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Term Project

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Name of Project: COMMON RAIL DIESEL SYSTEMS

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ABSTRACT

Common Rail is a fuel injection system used in diesel engines and basically works as synchronized injection via a common pipe. Compared to the conventional type of diesel injection systems, it is a superior system for fuel consumption, exhaust gas emission, operating system and noise reduction. Common-Rail technology is designed to improve for atomize/pulverization diesel fuel in injection process. Traditional diesel engines must produce fuel pressure for every injection. However, the pressure in the CRDI engine generates as an injection sequence and remains consistently in the fuel line. Unlikely single pumping systems, pressure build-up and spraying are separated in Common-Rail. While conventional diesel direct injectors operate at pressures of approximately 900 bar, the Common-Rail System distributes the fuel to the injectors via a common pipe with a pressure up to 1600 bar. The ECU adjusts this high pressure, depending on the engine speed and load. This injection process is accomplished by the high-speed solenoid valves to obtain the fuel required by the cylinder. In general, the advantage of CRDI is that pressurization and fuel injection can operate independently from each other. The amount of fuel to be sent to the cylinders is adjustable. Moreover, with these new possibilities, the Pre-Spraying, which is a perfect advantage of the new system, is emerging. For all these reasons are combined, fuel consumption and emission values are reducing. According to studies, vehicles using CRDI technology burn 25% less fuel than conventional diesel vehicles.

1. INTRODUCTION

The Common-Rail system prototype was developed by Robert Huber and Dr. Marco Ganser at the Swiss Federal Institute of Technology in the late 1960s. But the first successful usage of this technology accomplished by Japan in the 1990s. For the first time, this technology was used on heavy vehicles and later adapted to automobiles and passed mass production.

In CRDI (Common Rail Direct Injection), there is a common line which is called Common-Rail, and each injector is connected to this line. Through this line, fuel sent into the cylinders. In conventional diesel engines the pressure needs to be readjusted for each injection process, while in CRDI the pressure is always constant and this pressure remains constant along the fuel line. The ECU adjusts the injection timing of the injectors depending on the engine load and speed. The amount of fuel to be delivered to the combustion chamber is set by the ECU with the information which is provided by the sensors in the engine. Fuel is supplied to the combustion chamber when it is needed, fuel is not sent to the combustion chamber when it is not needed. This saves fuel and reduces emissions. As mentioned before, fuel measures more accurately in CRDI technology that’s why the amount of unburned fuel is significantly reduced after combustion stage and the Euro V emission standards achieves. Figure 1.1 shows working principle of CRDI technology.

