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INFLUENCE OF FUEL POLLUTANTS ON OPERATING PARAMETERS OF CONTEMPORARY FUEL INJECTOR

Tomasz Osipowicz, Tomasz Stoeck, Wawrzyniec Gołębiewski

West Pomeranian University of Technology
Department of Automotive Engineering
Piastów Avenue 19, 70-310 Szczecin, Poland
tel.: +48 91 4494947
e-mail: tosipowicz@zut.edu.pl, tstoeck@zut.edu.pl,
wgolebiewski@zut.edu.pl

Abstract

Article describes the operation issues of contemporary injection systems of Diesel engines. Common-rail system has been used since 1997, and since then there has been a significant evolution in its construction. In this aspect, there are changes in generations of high-pressure injection pumps and fuel injectors as well as methods of steering them, but exploitation problems are the same.

The most prone to malfunction elements of the system are the fuel injectors. Their task is to distribute and to spray of the fuel in the combustion chamber of engine. Common Rail fuel injectors generate few injection dosages in the one work cycle. The rate of injection is depended on the design of the steering valve. One very important parameter of fuel injector is fuel injection delay time.

If the time from control start of fuel injector to begin injection is shorter then it causes generation of greater number of injection dosages. Pollutants in fuel in the form of various amorphous solids of the size an even few microns cause the decrease of operating parameters of injector, which adversely affects the operation of the engine. Article shows contemporary fuel injectors, the methods of their examination, the types of fuel pollutants and their impact on fuel injector work.

Keywords: *fuel injector, Diesel engine, Common Rail injection systems*

1. Introduction

Diesel engine fuel injectors are responsible for distribution and spray the fuel to combustion chamber. In recent years, compression-ignition (CI) engines have attracted particular attention owing to their dynamic development [1, 3, 10]. In 1997, a Common Rail (CR) fuel injection system, which evolving all the time, was introduced due to the standards referring to exhaust gas toxicity. The main advantages of CR system are division of injected fuel dose by electronic control of fuel injector operation and possibility to reach high fuel injection pressure at present up to 250 MPa [2, 4, 9, 12]. The intention is that the rate of modern engine fuel supply system development meets the rigorous standards through such an organisation of the process of air-fuel mixture combustion so that as little toxic substances as possible are emitted to the air by the engine at the lowest possible fuel consumption, preserving its basic operating parameters, such as power and torque. The most dangerous for correct work of Diesel injectors is polluted fuel [5, 6, 7]. Following factors such as Diesel oil composition and content of refined substances and pollution penetrate during production, the percentage content of Biodiesel and transportation process has influence on fuel pollution. Deposits and contaminates are affected on dosages and discharges of Diesel fuel injectors [8, 11].

2. Study objective

The purpose of research was an analysis of influence of fuel pollutants on operating parameters of Common Rail fuel injectors. Experiments have been made according to following methodology:

– initial test of tested fuel injector,
– disassembly of injector on spare parts,
– microscope analysis,
– assembly and adjustment of fuel injector,
– final test.

3. Characteristic of research object and workstation

Experiments have been made in special laboratory, which dealt with research and repair of fuel injection systems. Initial test of fuel injector has been made by using test machine STPiW 3 (Fig 1). It has consisted of injection dosage and discharge research and it has been examined organoleptic stream of injected fuel [5, 7]. By using testing machine has been plotted the operation characteristic of tested fuel injector. Injection dosage and discharge have been measured by test machine and it has been evaluated the visual condition of spare parts, responsible for injector correct work, by using microscope.

