ASPECTS REGARDING THE ELECTRICAL COMMAND OF DIESEL INJECTION

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Abstract

The paper presents the preliminary tests for a new method of controlling diesel injection at the injector of a compression ignition engine. The purpose of the paper is to verify the possibility of obtaining certain quantities of fuel, sprayed by injector by this method. It was also verified the possibility of changing the value amount of diesel sprayed by injector according to certain parameters. Unlike conventional injection systems, in this method the injector receives the fuel from an electrically operated piston pump element via an electromagnet. The entry into service of the electromagnet is controlled by an electrical circuit equipped with a capacitor battery. The capacitor battery is designed to store electricity and restore it to the action control of the electromagnet. In this way, the actuation time of the piston pump element is very short. The opening time of the injector can also be easily modified. The tests presented in the work are carried out using a prototype, which has been tested only on a stand designed by the author and not on a running engine. At this preliminary testing stage it was followed whether the proposed method allows fuel injection through the injector. It was also monitored if there was a possibility of changing the dose of injected fuel. It was looked which of the constructive and functional factors influence the modification of the injected dose.

Key words: diesel, fuel, injection

In compression-ignition engines, the fuel is introduced into the engine cylinder via an injector. It usually introduces, at each operating cycle, a diesel quantity of 10...200 cubic millimetres/cycle (Danciu A., 2013; Rakosi E. 2013; Roșca R., 2015). Expressed in millilitres these quantities are between 0.01 and 0.2.

A new idea in terms of pumping fuel to the injector is the electromagnetic drive of the pumping element. This proposal aims to reduce the injection time. An advantage of this method is the possibility to slightly change the injection advance.

MATERIAL AND METHOD

The proposed method for the electric control of diesel injection is based on the use of a capacitor bank. This provides the energy needed to operate an electromagnet whose movable core is rigidly attached to the piston rod of a piston pump element. Changing the position of the electromagnet core will change the position of the pump element piston.

The fuel is located inside the pump element at a preset working pressure. By moving the piston, the diesel is transmitted to a conventional injector, which sprays it.

The injector is mounted at a short distance from the pump element.

The tests performed at this stage of the study looked at whether the proposed method for electrical control of the diesel injection allows certain amounts of fuel to be sprayed by the injector. It was also monitored at whether the amount of diesel sprayed can be changed.

The tests were not carried out on a compression-ignition engine, but on a simple stand designed by the author. The components of the test stand are shown in *figure 1*.

The fuel from the tank (1) is sent by the manually operated pump (2) into the pump element (5), at a pressure lower than that of the injector opening (6). The manually operated pump was chosen to make it easier to adjust the pressure in the pump element (5).

The supply pressure of the pump element (5) is monitored by means of the manometer (3).

The valve (4) allows the flow of fuel in only one direction, from the manually operated pump (2) to the pump element (5). This avoids reversing the flow direction of the fuel when the pump element (5) starts operating.

When the supply pressure of the pump element has reached the test value, the electromagnet (8) is switched on. This will move the piston pump element (5), which will increase the fuel pressure to the injector opening value.

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The fuel sprayed by the injector is collected in a graduated cylinder. It allows the measurement of the amount of fuel sprayed by the injector.

The return of the pump element piston (5) to the initial position is due to the pressure of the fuel sent by the manually operated pump.

The amount of fuel sprayed through the injector is small. In order to prevent measurement errors, in the case of the proposed test stand, it was accepted that the measurement of the amount of fuel, sprayed by the injector, under conditions of a certain supply pressure and a certain charging time of the condenser bank, should be done by collecting in the graduated cylinder the quantities obtained for one hundred successive tests.