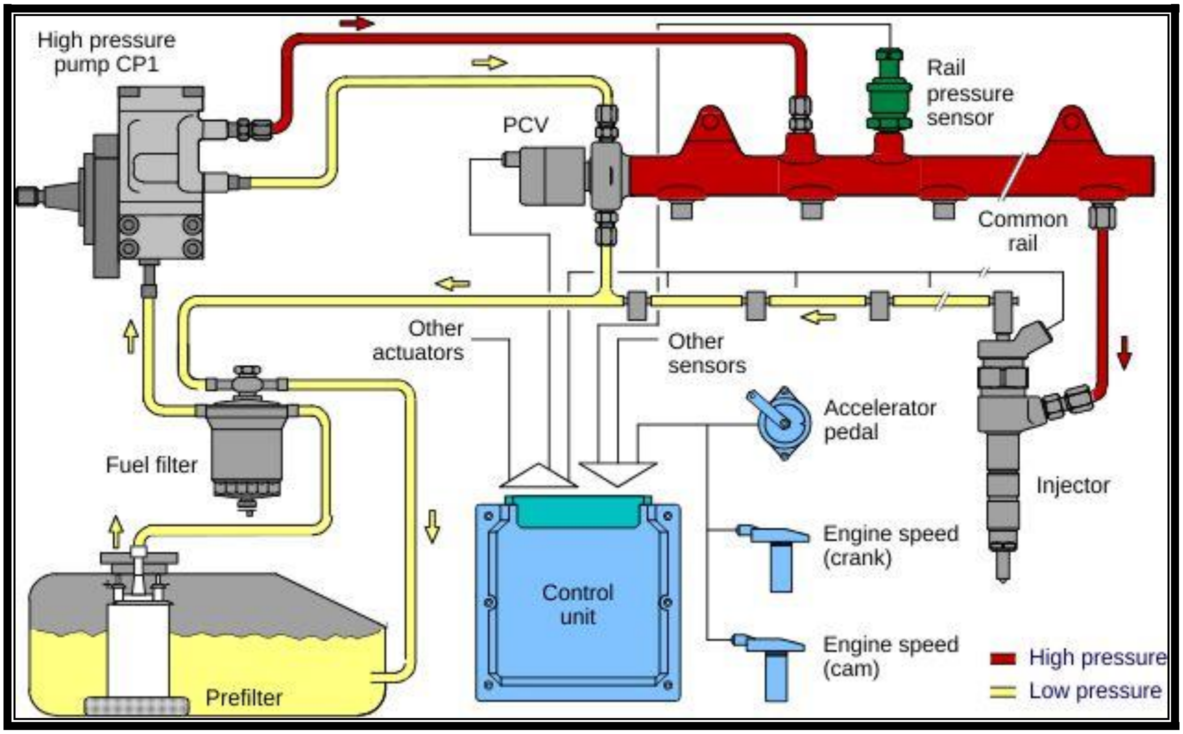

Figure 1.1: Common rail diesel fuel injection system with pressure control valve located on the rail.

2. Features of CRDI Technology

The emission problem has always been a problem for ships, trains, heavy duty vehicles, generators and other vehicles with diesel engines. Another important problem was that customers were constantly looking for economical engines with lower fuel consumption. The emission problem was solved by diesel particle filters and catalytic converters, but this time, these systems were causing problems with the large space requirements. To cope with these problems a few changes had to be made in the diesel engines. Because of this, the engineers decided to develop an internal combustion diesel engine.

It is known that the fuel must be burned completely to get high efficiency. The NOx level also decreases when fuel is completely burn. But at low speeds it is almost impossible to burn the fuel completely. To achieve this, multiple injection was developed. Generally, Multi-injection consists of five steps, such as Pilot Injection, Pre-Injection, Main Injection, After Injection and Post Injection.

In first stage, pilot injection occurs immediately before the ignition. It allows fuel and air to mix properly. In second stage, Pre-injection occurs and it is reducing ignition delay before main injection. NOx level, noise and vibration are reduced at this stage. The heat generated by the pre-injection is much higher than the heat required for the fuel itself to ignite. In this case, when the main injection takes place as third stage the yield from the fuel becomes higher. In fourth stage, after-injection takes place and unburned fuel is burned. Finally, post-injection helps the generate heat which is required by the catalytic converter. In this way, the catalytic converter works more efficiently. According to DENSO data’s 1800-bar common rail system increases engine torque up to 35 percent, engine power up to 24 percent and low idle noise decreases 6.5 dB down on a 2.0-liter diesel engine, as compared with DENSO’s conventional model. Figure 2.1, shows stages of the five staged multi injection system of Fiat.

