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STUDIES ON THE OPERATION OF DIESEL SOLENOID INJECTORS

BY

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Abstract. The Diesel engine due to higher efficiency than petrol engine is frequently met on vehicles. The most injection system met on the Diesel engines is common rail injection system. This system is a high performance one of electro hydraulic type, able to satisfy the requirements of the European Union in terms of reducing pollution. One of the injectors used in this injection system is the solenoid injector. From constructive functional analysis has been resulted that this type of injector from the hydraulic point of view can be assimilated with a hydraulic bridge. The proposed scheme allow the dynamic analysis of hydraulic solenoid injector using a modeling program.

Key words: injector, hydraulic, bridge, chart.

1. Introduction

Both gasoline and Diesel engines transform the chemical energy of the fuel into mechanical energy by a series of explosions called combustions. The distinction between the two types of engines is made by the manner in which combustion occurs (Nenerică *et al.*, 2012; http://auto-tehnica.ro/?p=48; http://www.scribd.com/doc/15116715/cursinjectdiesel).

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In the gasoline engine, the fuel is mixed with air, compressed by a piston and lit by a spark generated by the spark plug.

In the Diesel engine, the air is compressed up to a particular pressure, and only then the fuel is injected. The fuel lights spontaneously due to the temperature that the air reaches during compression (http://motorul-diesel.blogspot.ro/).

The role of the injection equipment is to feed the combustion chamber of the engine with fuel, so that the combustion should correspond at any time with the engine's operation mode, which is determined, in its turn, by an exterior load.

In order for the engine to work properly and at the same time to save fuel, the injection equipment should comply with a series of requirements, the most important of which are:

− to increase the fuel pressure up to a predetermined value and to pulverize it in the combustion chamber, so as to optimize the air and fuel mixture and to achieve the most complete combustion possible;

− to start injecting the fuel at a particular moment and to finish it at a preset time;

− to inject the fuel by observing the engine's combustion method in respect to the spurt position and shape;

− to inject an amount of fuel which always observes the engine load;

− to achieve an even fuel outflow on each cylinder.

This may be determined by the Diesel fuel coefficient or "degree of unevenness" (Nenerică *et al.*, 2012; http://www.scribd.com/; http://aynstein.; http://www.howstuffworks.com/diesel2.htm).

One of the most significant advantages of compression firing engines (MAC or Diesel) is their better output, which is due to their compression ratio that is superior to that of spark firing engines (gasoline). Hence, lower fuel consumption rates.

Modern Diesel engines are equipped with two types of injection systems:

− the common rail injection system

− the pump-line-nozzle injection system (injector pump).

Of the two Diesel injection systems, the common rail is the most common.

This is a high performance system that works at high pressures and is capable to comply successfully with the ever demanding pollution requirements of the European Union.

The common rail injection system provides the necessary development trends that would allow the implementation of a new pollution reduction system (Euro 6,7). This may be achieved by increasing the power density of the high pressure pump, by reducing the clearance and roughness of the components in relative movement, by reducing the fuel volume in the injector return line, by replacing the solenoid injector by a piezoelectric injector.

2. The Structure of the Common Rail Injection Systems

The common rail injection system, Fig. 1, may be divided into two components, *i.e.* the low pressure component and the high pressure component.

The low pressure component includes the (Nenerică *et al*., 2012):
• fuel tank
• low pressure fuel pump (transfer pump)
• fuel filter
• low-pressure pipe

The high pressure component comprises the:
• high pressure pump
• accumulator or rail
• injector
• the high pressure pipe

The injection systems containing safety and control elements and control elements.

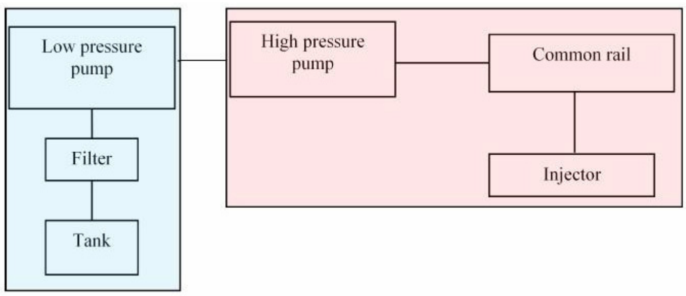

Fig. 1 − The common rail injection systems structure.

In Fig. 2 it presents the block diagram of the solenoid injectors

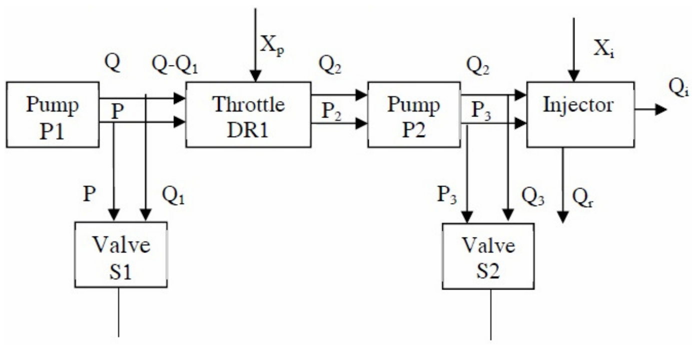

Fig. 2 − The block diagram of the common rail injections systems low pressure pump P1; throttle controlled by ECU (computer car) DR1; discharge valve S 1,2; high pressure pump P 2; injector; X_p, X_i – injector and pump imput.