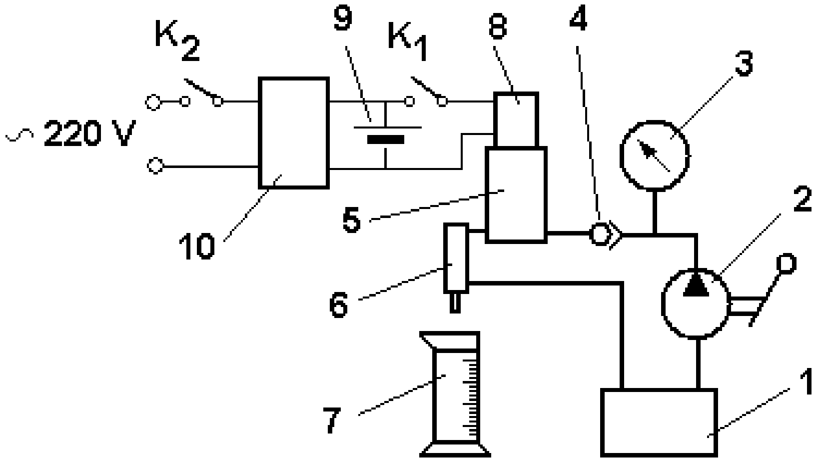

Figure 1 **Composition of the test stand**
1- tank; 2 – hand-operated pump; 3 – manometer; 4 – sense valve; 5 – pump element; 6 – injector; 7 – graduated cylinder; 8 – electromagnet; 9 – capacitor bank; 10 – rectifier deckK1; K2 – electrical switches.

As can be seen from Figure 1, the electromagnet (8) is powered by an electrical circuit which also includes the capacitor bank.

The electrical circuit is connected to a 220 Volt AC power source with a frequency of 50 Hz. A capacitor bank is charged by this source by means of a rectifier bridge. An electrical resistor has been installed on the supply circuit of the rectifier bridge, which has the role of limiting the current at its level.

In the first stage, the capacitor bank is charged. For this, switch K2 is in the closed position and switch K1 is in the open position. After charging the battery, switch K2 opens. When the electromagnet has to start, switch K1 switches to the closed position. In this way the current from the capacitor bank will reach the electromagnet.

When the capacitor bank is charging , switch K1 is kept open to prevent it from discharging.

It was decided to use a co-capacitor bank, because this solution allows to obtain a high activation energy of the electromagnet and allows to achieve a short actuation time.

The pump element (5) consists of a cylinder and a piston of the type used in the construction of in-line injection pumps, which equip the engines of U 650 tractors. The cylinder and the piston are mounted in a body with a threaded cap.

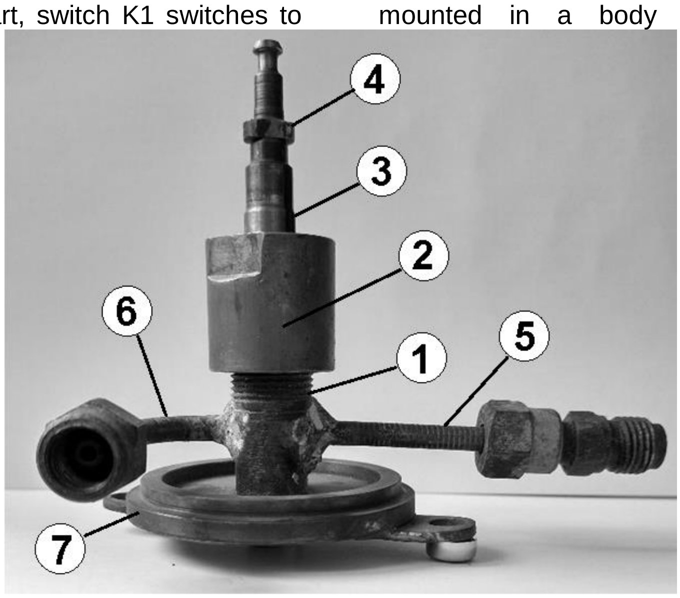

Figure 2 **Overview of the pump element (5)**
1- body; 2 – threaded cap; 3 – cylinder; 4 - piston; 5 – supply line; 6 – injector connecting pipe; 7 – support.

The body of the pump element (5) is provided with a supply line and a connection line with the injector. An overview of the pump element (5) is shown in *figure 2*.