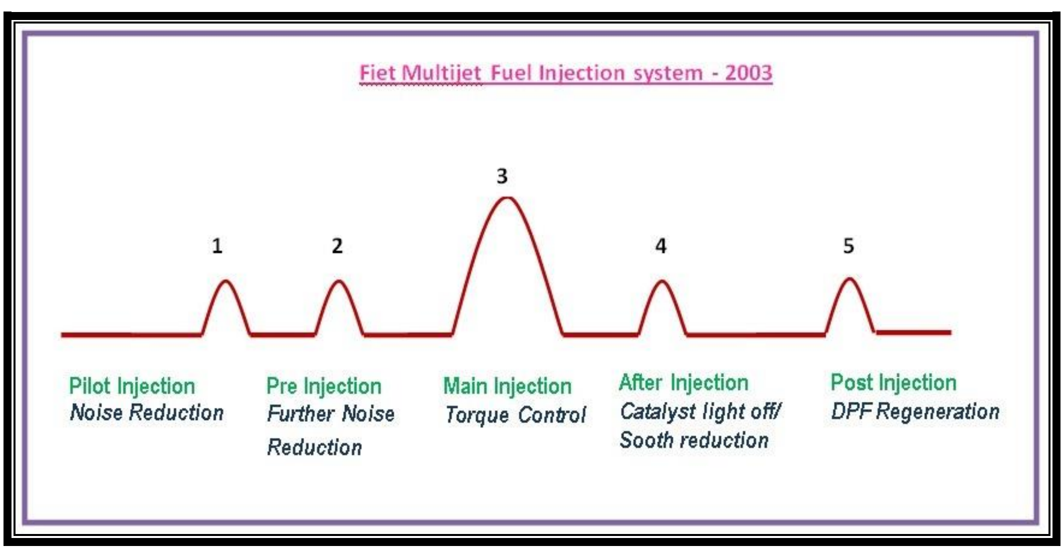

Figure 2.1: Five staged Multijet Fuel Injection system of Fiat.

Compared to diesel and gasoline, diesel fuel is less qualified and denser than gasoline. So, it is difficult to atomize diesel fuel. In order to get better atomized diesel fuel, fuel must be injected with high pressure. For this reason, CRDI technology has a high-pressure fuel pump. This pressure is maintained even if the vehicle is at idling position. That’s why, the fuel is injected quickly when the injectors are opened. CRDI improves atomization as well as shortens injection time. The problem we call "diesel knuckle" is also reduced.

3. Advantages & Disadvantages of CRDI Engine

3.1 Advantages of CRDI Engine

- Higher fuel injection pressure and better atomization
- Injection pressure created independently from engine speed
- Multiple Injection for each cylinder is possible
- 25% or more engine power and torque
- Lower vibration and noise level
- Lower fuel consumption
- Lower emission levels

3.2 Disadvantages of CRDI Engine

- High engine cost
- High maintenance cost
- Expensive spare parts

4. Components of CRDI Engine

There are various types, designs and trade marks of CRDI system such as Bosch, Denso and Delphi. However, all works in same principle. Figure 4.1 shows Bosch's EDC 16 CRDI model.