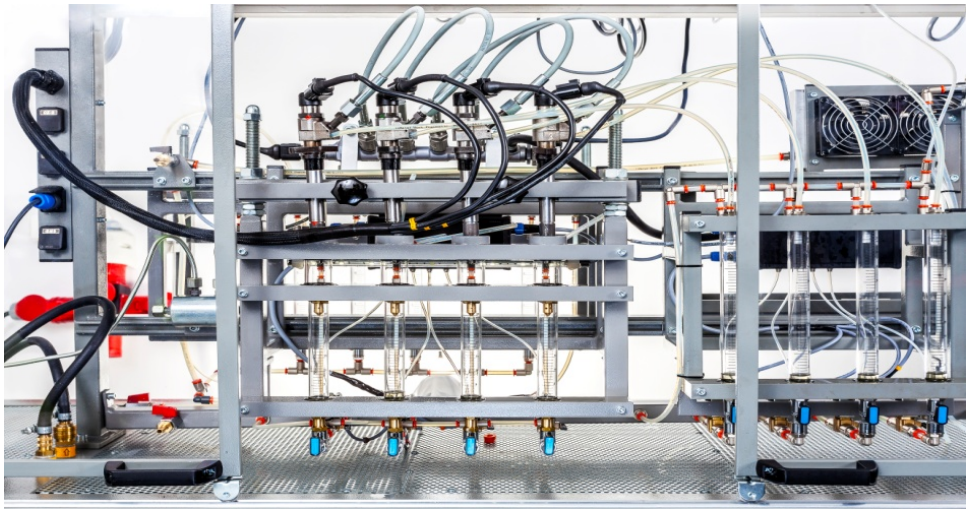

Fig. 1. Fuel injector test machine STPiW3

Analysis of subassemblies of researched fuel injector has been made by using stereoscopic microscope FL 150/70 equipped with the digital camera (Fig. 2).

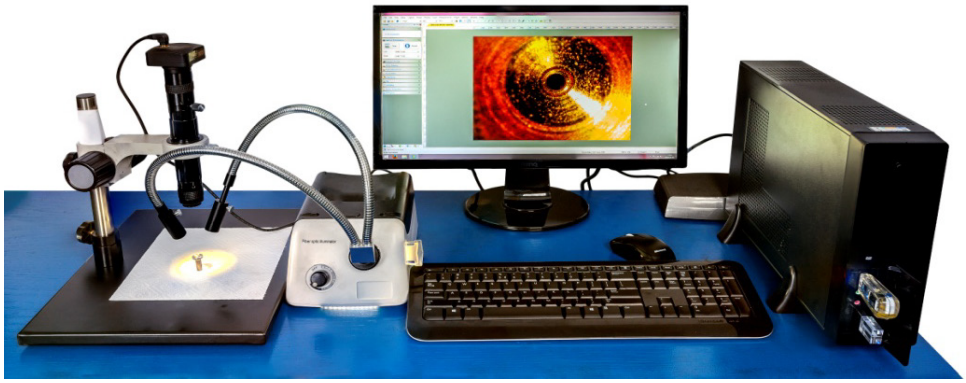

Fig. 2 Stereoscopic microscope used in laboratory researches

Disassembled fuel injector has been cleaned in ultrasonic washers (Fig. 3). Then, the injector has been assembled and adjusted using special instruments. CR valve adjustment has been made and it was the third phase of repair. In Fig. 4, it has been shown this stage of researches.

Fig. 3. Ultrasonic washers

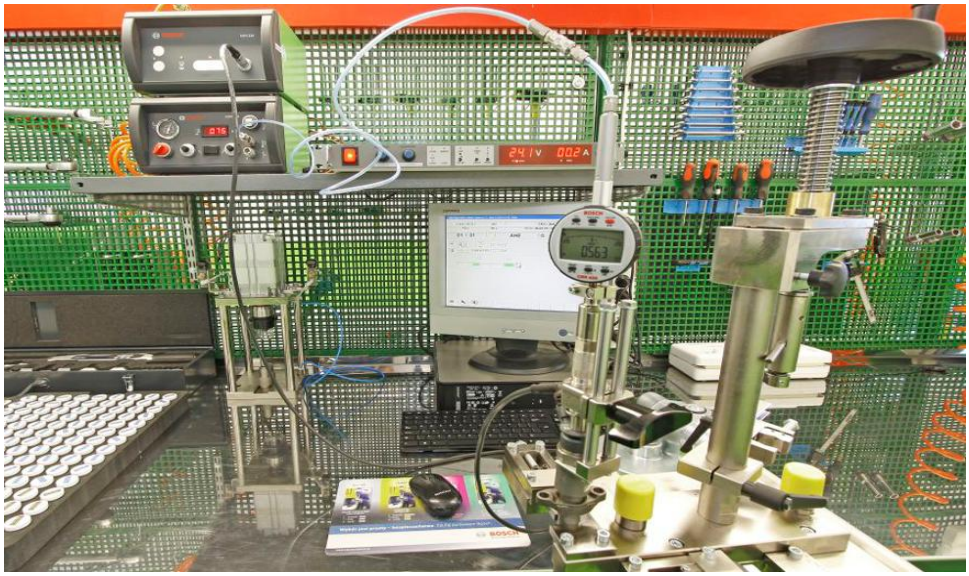

Fig. 4. Test stand for adjustment of electromagnetic valves of Common Rail Bosch injectors

