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A PAPER ON COMMON RAIL DIRECT INJECTION ENGINE TECHNOLOGY

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Abstract

Common-rail technology is intended to improve the pulverization process. Conventional direct injection diesel engines must repeatedly generate fuel pressure for each injection. But in the CRDI engines the pressure is built up independently of the injection sequence and remains permanently available in the fuel line. CRDI system that uses an ion sensor to provide real-time combustion data for each cylinder. The common rail upstream of the cylinders acts as an accumulator, distributing the fuel to the injectors at a constant pressure of up to 1600 bar. Here high-speed solenoid valves, regulated by the electronic engine management, separately control the injection timing and the amount of fuel injected for each cylinder as a function of the cylinder's actual need. In other words, pressure generation and fuel injection are independent of each other. This is an important advantage of common-rail injection over conventional fuel injection systems as CRDI increases the controllability of the individual injection processes and further refines fuel atomization, saving fuel and reducing emissions. Fuel economy of 25 to 35 % is obtained over a standard diesel engine and a substantial noise reduction is achieved due to a more synchronized timing operation. The principle of CRDI is also used in petrol engines as dealt with the GDI (Gasoline Direct Injection), which removes to a great extent the draw backs of the conventional carburetors and the MPFI systems.

Keywords: CRDI; MPFI; Injection system.

1. INTRODUCTION

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 pressures a new 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.

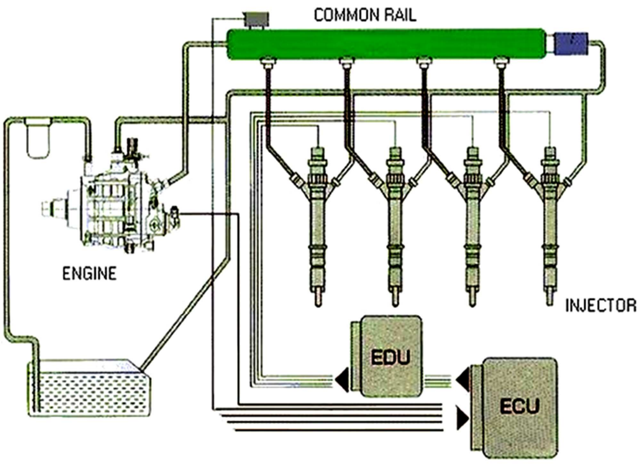

Figure 1 Views of Common Rail Injection System.

More accurately measured and timed mixture spray in the combustion chamber significantly reducing unburned fuel gives CRDI the potential to meet future emission guidelines such as Euro V. CRDI engines are now being used in almost all Mercedes-Benz, Toyota, Hyundai, Ford and many other diesel automobiles.

2. Common Rail Direct Injection Features:

Common rail refers to the single fuel injection line on the CRDI engines. Whereas conventional direct injection diesel engines must repeatedly generate fuel pressure for each injection, in CRDI engines the pressure is built up independently of the injection sequence and remains permanently available in the fuel line. In the CRDI system developed jointly by Mercedes-Benz and Bosch, the electronic engine management system continually adjusts the peak fuel pressure according to engine speed and throttle position. Sensor data from the camshaft and crankshaft provide the foundation for the electronic control unit to adapt the injection pressure precisely to demand.

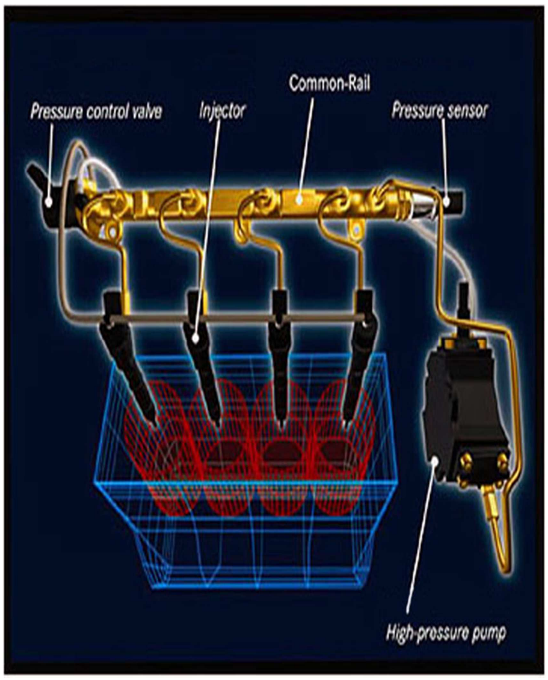

Figure 2 Flow of Common Rail Injection System

Common Rail Direct Injection is different from the conventional Diesel engines. Without being introduced to an antechamber the fuel is supplied directly to a common rail from where it is injected

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directly onto the pistons which ensures the onset of the combustion in the whole fuel mixture at the same time. There is no glow plug since the injection pressure is high. The fact that there is no glow plug lowers the maintenance costs and the fuel consumption. Compared with petrol, diesel is the lower quality fuel from petroleum family. Diesel particles are larger and heavier than petrol, thus more difficult to pulverize. Imperfect pulverization leads to more unburned particles, hence more pollutant, lower fuel efficiency and less power. Common-rail technology is intended to improve the pulverization process. To improve pulverization, the fuel must be injected at a very high pressure, so high that normal fuel injectors cannot achieve it. In common-rail system; the fuel pressure is implemented by a very strong pump instead of fuel injectors. The high-pressure fuel is fed to individual fuel injectors via a common rigid pipe (hence the name of "common-rail").