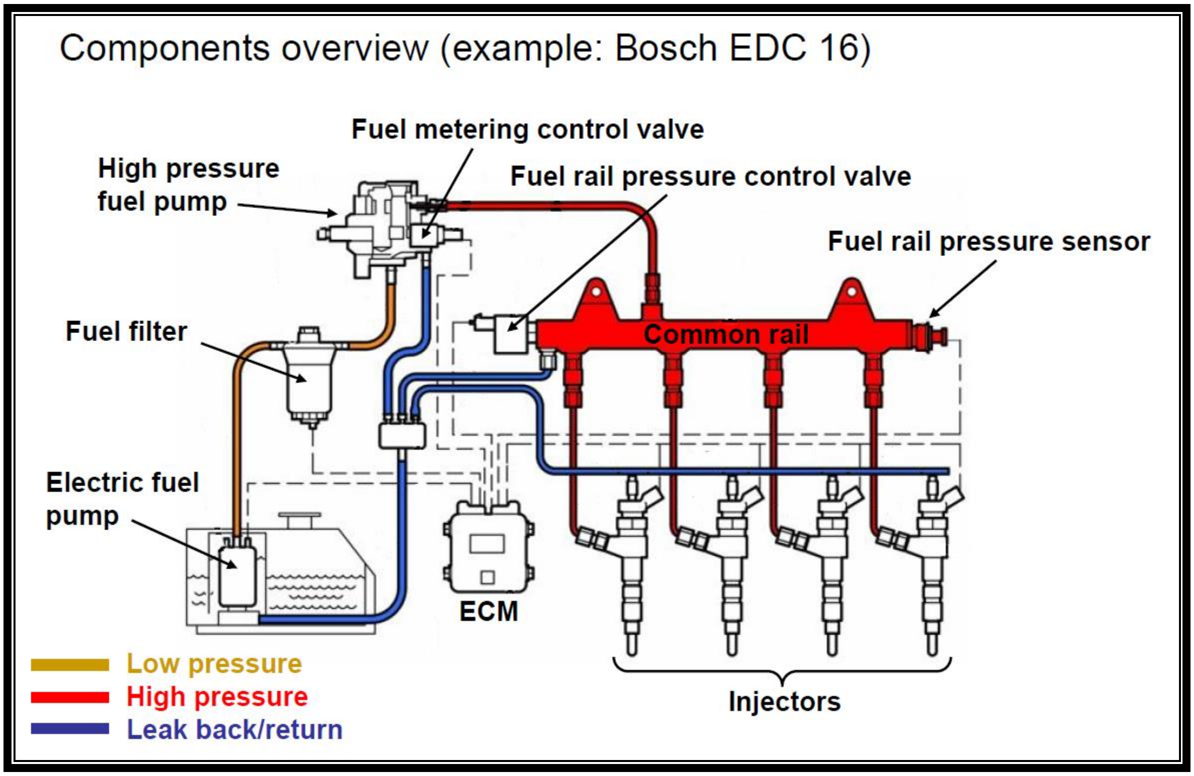

Figure 4.1: Components of Bosch EDC 16 Common Rail Direct Injection System.

4.1 High Pressure Fuel Pump

The high-pressure fuel pump is located between the low pressure and high-pressure pipes. The basic function is to transmit the fuel to the system at the required pressure. Figure 4.1.1 shows different trademarks of High Pressure Fuel Pumps.

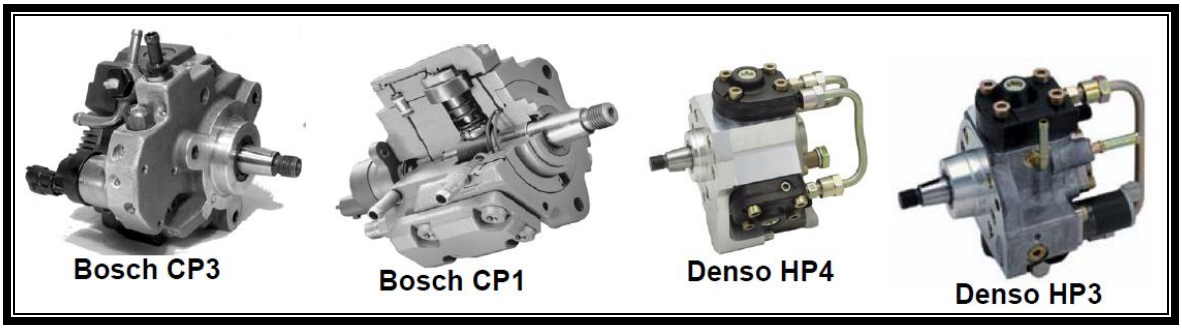

Figure 4.1.1: Different trademarks of High Pressure Fuel Pumps**.**

The high-pressure fuel pump is supplied by electric. This pump produces the fuel pressure required for the high-pressure injector to provide ideal mixing of the fuel and air directly into the combustion chamber. Some systems also have a transfer pump with an electric pump. Figure 4.1.2 shows detailed explanation of parts in the HPP.