The piston stroke can be adjusted by means of a limiter.

At the top of the piston rod is mounted a plate that has the role of taking over the pushing force created by the electromagnet.

A housing is used to fix the described components.

The piston rod of the pump element is set in motion on the active stroke by an electromagnet. Two types of electromagnets (Figure 3) were used for the tests at this stage.

The Type 1 electromagnet is an electromagnet taken from the IEPS 2140 starter of the engine that equips the Dacia 1300. Its power supply voltage is 12 volts. The Type 2 electromagnet (DISH50) is taken from the SAVIEM starter. Its power supply voltage is 24 volts.

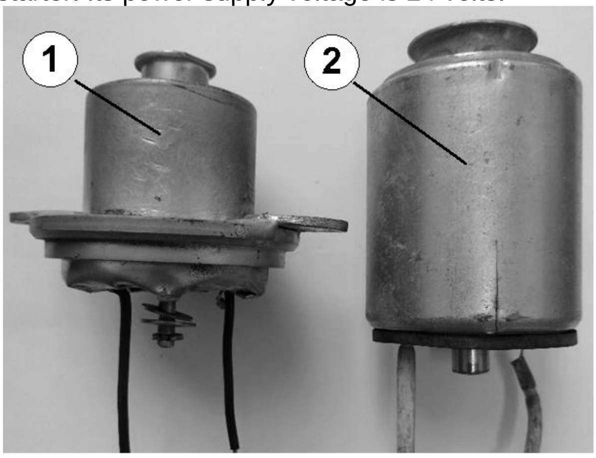

Figure 3 **Electromagnets used on the test stand**
1- Type 1 electromagnet; 2 – Type 2 electromagnet.

Two types of injector sprayers (*figure 4*) were used during the tests.

Injector A is a monojet type. Such an injector is equipped with a sprayer type RO DN 0 SD 21.

Injector B is multijet. The sprayer used by it is RO DLLA 145 S 448.

In both types of injectors, the sprayer needle opens due to the pressure of the diesel.

The test stand allows the power pressure of the pump element to be adjusted (5), the capacitor bank charging time and capacity adjust.

RESULTS AND DISCUTIONS

In the first stage of the tests, the quantities of diesel, passing through the RO DLLA 145 S448 sprayer, were compared for the use of the Type 1 electromagnet and for the use of the Type 2 electromagnet.

For tests carried out with each type of electromagnet, two values were used for the capacitor bank capacity. These values were 1000μF and 2000μF.

Five values were analyzed for the capacitor battery charge time, namely: 1 second, 2 seconds, 3 seconds, 4 seconds and 5 seconds. Another parameter that was taken into account in the case of these tests was the pump element power pressure. The power pressure values used during the tests were 2,5 MPa, 5 MPa, 7,5 MPa, 10 MPa and 12 MPa.

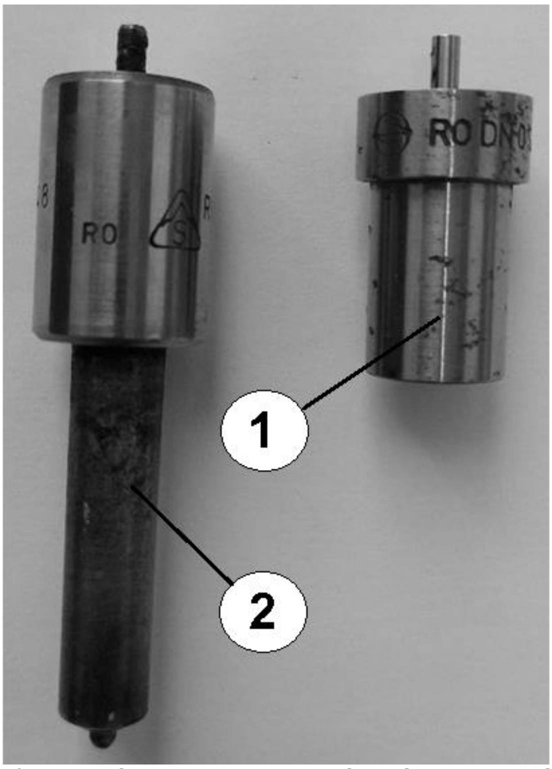

Figure 4 **Injector sprayers used on the test stand**
1- Type A sprayer; 2 sprayer – Type B.

