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Piezoelectric Diesel Injectors & Emission Control

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Abstract: ***Diesel Injectors are one of the changing parameters in engine design. Piezoelectric Diesel Injectors are one of the changing designs adopted in engine systems especially CRDi engines. It enables better fuel economy and emission control. This paper provides with an overview, design and constructional features, working and applications of piezoelectric diesel Injectors.***

Keywords: Piezoelectric, crystals, CRDi, Atomization, Emission.

1. Introduction

In a diesel engine, combustion within the cylinder is closely related to the injection process. By controlling injection timing and duration, fuel quantity, and rate shape (flow rate profile as a function of time), it is possible to effectively control engine performance. A single injection rate profile will not simultaneously provide the lowest emissions, best fuel economy, and highest torque performance. Bosch, Continental, and Delphi, among others, have harnessed this peculiar property of expanding piezo material—rather than the usual electromagnet—to open the fuel-**injector nozzle** and precisely spray fuel into both gasoline and **diesel engines**. This led to the invention of piezoelectric diesel Injectors. The basic principle involved is piezoelectric and inverse piezoelectric effect.

2. Design Features

Piezo injectors use piezoelectric technology to open and close fuel injectors at extremely high speeds and precision to inject fuel into an internal combustion engine. These injectors are used in both petrol and diesel engines to improve their performance and efficiency. Piezo electricity results from squeezing or applying pressure from certain crystal like materials or certain ceramics. If this process is reversed and electricity is applied to these same materials they will expand and return to their original size as soon as the electricity is cut off. The expansion of one crystal is too small to see with the naked eye. One reason is that the expansion of the piezo crystals is minuscule.

A slice of piezo material two-hundredths of an inch thick expands only about 0.00002 inch when it gets hit with roughly 140 volts of electricity. That two-hundred-thousandths of an inch is not nearly enough to move an injector's pintle, which is the part that seals the nozzle and must open to inject fuel.

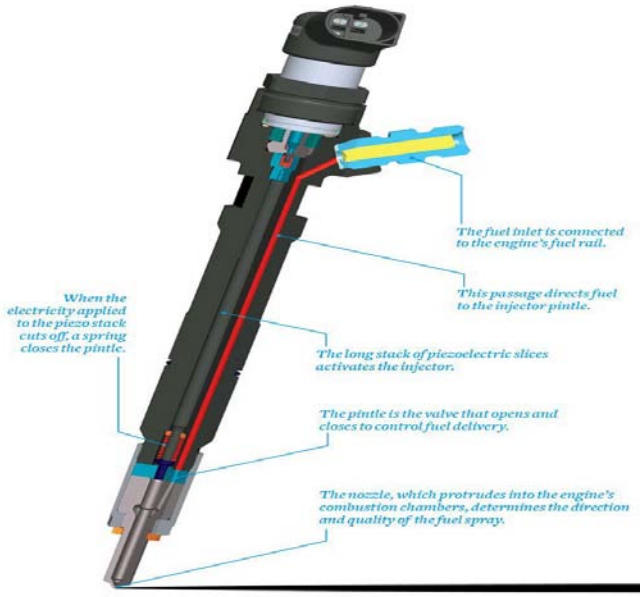

Figure 1: .Piezoelectric Injector Construction

3. Operation

The Continental injector has hundreds of little piezo slices stacked on top of each other so that the combined expansion increases the total motion. The stack produces 0.004 inch of movement—enough to move the pintle far enough to inject fuel. But because this motion is in the wrong direction—down, not up—the addition of two tiny levers allows the expansion of the piezo stack to cause the pintle to be lifted and the fuel spray to begin. When the injection is complete, the voltage cuts off, the piezo stack shrinks, and a spring closes the pintle. In a piezo injector, the electronic engine management system also sends an electrical signal to the valve. But the unique property of a piezo crystal is that it changes shape when exposed to electric current. The actual movement is microscopic, but enough to make the piezo element act as the valve. Piezo injectors are quieter and more precise than solenoid units, a benefit in a microsecond environment, but they are more expensive.

4. Benefits

Piezo injectors have a few key benefits that justify all of this bother. For one thing, they open and close much faster than conventional injectors. That makes for more precise control of the injection interval, which determines how much fuel is

sprayed into the engine. Piezo units also provide feedback by producing minute fluctuations in the electricity used to activate them.

For example, if the engine-control computer calls for an injector-opening time of 0.5 second, and the injector response shows that it opened for only 0.496 second, the computer can add a tiny bit of time to the next injection cycle to compensate. Such precise fuel metering makes for improved combustion, which leads to better fuel economy and reduced emissions.

Not only are piezo injectors more accurate than conventional solid injectors, they also can perform some tricks that are completely beyond the capabilities of their predecessors. For one thing, by applying a little less electricity, the piezo crystals expand less so the injectors can open partway. A smaller opening means a longer injection time, which is beneficial when trying to accurately inject a tiny amount of fuel, such as when a car is nearly coasting. Because they act so quickly, piezo injectors also can inject several times (as many as seven in some diesels) during a single combustion cycle. This flexibility can reduce emissions in all engines as well as limit soot in diesels.