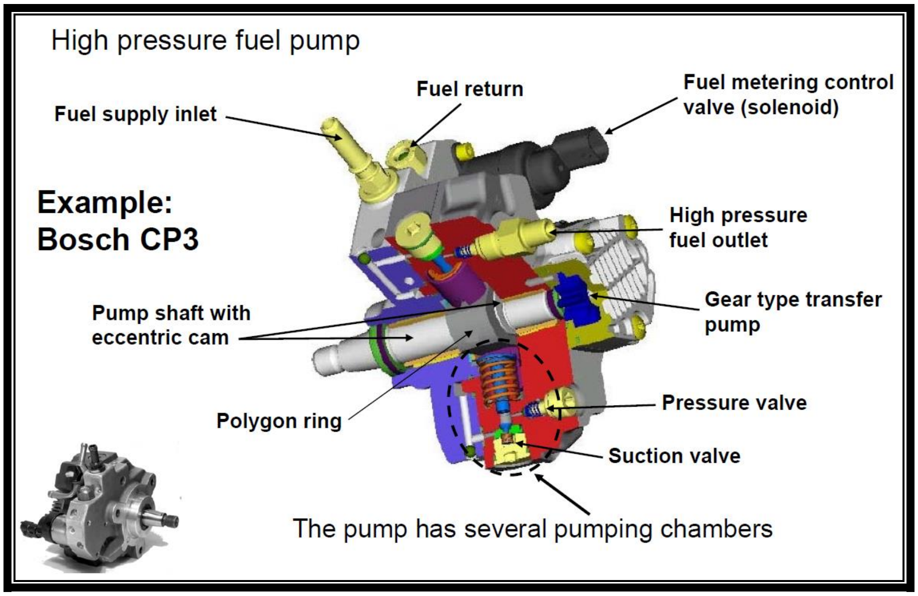

Figure 4.1.2: Detailed explanation of High Pressure Fuel Pump.

4.2 Fuel Metering Control Valve

- It is located back side of the HPP.
- Controls amount of fuel.
- Controlled by ECU.

When there is no energy on solenoid, valve is open and low volume of fuel charging to the HPP. When there is energy on solenoid, valve is closed and high volume of fuel charging to the HPP. Figure 4.2.1 shows the fuel volume intake control.

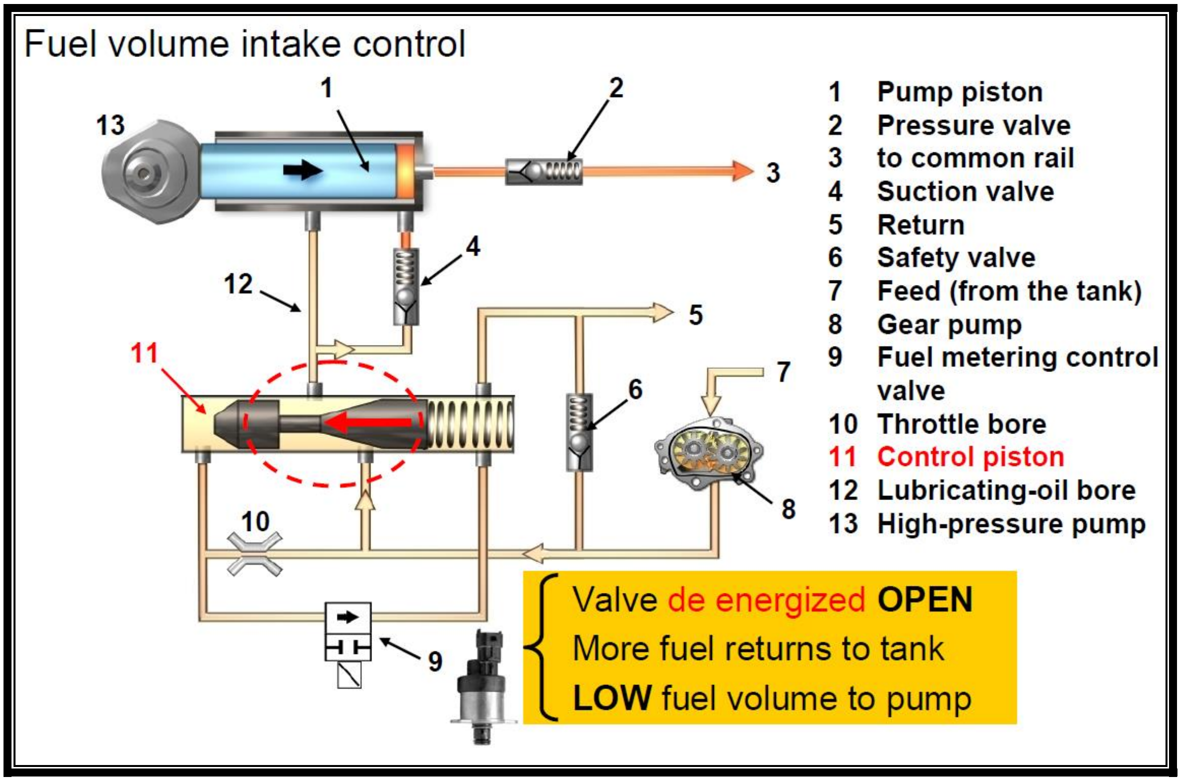

Figure 4.2.1: Fuel volume intake control.

