ECONTECHMOD. AN INTERNATIONAL QUARTERLY JOURNAL – 2016, Vol.5, No.4, 79-84

RESEARCH INTO ELECTRONIC CONTROL SYSTEMS EDC

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Received November 21.2016: accepted December 22.2016

Abstract. The article present proposed diagnostic procedures of the EDC 1.2.9 system made it possible to carry out tests and compare the results with the results provided by the manufacturer. As part of the research prior to diagnostic tests, verification tests of Siemens and Bosch pumps were carried out. Experimental study, test procedures making it possible to check particular elements of the EDC system were developed. The developed research program included the fuel system and tests were conducted for: the air intake system, engine sensors, vehicle sensors, the exhaust fumes emission system, transmitters and system elements on the controller connection. The second system, which was subject to experimental testing, was the injection system Common Rail (CR), on which tests of three sets of injectors were conducted. The following values were recorded: engine rotational speed, driver injection dose, pre-injection time, fuel dose in the main injection, fuel dose correction, the adjustment of idle running for the first, second, third and fourth cylinder. The conducted diagnostic tests make possible to predict the state of particular EDC systems reliability.

Key words: electronic diesel control, common rail, injection dose, diesel fuel pump.

INTRODUCTION

The electronic control system EDC (Electronic Diesel Control) meets high demands which modern injection systems face. Unlike in vehicles with diesel engines equipped with conventional row or distributor injection pumps, in the EDC system the driver has no direct influence on the dose of the injected fuel, e.g. by pressing the accelerator pedal cooperating with the pump through the pull system.

The appropriate injection dose is calculated by the system on the basis of the obtained information, e.g. about the state of engine work, the decision of the driver, the emission of exhaust fumes etc. The concept of safety realized by the system consists in identifying common errors and introducing appropriate corrections, e.g. reducing torque or emergency operation in idle running rotational speed. The electronic system of engine control also enables exchanging data with other electronic systems of the vehicle (with the ASR system and the system of gearbox electronic control) for the purpose of increasing driving comfort and safety [7, 8, 9, 13, 16].

THE ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

Modern engines have to meet increasingly strict standards concerning the reduction in the emission of harmful fuel components and noise. This means higher requirements concerning the electronic injection system EDC and its regulation:

- high injection pressure,
- shaping the course of injection,
- variable injection start,
- variable injection advance,
- adjusting injection dose, charge pressure and injection start to each state of engine work,
- starting dose adjusted to temperature,
- regulation of idling rotational speed independent of load,
- driving speed control,
- controlled exhaust fumes recirculation,
- preserving small tolerances and high precision of engine parts [3-5].

Signals from sensors are fed to the EDC controller by the following circuits:

- analog input signals, information from analog sensors concerning the amount of sucked-in air, pressure, engine temperature, sucked-in air temperature, battery voltage; they are converted into digital values in the microprocessor of the controller;
- digital input signals, impulses of Hall generator rotational speed, which can be processed directly in the microprocessor;
- pulse input signals from induction sensors with information about rotational speed, positions or references, which are prepared in a part of the driver electric circuit for the purpose of removing interference, and converting them into square-wave signals.

Final elements of the EDC are protected against fault to frame, higher battery voltage as well as damage due to current overload. The occurrence of this type of damage and interruptions in circuits is recognized by final elements and transmitted to the engine controller. Selected input signals of the controller are also transmitted to other systems.

The diagnostic system included in the controller is one of the basic electronic blocks of engine control. In addition to self-diagnostics, the driver supervises input and output signals as well as the communication between controllers [1, 2, 15, 17, 20, 25, 32].

Damages which cannot be detected by the board diagnostic system can be located by means of control measurements. These additional functions of the system diagnostics are built into the engine EDC controller or into a diagnostic tester and may be carried out by means of a diagnostic tester.

Measurements of basic electric values such as current, voltage and resistance can be performed with the use an all-purpose gauge or a diagnostic device. The use of an oscilloscope can make it possible to perform the verification of signals for regulator units. This is particularly important for regulator units which have not been programmed in the diagnostic block. Diagnosing increases the control of sensors and steering regulator units.

VERIFICATION OF COMMON RAIL SYSTEM ELEMENTS

As part of the research prior to diagnostic tests, verification tests of Siemens and Bosch pumps were carried out. The most common damages to the pumps are caused by the pollution of fuel. After dismantling, one can observe the damaged parts which were affected by corrosion, such as pressure sections, the shaft, the cam. Such damages occur when fuel polluted by a small amount of acids is used.

Damages, which occur most frequently, include:

1 - Damages to section valves,

2 - Damages to sections that are subject to blocking or uneven wear (Fig. 1),

3 - Damage to the pump housing (Fig. 2),

4 - Damages to the shaft as a result of friction, visible grooves (Fig. 3),

5 - Damage to the section cover, microcracks occur,

6 - Damage to the roller (Fig. 4).