Research object was the electromagnetical Bosch Common Rail injector with the number 0445110030.

4. Experiment results

The first phase of researches was initial test of fuel injector. In Tab. 1, it was presented the results of this stage of experiments [4].

Tab. 1. Results of initial test of researched fuel injector

No.	Injection pressure [MPa]	Injection time [µs]	Range [mm^3/H]	Injector Catalogue number	0445110030
1	145	60	0.00-0.00	Dosage	0.0
			0.00-72.00	Discharge	84.1
2	135	780	34.71-49.69	Dosage	35.6
			16.00-58.00	Discharge	65.3
3	30	420	0.31-3.89	Dosage	0.15
			0.00-58.00	Discharge	28.67
4	80	260	0.31-4.09	Dosage	0.47
			0.00-58.00	Discharge	47.98
Passed test					No

After initial test the fuel injector has been disassembled on spare parts and the most crucial elements responsible for operation has been evaluated by using microscope. In Fig. 5, it was presented the Common Rail injector valve.

In Fig. 6, it was presented the dirty precision couple of injector steering piston. This element responded on discharge.

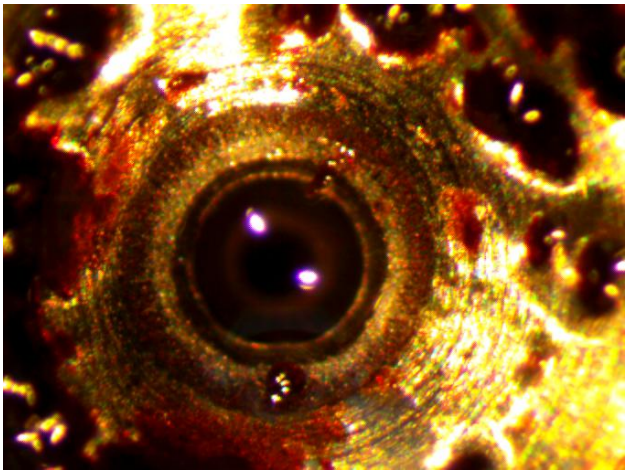

Fig. 5. Common Rail injector valve

Fig. 6. Steering piston of injector

In Fig. 7, it was presented damaged piston sealer of injector.

In Fig. 8, it was presented the contaminated precision couple of atomizer needle. There were many metallic fillings on this element, which originated from injection pump [6].