4.3 High Pressure Regulator Valve

- Controls high pressure fuel which is delivered to common rail.
- Sends excess fuel into the fuel tank
- Cool downs the fuel before sends it to the tank.

4.4 High Pressure Accumulator (Common-Rail)

The fuel is sent to the common rail at high pressure. The fuel is stored here and distributed by injection. In addition, common-rail eliminates vibration caused by the high-pressure pump. Figure 4.4.1 shows the common-rail part.

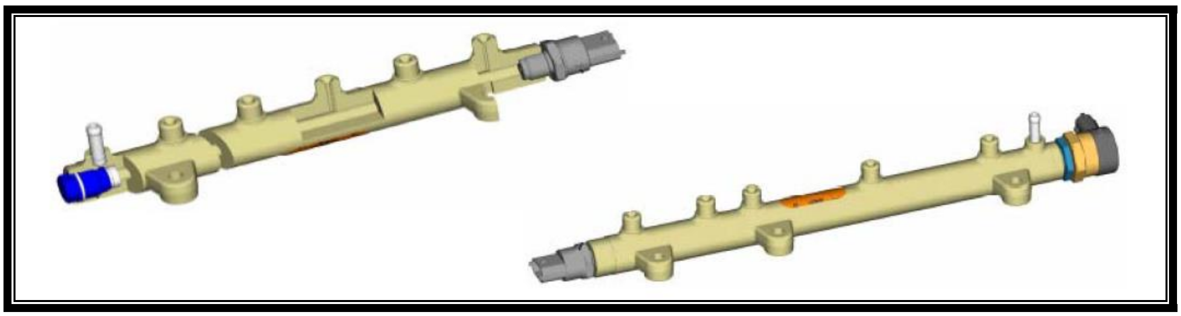

Figure 4.4.1: Common-Rail.

Generally, the fuel rail works between 300-400 bar at idle position and it can reach 1600-2200 bar at maximum working conditions.

4.5 Fuel Pressure Sensor

Fuel pressure sensor is located on the fuel rail. It measures the fuel pressure on the Common Rail and communicates with the engine computer. Figure 7 shows the fuel pressure sensor with gray color.

4.6 Rail Pressure Limiter Valve

It is located on the fuel rail. If there is generated excessive amount of pressure, that pressure relieved by the rail pressure limiter valve and excessive fuel sent back to fuel tank. Figure 7 shows the rail pressure limiter valve with blue color.

4.7 Fuel Injectors

Fuel injectors are controlled by solenoids or piezo-actuators. Excess fuel is returned to the fuel depot by the injector piston. Piezo-injectors are four times faster than solenoid injectors due to their fast response times. Main parts of the CRDI Injector shown in the figure 4.7.1.