Fig.1. Damage to the pressure section – uneven wear

Fig.2. Damage to the pump housing – indentation visible

Fig.3. Damage to the shaft – grooves visible

Fig.4. Surface damage to the roller – deformation visible

EXPERIMENTAL STUDY EDC SYSTEM

As part of the experimental study, test procedures making it possible to check particular elements of the EDC system were developed. The subject of the study was the EDC 1.2.9 system (wiring diagram – Fig. 6) mounted on the test bench (Fig. 5).

The developed research program included the fuel system and its results are presented in Table 1. Tests were conducted for: the air intake system, engine sensors, vehicle sensors, the exhaust fumes emission system, transmitters and system elements on the controller connection.

The second system which was subject to experimental testing was the injection system Common Rail (CR) shown in Fig. 7, on which tests of three sets of injectors were conducted. The following values were recorded with the use of the KTS 500 device: engine rotational speed, driver injection dose, pre-injection time, fuel dose in the main injection, fuel dose correction, the adjustment of idle running for the first, second, third and fourth cylinder. By varying rotation speed from 800 rpm. to 1600 rpm, particular values shown in Table 2 were recorded, and on the basis of them, the characteristics of fuel dose in the main injection (Fig. 8) and in the drive injection (Fig.9) were determined. The examined injectors have an efficient electromagnetic coil, which can be recognized by characteristic chirring. Only in one of them injection was observed, and in the other three the fuel dose was directed to a spill.

Fig.5. Test bench for testing the EDC system (1-battery, 2-controller engine, 3-fuel tank, 4-pump drive motor, 5- speed control system, 6- elements of the electronic control, 7-injection pump and fuel injectors)

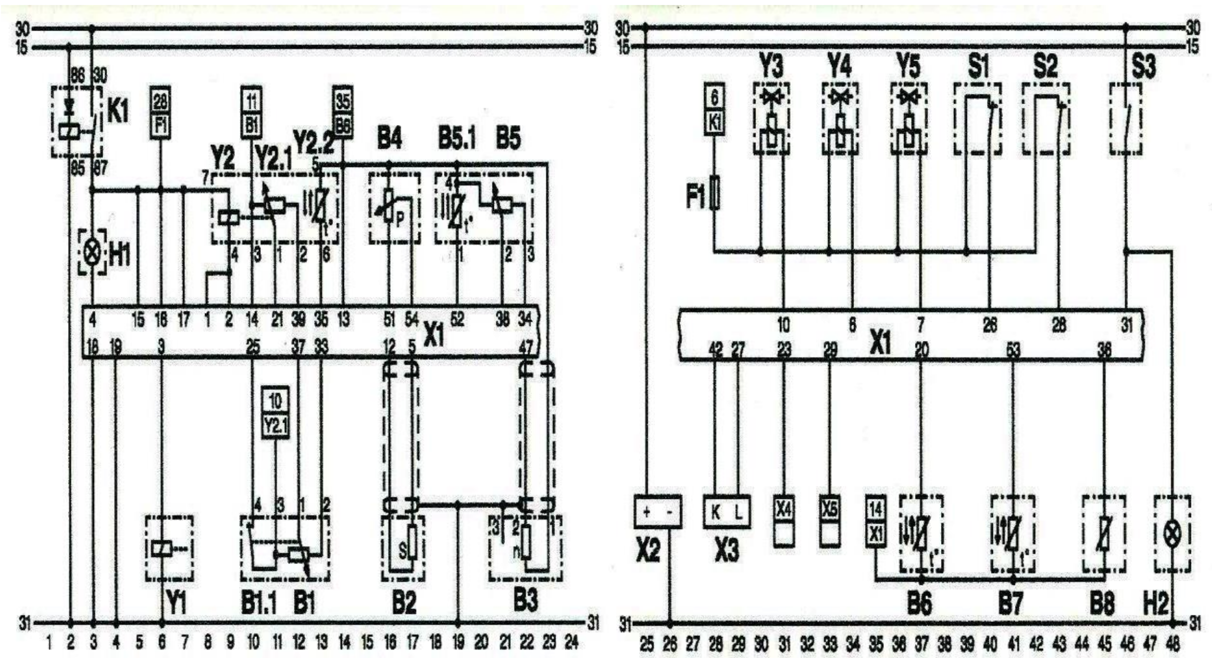


Fig.6. Diagram of the EDC wiring system. K1 - main transmitter, H1 - diagnostic light, Y1 - stop solenoid valve, Y2 - electromagnetic adjuster of fuel dose, Y2.1 – batcher position sensor, Y2.2 - fuel temperature sensor, B1 / B1.1 - accelerator lever position sensor, B2 - needle lift sensor, B3 - speed sensor, B4 - charge pressure sensor, B5 - air flow meter, B.5.1 - air temperature sensor, X1 - engine controller, X2 - power connector of the diagnostic device, X3 - diagnostic connector, F1 - fuse 10A, Y3 – solenoid valve of the injection start, Y4 - EGR solenoid valve, Y5 - solenoid valve of pressure charge regulation, S1 - brake switch 1, S2 - clutch switch, S3 - brake switch 2, B6 - air temperature sensor, B7 - engine temperature sensor, B8 - liquid level sensor, H2 - stop light switch