2.1. The Hydraulic Structure of the Common Rail Injection Systems

The bridge diagram of the solenoid injector results from its constructive functional analysis, Fig. 3.

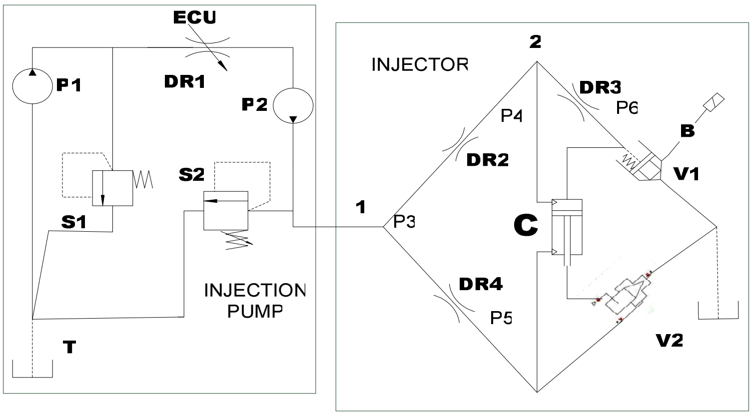

Fig. 3 − Hydraulic diagram of the common rail injection system.

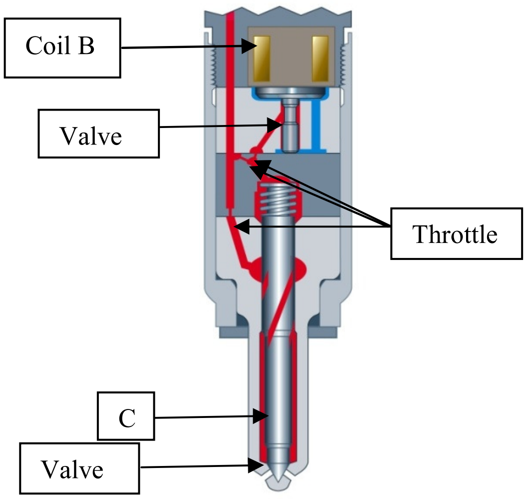

Fig. 4 − The Delphi injector (http://library.delphi.com/).

While at rest, the injector is normally closed. The injection pump is made up of a low pressure pump P1, a throttle DR1 driven by the vehicle computer (ECU) depending on the position of the accelerator pedal, a high pressure pump P2 and safety valves S1, S2.

From the hydraulic point of view, the injector is a hydraulic bridge in which the load is subset C made up of the body of the nozzle and of the injector needle.

Subset C is assimilated with a hydraulic cylinder. The fuel coming from the injection pump through the common rail enters the device in node 1, which is a bypass point. Some of it passes through throttles DR2, DR3 and reaches the normally closed valve V1.

Fixed throttles are fixed hydraulic resistances, which cause pressure to drop and consequently the downstream outflow to decrease.

Valve V1 is driven by coil B. The remaining fuel gets to point 1, passes through throttle DR4, then enters the left chamber of cylinder C and valve V2.

In point 2, the fuel enters the right chamber of cylinder C, thus balancing the pressure in the two cylinder chambers. Thus, the cylinder rod remains at rest.

When coil B is powered, it drives valve V1, which opens. Valve V1 works as valve V2 only in the 0 and 1 positions (closed or open) and thus pressure P6 begins to drop, P6 < P4. Pressure P4 begins to decrease, P4 < P5. An unbalance occurs between the pressures of the two cylinder chambers, so that the injector needle moves to the right and opens valve V2. Fuel injection occurs.

When the feeding of coil B stops, the spring of valve V1 closes the valve, pressure P4 starts to increase and then P6 also increases. For P4 >P5, the rod of cylinder C starts to move to the left, and closes valve V2. When it closes, pressure P5 also starts to increase until the P5 = P3 = P4 = P6 condition is meet. As the pressures are balanced, the injector is closed.

4. Conclusions

1. The injection system is one electrohydraulic type.
2. From the hydraulic point of view injector is a hydraulic bridge.
3. The hydraulic bridge design of the solenoid injector has been achieved.
4. The diagram shown allows the digital modeling analysis of the solenoid injector dynamics.

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STUDII PRIVIND FUNCŢIONAREA INJECTORULUI DIESEL CU SOLENOID

(Rezumat)

Motorul Diesel, datorită randamentului mai ridicat decât motorul pe benzină, este întâlnit în mod frecvent pe autovehicule.

Sistemul de injecție cel mai des întâlnit echipând motoarele Diesel este sistemul de injecție rampă comună. Acest sistem este unul performant, de tip electrohidraulic, capabil să satisfacă cerințele impuse de Uniunea Europeană în ceea ce priveşte reducerea poluării.

Unul din injectoarele folosite de acest sistem de injecție este injectorul cu solenoid.

Din analiza constructiv funcțională a rezultat faptul că acest tip de injector din punct de vedere hidraulic poate fi asimilat cu o punte hidraulică.

Schema hidraulică propusă permite analiza dinamică a injectorului cu solenoid cu ajutorul unui program de modelare.