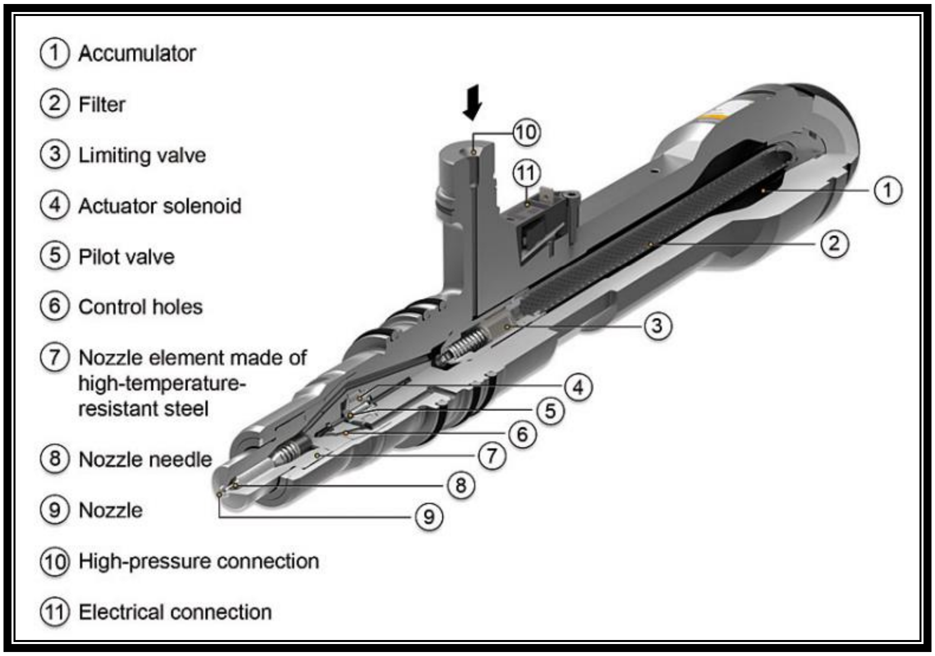

Figure 4.7.1: Main Parts of the CRDI Injector.

5. Discussion

This study provides information about CRDI engine technology. Basically, invention of CRDI technology, developing process, working principle, fuel consumption and emission values were explained. In addition, information is given about what the basic parts of the CRDI system and their duty. The advantages and disadvantages of this technology have been examined.

6. Conclusion

The main purpose of the CRDI system invention and its development is to consume less fuel and obtain more power and torque. At the same time, this technology has less noise and vibration than the conventional diesel engines. The electronically controlled combustion chamber can perform a clean and efficient combustion. In this case, the reduced emission values after combustion are further reduced by the catalytic converter.

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APPENDIX

Appendix A: Standards

3. Host control section

Host control section	
Chipset	Intel ARM X9
USB port	4
VGA port	1
Operating system	WindsCE
Design standards	Industrial control standards
1000 hours pressure test	Yes

4. System filtration and protection

Clogging reminder system	Yes
Filters	7
primary standard Filter	2, Euro III standard
secondary standard Filter	5 ,Euro III standard
Cooling method	2 synchronous cooling
Cooling system power	160W
Fuel Cooling method	Electric cooling fan blades
Radiator numbers	2 sets
Fuel tank	Combined automatical classified tank
Main tank capacity	45L
Auxiliary fuel tank	10L

Figure 3: Standards of CRDI Host control section & system filtration and protection