The measurement of the amount of fuel passing through the sprayer, for the preset values of the capacitor bank capacity, its charging time and the pump element supply pressure, was made by collecting in the graduated cylinder the quantities of fuel sprayed in 100 consecutive tests.

In the case of tests carried out with the Type 1 electromagnet, the results are shown in *table 1*, and for those carried out with the Type 2 electromagnet, are shown in Table 2.

From the data in Table 1, it is noted that a capacitor bank charge time of more than 2 seconds does not affect the amount of fuel sprayed by the injector.

It is also noted that for the power pressures of the pump element with values of 2,5 MPa and 5 MPa and for capacitor battery charging times of more than 2 seconds, the quantities of fuel sprayed by the injector are maintained at the same value.

The largest quantities of fuel sprayed by the injector were obtained for the pressure value, 12MPa pump element supply and capacitor battery charging times of more than 2 seconds.

For most pump element power pressure values and capacitor battery charging times of more than 3 seconds, it is noted that the capacitor bank capacity value does not affect the amount of fuel sprayed by the injector.

And in the case of the data in *table 2*, it is noted that a capacitor bank charge of more than 2 seconds does not affect the amount of fuel sprayed by the injector.

Also, for capacitor battery charge time values of more than 2 seconds, the capacitor battery capacity value does not affect the amount of fuel sprayed by the injector.

In the case of *table 2*, it is also noted that the largest quantities of fuel sprayed by the injector were obtained for the pressure value, the power of the pump element, of 12MPa.

Comparing Table 1 with Table 2, it is noted that in the case of the use of the Type 2 electromagnet the quantities of fuel sprayed by the injector are higher than in the case of the use of the Type 1 electromagnet.

Table 1

Quantities of fuel, in millilitres, passing through the Type B sprayer, when using the Type 1 electromagnet

Power pressure (MPa)	Capacitor bank capacity (μF)	Capacitor battery charging time (s)				
		1	2	3	4	5
2.5	1000	4.0	4.0	4.0	4.0	4.0
	2000	2.0	4.0	4.0	4.0	4.0
5.0	1000	3.6	4.0	4.0	4.0	4.0
	2000	2.0	4.0	4.0	4.0	4.0
7.5	1000	3.2	5.0	5.0	5.0	5.0
	2000	2.0	4.0	4.0	4.0	4.0
10.0	1000	3.2	6.0	7.0	7.0	7.0
	2000	4.0	7.0	7.0	7.0	7.0
12.0	1000	4.0	7.0	8.0	8.0	8.0
	2000	4.0	8.0	8.0	8.0	8.0

Table 2

Quantities of fuel, in millilitres, passing through the Type B sprayer, when using the Type 2 electromagnet

Power pressure (MPa)	Capacitor bank capacity (μF)	Capacitor battery charging time (s)				
		1	2	3	4	5
2.5	1000	4.0	6.0	6.0	6.0	6.0
	2000	4.0	6.0	6.0	6.0	6.0
5.0	1000	7.0	8.0	8.0	8.0	8.0
	2000	6.0	8.0	8.0	8.0	8.0
7.5	1000	9.0	9.0	10.0	10.0	10.0
	2000	9.0	10.0	10.0	10.0	10.0
10.0	1000	12.0	12.0	12.0	12.0	12.0
	2000	12.0	12.0	12.0	12.0	12.0
12.0	1000	14.0	14.0	14.0	14.0	14.0
	2000	14.0	14.0	14.0	14.0	14.0

In the case of the supply pressure of 12 MPa and for the value of the capacitor battery capacity of 2000 μF this increase is 42.8%.

