fuel poured into the intake air stream combines with the incoming air and vaporises. The ECU controls the injector to give just enough fuel to maintain a 14:7:1 air/fuel ratio [18].
- ECU control determines the precise amount of fuel given to the engine. The basic injection quantity is determined by the ECU based on the detected intake air volume and engine rpm [19].
- The ECU provides details of variables including coolant temperature, engine speed, throttle angle, and oxygen content in the exhaust and makes injection modifications that determine the final injection quantity [20].

8. DIFFERENT TYPES OF FUEL INJECTION SYSTEM

8.1 THROTTLE BODY OR SINGLE-POINT INJECTION SYSTEM:

A single-point injection system is a form of the injector-based injection system. Although the engine has four cylinders, there is only one injector. This technology was discovered during the early stages of automobile engine injection systems. An injector was installed on the throttle body as a substitute for a jet carburettor at the time [21]. As engine manufacturers migrated from carburettors to fuel injection, this style of fuel injection became more popular.

The overall result is identical to that of the carburettor system. The whole body room can be sprayed with gasoline, although this gasoline comes from an injector rather than a carburettor jet. When compared to carburettors, it is superior because the amount of gasoline volume has already been computed by the ECU[22].

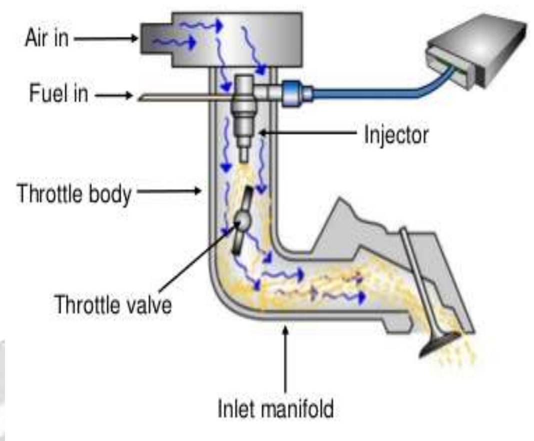

Fig 6: Throttle Body Injection System

8.2 MULTIPORT INJECTION SYSTEM:

Separator injector nozzles are placed in each cylinder's intake port in multiport fuel injectors. This is why the technique is sometimes referred to as a port injector. The fuel vapour is shot near the intake point, ensuring that it is entirely pulled into the cylinder [23]. When compared to a single point, one of the advantages of this injector is that it metres gasoline more precisely. It's also suitable for achieving the required fuel-to-air ratio, as it almost eliminates the possibility of fuel condensation or collection in the intake manifold [24].

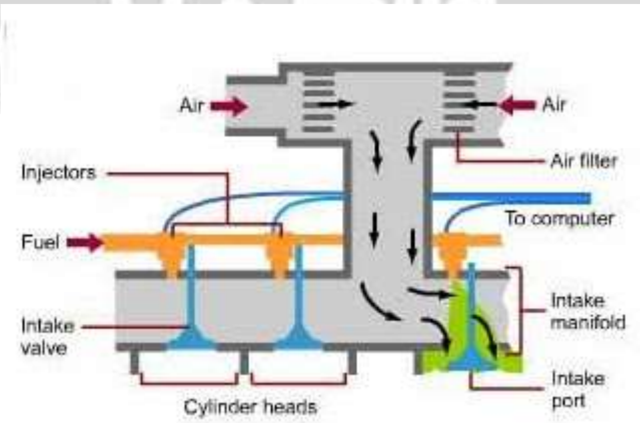

Fig 7: Multiport Injection System

8.3 SEQUENTIAL FUEL INJECTION:

Sequential fuel injection is a sort of multiport injection that is also known as sequential port fuel injection (SPFI) or timed injection. Multiple injectors are used in basic MPFI, but they all spray their fuel at the same time or in groups. As a result, when the engine is idling, the fuel may "hang around" the port for as long as 150 milliseconds. Each injector nozzle is separately triggered by sequential fuel injection. They spray the fuel just before or as their intake valve opens, just like spark plugs. It may appear to be a small step, but efficiency and pollution reductions occur in small doses [25].