In the current first generation design, the pipe withstands pressures as high as 1,600 bar or 20,000 psi. Fuel always remains under such pressure even in stand-by state. Therefore whenever the injector (which acts as a valve rather than a pressure generator) opens, the high-pressure fuel can be injected into combustion chamber quickly. As a result, not only pulverization is improved by the higher fuel pressure, but the duration of fuel injection can be shortened and the timing can be more precisely controlled. Precise timing reduces the characteristic “Diesel Knock” common to all diesel engines, direct injection or not. Benefited by the precise timing, common-rail injection system can introduce a "post-combustion", which injects small amount of fuel during the expansion phase thus creating small scale combustion after the normal combustion takes place.

This further eliminates the unburned particles and also increases the exhaust flow temperature thus reducing the pre-heat time of the catalytic converter. In short, "post-combustion" cuts pollutants. The drive torque and pulsation inside the high-pressure lines are minimal, since the pump supplies only as much fuel as the engine actually requires. The high-pressure injectors are available with different nozzles for different spray configurations. Swirler nozzle to produce a cone-shaped spray and a slit nozzle for a fan-shaped spray. The new common-rail engine (in addition to other improvements) cuts fuel consumption by 20%, doubles torque at low engine speeds and increases power by 25%. It also brings a significant reduction in the noise and vibrations of conventional diesel engines. In emission, greenhouse gases (CO2) is reduced by 20%. At a constant level of NOx, carbon monoxide (CO) emissions are reduced by 40%, unburnt hydrocarbons (HC) by 50%, and particle emissions by 60%.CRDI principle not only lowers fuel consumption and emissions possible; it also offers improved comfort and is quieter than modern pre-combustion engines. Common-rail engines are thus clearly superior to ordinary motors using either direct or indirect fuel-injection systems. This division of labor necessitates a special chamber to maintain the high injection pressure of up to 1,600 bar. That is where the common fuel line (rail) comes in. It is connected to the injection nozzles (injectors) at the end of which are rapid solenoid valves to take care of the timing and amount of the injection. The microcomputer regulates the amount of time the valves stay open and thus the amount of fuel injected, depending on operating conditions and how much output is needed. When the timing shuts the solenoid valves, fuel injection ends immediately. With the state-of-the-art common-rail direct fuel injection used an ideal compromise can be attained between economy, torque, ride comfort and long life.

3. CRDI – Future Trends

3.1 Ulra-High Pressure Common –Rail Injections:

Newer CRDI engines feature maximum pressures of 1800 bar. This pressure is up to 33% higher than that of first-generation systems, many of which are in the 1600-bar range. This technology generates an ideal swirl in the combustion chamber which, coupled with the common-rail injectors’ superior fuel-spray pattern and optimized piston head design, allows the air/fuel mixture to form a perfect vertical vortex resulting in uniform combustion and greatly reduced NOx (nitrogen oxide) emissions. The system realizes high output and torque, superb fuel economy, emissions low enough to achieve Euro Stage IV designation and noise levels the same as a gasoline engines. In particular, exhaust emissions and Nox are reduced by some 50% over the current generation of diesel engines.

3.2 CRDI and Particle Filter:

Particle emission is always the biggest problem of diesel engines. While diesel engines emit considerably less pollutant CO and Nox as well as green house gas CO2, the only shortcoming is excessive level of particles. These particles are mainly composed of carbon and hydrocarbons. They lead to dark smoke and smog which is very crucial to air quality of urban area, if not to the ecology system of our planet. Basically, particle filter is a porous silicon carbide unit; comprising passageways which has a property of easily trapping and retaining particles from the exhaust gas flow. Before the filter surface is fully occupied, these carbon / hydrocarbon particles should be burnt up, becoming CO2 and water and leave the filter accompany with exhaust gas flow. The process is called regeneration. Normally regeneration takes place at 550° C. However, the main problem is: this temperature is not obtainable under normal conditions. Normally the temperature varies between 150° and 200°C when the driving in town, as the exhaust gas is not in full flow. The new common-rail injection technology helps solving this problem. By its high-pressure, precise injection during a very short period, the common-rail system can introduce a "post-combustion" by injecting small amount of fuel during expansion phase. This increases the exhaust flow temperature to around 350°C. Then, a specially designed oxidizing catalyst converter locating near the entrance of the particle filter unit will combust the remaining unburnt fuel come from the "post-combustion". This raises the temperature further to 450° C. The last 100°C required is fulfilled by adding an addictive called Eolys to the fuel. Eolys lowers the operating temperature of particle burning to 450° C, now regeneration occurs. The liquid-state additive is store in a small tank and added to the fuel by pump. The PF unit needs to be cleaned up every 80,000 km by high-pressure water, to get rid of the deposits resulting from the additive.

4. CONCLUSION:

In this system it is seen that the CRDI engine developed more power and also increased the fuel efficiency. By using this system there is reduction of noise and Pollutants. Particulates of exhaust are reduced. Exhaust gas recirculation is enhanced and precise injection timing is obtained. More pulverization of fuel is obtained in this system. The powerful microcomputer makes the whole system more perfect and doubles the torque at lower engine speeds.

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