Another aspect that was followed during the tests was related to the quantities of fuel sprayed by the injector when using the two types of sprayers (Type A and Type B).

The opening pressure for the Type A spray injector is 12 MPa and for the Type B spray injector is 13 MPa.

Table 3 shows the results of the tests with these types of sprayers.

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According to this table, both types of sprayers spray fuel within the same limits (between 4 and 14 millilitres for 100 consecutive cycles).

The amount of fuel sprayed through the Type B sprayer is less influenced by the capacitor battery charge time than in the case of the Type A sprayer for pump supply pressures between 2.5 and 10 MPa.

Table 3

Quantities of fuel, in millilitres, passing through the Type A sprayer and type B sprayer, in the case of the use of the Type 2 electromagnet,

Power pressure (MPa)	Capacitor bank capacity (μF)	Injector sprayer type	Capacitor battery charging time (s)				
			1	2	3	4	5
2.5	1000	Type A	4.0	4.0	5.0	5.0	6.0
		Type B	4.0	6.0	6.0	6.0	6.0
	2000	Type A	4.0	6.0	8.0	8.4	8.4
		Type B	4.0	6.0	6.0	6.0	6.0
5.0	1000	Type A	6.0	6.0	6.0	7.0	7.0
		Type B	7.0	8.0	8.0	8.0	8.0
	2000	Type A	4.0	6.0	8.4	8.4	8.4
		Type B	6.0	8.0	8.0	8.0	8.0
7.5	1000	Type A	7.0	7.0	8.0	8.0	8.0
		Type B	9.0	9.0	10.0	10.0	10.0
	2000	Type A	6.0	8.0	10.0	10.0	10.2
		Type B	9.0	10.0	10.0	10.0	10.0
10.0	1000	Type A	8.0	8.0	10.0	10.0	10.0
		Type B	12.0	12.0	12.0	12.0	12.0
	2000	Type A	10.0	10.0	12.1	12.0	12.0
		Type B	11.0	12.0	12.0	12.0	12.0
11.5	1000	Type A	10.0	10.0	10.0	10.0	10.0
	2000	Type A	14.0	14.0	14.0	14.0	14.0
12.0	1000	Type B	14.0	14.0	14.0	14.0	14.0
	2000	Type B	14.0	14.0	14.0	14.0	14.0

For maximum test pressures, the battery charge time of capacitors does not affect the amount of fuel sprayed by the sprayer.

It is noted that for power pressures of the pump element, greater than 5 MPa and for capacitor battery charging times greater than 2 seconds, the amount of fuel sprayed is no longer influenced by the battery charging time of the capacitors.

It is also noted that for power pressures greater than 2,5 MPa and for the value of the battery capacity of 1000 μF accumulators, the quantities of fuel sprayed by the Type B sprayer are greater than those sprayed by type A.

For the value of the 2000 µF capacitor bank capacity, for charging times greater than 2 seconds and for power pressures greater than 5 MPa, both types of sprayers behave the same way.

CONCLUSIONS

The preliminary tests carried out using the test stand in Figure 1 show the following conclusions:

- the proposed method for the electrical control of the diesel injection corresponds to the intended purpose;
- the prototype pum element made corresponds to the intended purpose
- the proposed method allows a cyclic dose necessary for the operation of a compression-ignition engine;
- the proposed method allows the amount of fuel sprayed by the injector to be modified;
- increasing the supply pressure of the pump element leads to an increase in the amount of fuel injected;
- the charging time of the capacitor bank does not affect the amount of fuel injected by the sprayer at a pressure of 11.5 and 12 MPa;
- the charging time of the capacitor bank does not affect the amount of fuel injected through the Type B sprayer at the supply pressure of the pump element, of 11,5 and 12 MPa;
- in the case of a type B sprayer at the supply pressure of the pump element, the capacity of the capacitor bank does not affect the amount of fuel injected through the sprayer;
- at the next stage of the tests, it is necessary to use an electromagnet that operates at a higher frequency, a capacitor bank to charge in a shorter time and a more evolved test stand.

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