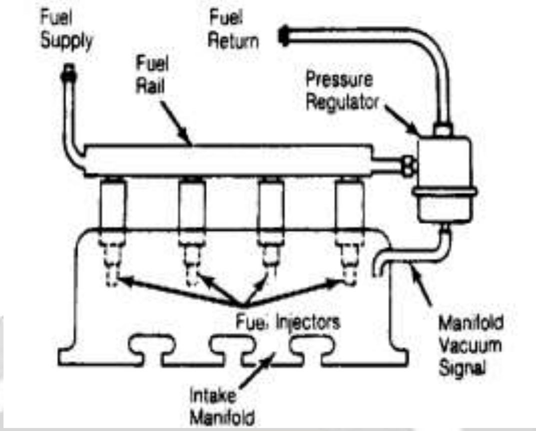

Fig 8: Sequential Fuel Injection

8.4 DIRECT INJECTION:

The direct injection system is a type of fuel injection system in which the injector is placed directly in the cylinder. So, it resembles a diesel engine, with the fuel sprayed straight into the cylinder via the injector [26]. The main benefit of this type is fuel economy because the prior type sprayed fuel into the intake, which could cause fuel to condense on the intake. The DI system, on the other hand, directs all of the fuel into the cylinder, making it more cost-effective [27].

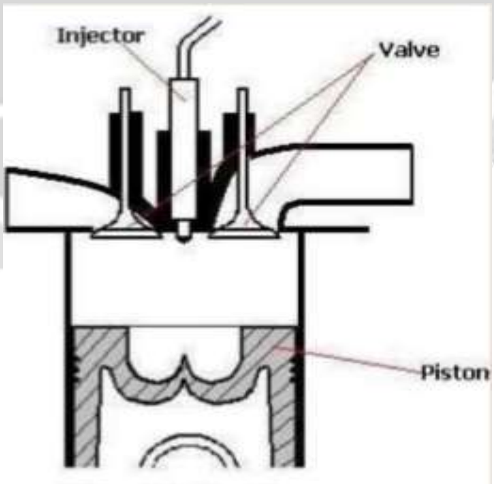

Fig 9: Direct Injection

9. MERITS OF ELECTRONIC FUEL INJECTION:

- Engines with electronic fuel injection (EFI) produce more power and torque than those with carburettors. They ensure continual optimum performance by optimizing air/fuel ratios and ignition timing.
- One of the most important features of an EFI engine is that it does not require the maintenance or replacement of a carburettor. That's a significant time and money saver. The EFI system is sealed, so the fuel is never exposed to the oxygen that causes it to spoil.
- EFI systems have a much better cold and hot starting performance than carburetted systems due to their ability to establish the ideal air/fuel ratio for starting.
- Random engine stops, oily spark plugs, and other issues related to sub-optimal air/fuel ratios are all eliminated with EFI systems. EFI engines remove the need for regular adjustments, which are common with carburettors. This improves reliability while reducing maintenance time and costs.
- To ensure optimal combustion conditions, the ECU constantly monitors and adjusts the air/fuel ratio, as well as determines the precise amount of fuel that the injector needs to deliver.

10. DEMERITS OF ELECTRONIC FUEL INJECTION:

- When compared to a carburettor, a lot of maintenance is necessary.
- If that any of the sensors used in EFI fail, it becomes quite complicated and not easily programmable, as well as difficult to get to work properly.

11. CONCLUSION:

The following are the key findings drawn from the data in this paper:

- Electronic fuel injection system advancements have made it possible to reduce pollutant levels and enhance engine efficiency in terms of metrics such as fuel economy. It has fully eliminated short-circuiting losses. Because of increased control over the air-fuel ratio, injection time optimization considerably reduces specific fuel consumption and exhaust emissions. The use of a direct injection (DI) system can increase atomization, resulting in more efficient and cleaner fuel combustion.
- EFI is a viable option that may easily provide the control flexibility required for optimal overall engine performance. An electronically operated injection valve with an adequate flow rate and actuation speed can be produced and used in either a port or a direct injection system. The EFI system decides the injection quantity based on electrical signals from the airflow meter and engine rpm. Backfire into the intake manifold can be avoided by delaying fuel delivery using a delayed injection approach, either at the inlet port or directly into the cylinder.
- Overall, this technology prevents fuel from being wasted, allowing manufacturers to improve their vehicles fuel economy. It also reduces the amount of pollution produced by automobiles, which has become increasingly significant as government regulations have tightened.

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