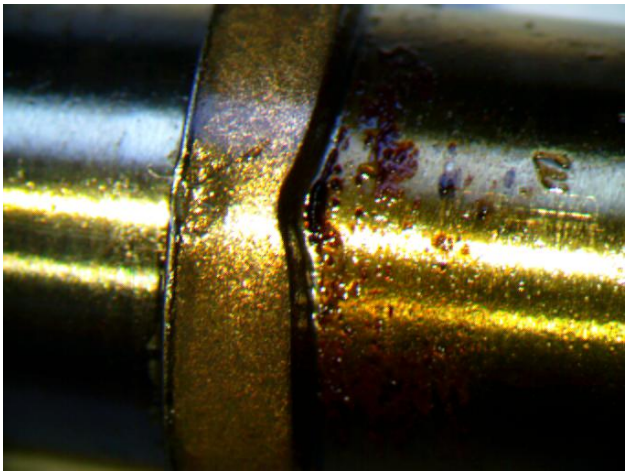

Fig. 7. Piston sealer of injector

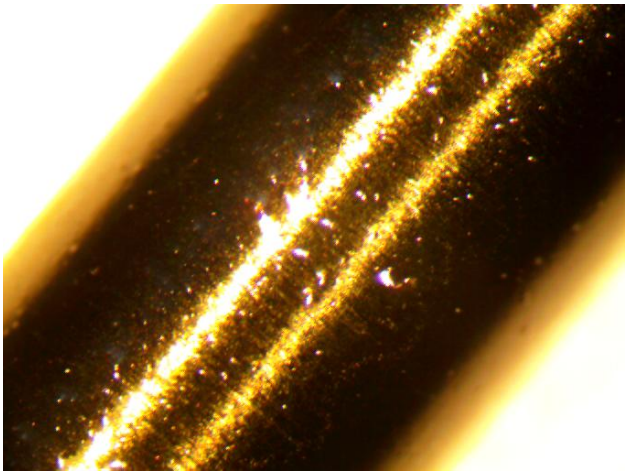

Fig. 8. Precision couple needle of injector

In Fig. 9, it was presented the conical sealing valve of the injector needle. There were some deposits and corrosion on this element originated from fuel [4].

It has been adjusted CR valve. Work range of valve had been set on 0.055 μm. The last phase of researches was the final test. Results of it have been presented in Tab. 2. In Fig. 10, it was presented the fuel injector operation characteristic. These are relations between dosages by various injection times and pressures.

5. Conclusions

The conducted analysis has shown that the tested fuel injector retained its operation parameters after cleaning, sealing and adjusting process. According to the pictures that have been made during

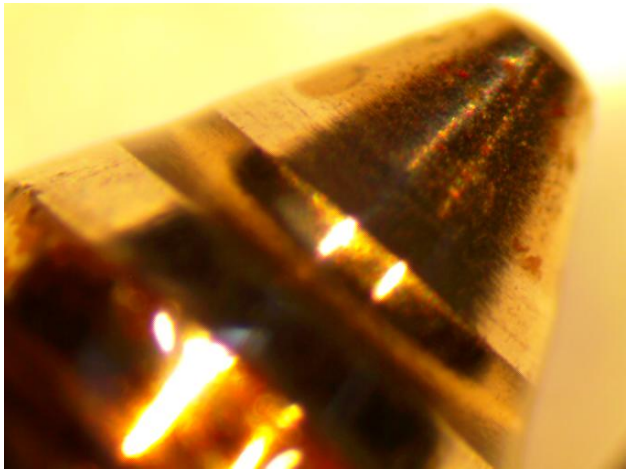

Fig. 9. Fuel injector needle

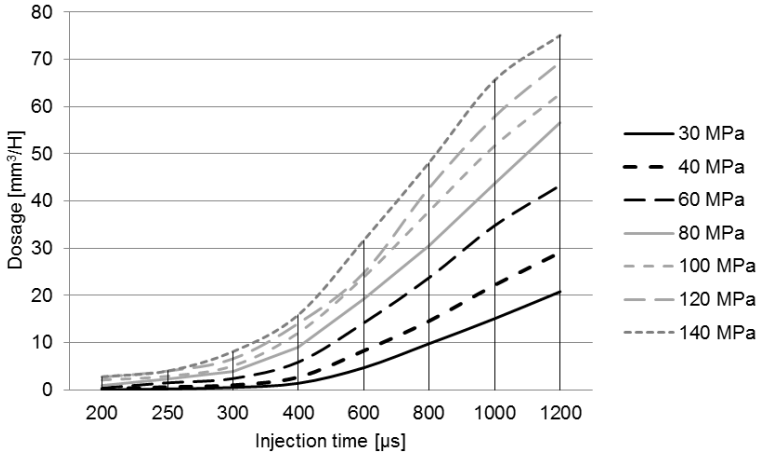

Fig. 10. Operation characteristic of tested injector

Tab. 2 Results of final test

No.	Injection pressure [MPa]	Injection time [µs]	Range [mm³/H]	Injector Catalogue number	0445110030
1	145			Dosage	0.0
			0.00-72.00	Discharge	43.1
2	135	780	34.71-49.69	Dosage	42.6
			16.00-58.00	Discharge	14.3
3	30	420	0.31-3.89	Dosage	2.26
			0.00-58.00	Discharge	15.08
4	80	260	0.31-4.09	Dosage	3.23
			0.00-58.00	Discharge	11.09
Passed test					Yes

microscope examination it was shown low use and huge contamination of steering valve and precise vapour elements. Theoretically, these spare parts should be change for new. But finally, dosages and discharges tests showed that in spite of cavity use of spare parts injector had all work parameters correct. It has meant that it can be recognized as able to good working.