APPENDIX B: TECHNICAL DRAWINGS

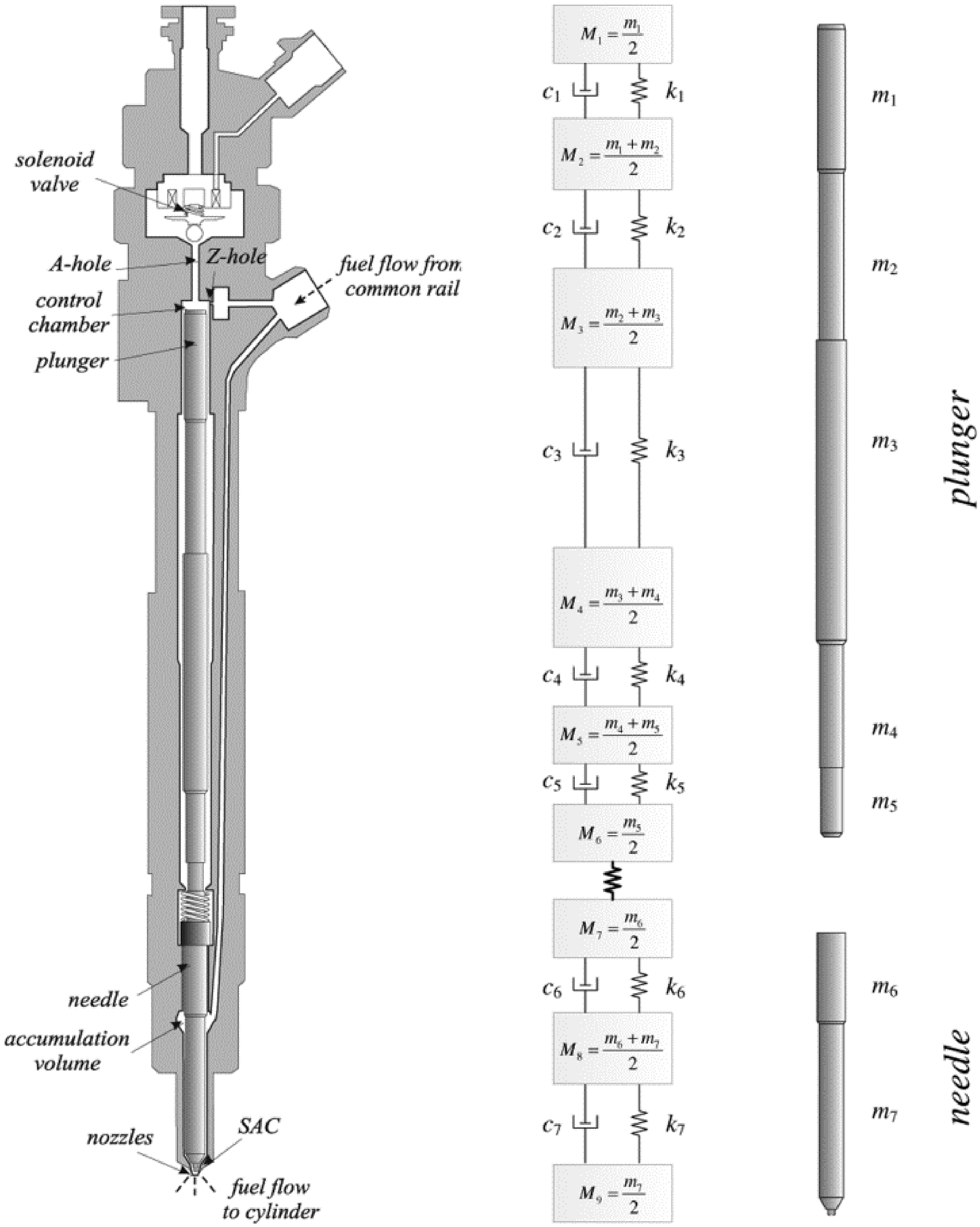

Figure 4: Common Rail Diesel Injector

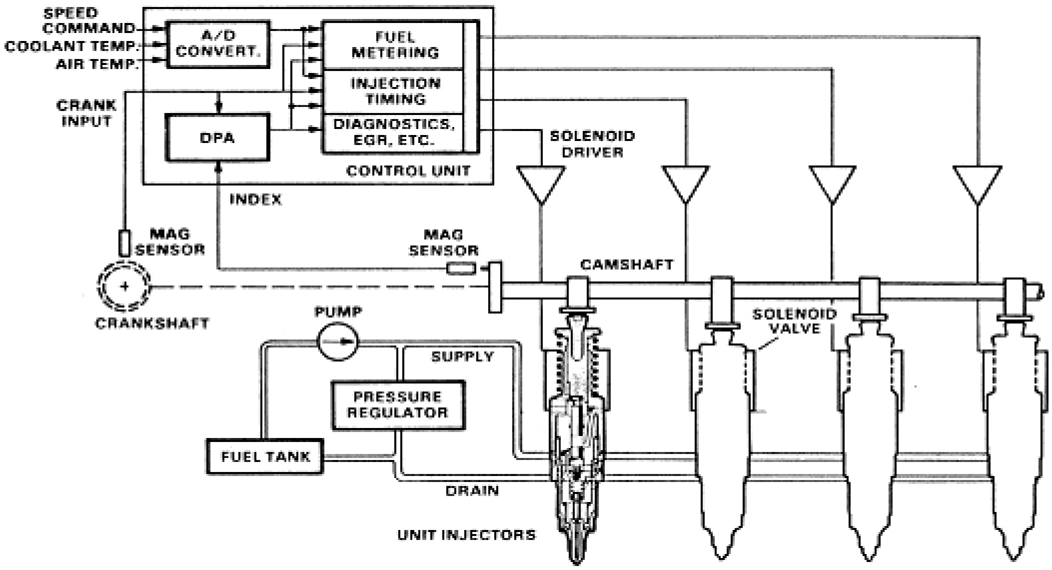

Figure 5: Diagram of the Bendix Injection System