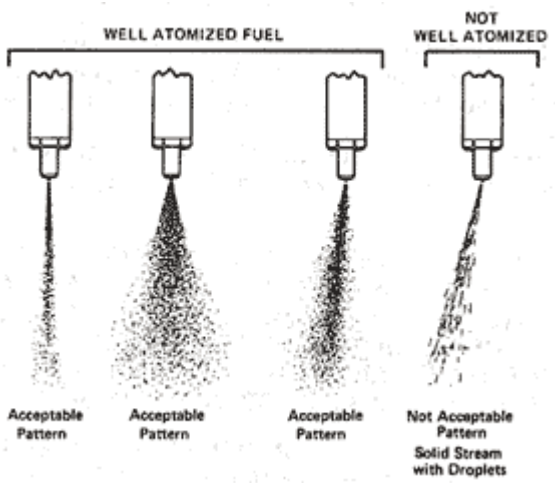

Figure 2: Atomized Fuel Spraying out of Injector.

5. Applications

Piezoelectric Diesel Injectors finds its application in CRDi-Common Rail Direct Injection Engines. CRDi stands for Common Rail Direct Injection meaning, direct injection of the fuel into the cylinders of a diesel engine via a single, common line, called the common rail which is connected to all the fuel injectors. Whereas ordinary diesel direct fuel-injection systems have to build up pressure anew for each and every injection cycle, the new common rail (line) engines maintain constant pressure regardless of the injection sequence. This pressure then remains permanently available throughout the fuel line. The engine's electronic timing regulates injection pressure according to engine speed and load. The electronic control unit (ECU) modifies injection pressure precisely and as needed, based on data obtained from sensors on the cam and crankshafts. In other words, compression and injection occur independently of each other. This technique allows fuel to be injected as needed, saving fuel and lowering emissions.

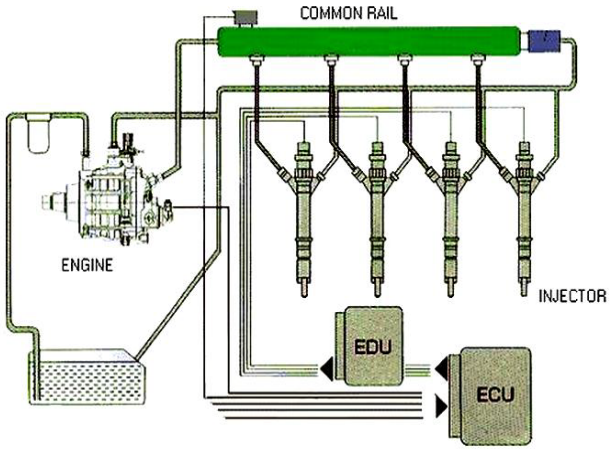

Figure 3: Common Rail Direct Injection System

The Common Rail system in particular gives engine developers the freedom they need to reduce exhaust emissions even further, and especially to lower engine noise. The particular design of Common Rail, with its flexible division of injection into several pre-, main and post-injections, allows the engine and the injection system to be matched to each other in the best possible way.

In the Common Rail accumulator injection system, the generation of the injection pressure is separate from the injection itself. A high-pressure pump generates in an accumulator – the rail – a pressure of up to 1,600 bar (determined by the injection pressure setting in the engine control unit), independently of the engine speed and the quantity of fuel injected. The fuel is fed through rigid pipes to the injectors, which inject the correct amount of fuel in a fine spray into the combustion chambers. The Electronic Diesel Control (EDC) controls extremely precisely all the injection parameters – such as the pressure in the Rail and the timing and duration of injection – as well as performing other engine functions.

6. Advantages

Some of the advantages of using piezoelectric diesel injectors are as follows.

- Increased injection pressure
- Less emissions
- Multiple-nozzle injection
- Enhanced injection timing.
- 5 times faster than conventional injectors.

7. Emission Control

Emissions is a collective term that is used to describe the undesired gases and particles which are released into the air or emitted by various sources, Its amount and the type change with a change in the industrial activity, technology, and a number of other factors, such as air pollution regulations and **emissions controls.** Undesirable Emissions in Internal

Combustion engines are of major concern because of their negative impact on air quality, human health, and global warming. Therefore, there is a concerted effort by most governments to control them. Undesirable emissions include unburned hydrocarbons (HC), carbon monoxide (CO), nitrogen oxides (NOx), and particulate matter (PM).

With the advent of catalytic converters, automobile industries have always found a way to reduce hydrocarbons and NOx emissions from the IC engines. CO_2 emission reduction is the greatest challenge still to be resolved. By designing better injectors CO_2 emissions can be completely reduced. One of the fine methods to reduce CO_2 is to use less fuel. Piezoelectric Injectors help in injecting fine spray of diesel which indirectly reduces the fuel consumption.

8. Conclusion

Even though there are several approaches being taken in reduction of CO2 and other toxic emissions. Two of the main methods adopted are either usage of alternate fuels or design parameters change inside the IC Engine system .The design of Piezoelectric Diesel Injectors greatly contribute to the emission control. Changes in Injector nozzle positioning and orientation angles can also contribute to less fuel consumption.

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