Worrying is fact that appeared the metal filings on piston surface of injector steering valve and precise vapour of atomizer needle. It meant that it has to be conducted the disassembly of whole injection system, dismantle and check high-pressure pump because the metal filings came from it.

One reason of faster injector's damages is the use of high-pressure pumps, which soiled whole injection system with the metal filings. Sometimes these filings are so small that fuel filter cannot stop them. The second reason of malfunction of fuel injectors are contamination and deposits inside [8]. These factors influence on magnitude doses, discharges, and quality of injector seals. Pollution gets to injector valve as well as precise vapour elements and changing its work parameters what influences on engine work. Especially piezoelectric injectors are very sensitive on it. Therefore whole injection system should be cleaned sometimes.

References

[1] Ambrozik, A., Ambrozik, T., Łagowski, P., *Fuel impact on emissions of harmful components of the exhaust gas from the CI engine during cold start-up*, Maintenance and Realiability, Vol. 17, No 1, pp. 95-99, 2015.

[2] Idzior, M., Borowczyk, T., Karpiuk, W., Stobnicki, P., *Możliwości badania stanu technicznego nowoczesnych wtryskiwaczy silników o zapłonie samoczynnym*, Logistyka, Nr 3, pp. 933-942, 2011.

[3] Jankowski, A., *Reduction Emission Level of Harmful Components Exhaust Gases by Means of Control of Parameters Influencing on Spraying Process of Biofuel Components for Aircraft Engines*, Journal of KONES 2011, Vol. 18, No 3, pp. 129-135, Warsaw 2011.

[4] Kuszewski, H., Ustrzycki, A., *Metodyka diagnozowania wtryskiwaczy układu Common Rail z wykorzystaniem stołu probierczego EPS 815*, X Słupskie Forum Motoryzacji. Innowacje w motoryzacji a ochrona środowiska, pp. 243-252, Starostwo Powiatowe w Słupsku, 2007.

[5] Osipowicz, T., *Influence biodiesel on operating Common Rail systems*, Autobusy. Technika, Eksploatacja, Systemy Transportowe, Nr 6, pp. 210-213, 2014.

[6] Osipowicz, T., *Diagnosing Common Rail fuel injectors using fuel micro-doses*, TEKA. Commission of Motorization and Energetics in Agriculture, Vol. 15, No. 1, pp. 61-64, 2015.

[7] Osipowicz, T., *Testing of Modern Fuel Injections Pumps*, TEKA. Commission of Motorization and Energetics in Agriculture, Vol. 15, No. 1, pp. 57-60, 2015.

[8] Osipowicz, T., Kowalek, S., *Evaluation of modern Diesel engine fuel injectors*, TEKA. Commission of Motorization and Energetics in Agriculture, Vol. 14, No. 3, pp. 83-88, 2014.

[9] Sowa, K., Zabłocki, M., Jankowski, A., Sandel, A., *Engine and laser researches of novel injector with varied cross section nozzle for performance improvement*, Journal of KONES, Vol. 11, No. 3-4, pp. 195-217, Warsaw 2004.

[10] Sowa, K., Zabłocki, M., Jankowski, A., Sandel, A., *An investigations of varied cross section nozzle of injector of Diesel engines for performance improving and toxic exhaust gases emission reducing*, Vol. 7, No. 3, pp. 255-262, Warsaw 2004.

[11] Stoeck, T., Osipowicz, T., Abramek, K., *Methodology for the repair of Denso Common Rail solenoid injectors*, Maintenance and Reliability, Vol. 16, No. 2, pp. 270-275, 2014.

[12] Żurek, J., Jankowski, A.: *Experimental and Numerical Modelling of Combustion Process of Liquid Fuels under Laminar Conditions,* Journal of KONES, Vol. 21, No. 3, s. 309-316, Warsaw 2014.