Table 1. Table presenting measurement results of the fuel system

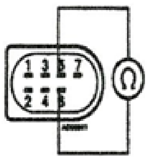
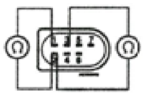
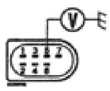
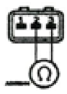
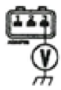
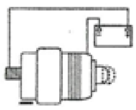
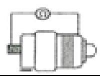
1- fuel system			
Element of the system	No. pin	State check	Measurer indication
Fuel temperature sensor 	5-6	0°C	6kΩ
	5-6	10°C	
	5-6	20°C	
	5-6	40°C	
	5-6	60°C	
	5-6	70°C	
	5-6	80°C	0,25kΩ
Batcher position sensor 	1-3		1.5KΩ
	2-3		2.5KΩ
Fuel batcher 	5-ground	Ignition on	11.5V
Adjuster injection start 	2-3		17Ω
Adjuster injection start 	3-ground	Ignition off	11.5V
Cut off fuel supply solenoid valve 		Battery connected	Open valve
		Battery in-connected	Close valve
Cut off fuel supply solenoid valve 			8Ω

Table 2. Measurement results of the first set of injectors

values	recorded values			
engine rotational speed	800 rpm	1000 rpm	1200 rpm	1600 rpm
drive injection dose	43 mg/H	35 mg/H	35 mg/H	30 mg/H
pre-injection time	0,0 ms	0,0 ms	0,0 ms	0,0 ms
fuel dose in the main injection	431 mg/H	433 mg/H	435 mg/H	440 mg/H
start main injection	0,6 Crank.S	0,7 Crank.S	0,9 Crank.S	1 Crank.S
fuel dose correction, adjustment of idle running, 1 cylinder	-0,3	-0,3	-0,2	-0,3
fuel dose correction, adjustment of idle running, 2 cylinder	0,1	0,1	0,1	0,1
fuel dose correction, adjustment of idle running, 3 cylinder	0,1	0,1	0	0,1
fuel dose correction, adjustment of idle speed running, 4 cylinder	0,1	0,1	0,1	0,1

Fig. 7. Test bench for simulating the work of the EDC system

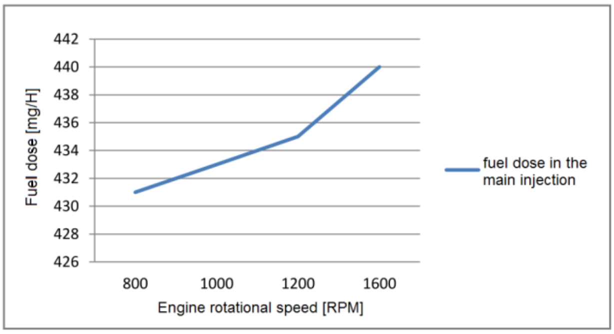


Fig.8. Fuel dose in the main injection

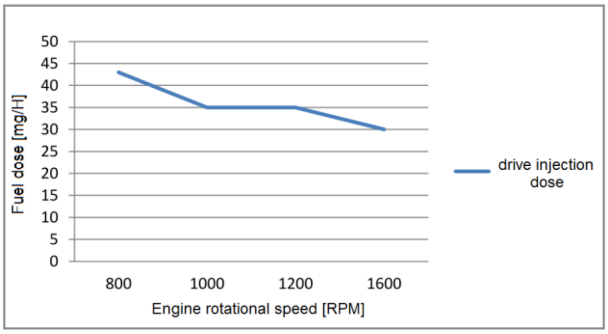


Fig.9. Drive injection dose

CONCLUSIONS

A part of experimental studies of the EDC system was verification analysis carried out by dismounting a high pressure pump which made it possible to identify the most frequent damages to the control system elements shown in the figures.

The proposed diagnostic procedures of the EDC 1.2.9 system made it possible to carry out tests and compare the results with the results provided by the manufacturer. The conducted simulation of damages to electronic elements facilitated the identification of error codes by means of the diagnostic equipment KTS 500 from Bosch. In the course of research, the developed bench enables checking the parameters of other pumps thanks to the universal mounting and the adjustment of the driving engine rotational speed with the use of the inverter.

The conducted study of the Common Rail system made it possible to determine the characteristics of injectors for the fuel dose in the main injection and the drive injection dose at variable engine rotational speed.

The designed and prepared test bench makes it possible to simulate the work of the speed sensor, the camshaft position sensor and determines the impact of particular signals on the parameters of the system. The complete installation of the connections of sensors and driver elements with the controller of the CR system facilitated the observation and simulation of the full diagnostic process and the verification with the theoretical model.

The conducted diagnostic tests preceded by the verification and analysis of the signs of wear after dismantling the pumps and injectors make it possible to predict the state of particular EDC systems reliability.

REFERENCES

1. **Artyukh A., Sidorov M., 2014.** Mathematical modeling and numerical analysis of nonstationary plane-parallel flows of viscous incompressible fluid by R-functions and Galerkin method. ECONTECHMOD. An international quarterly journal, Vol. 3. No. 3, 3-11.

2. **Bochenski C., Mruk R., 2002.** Diagnostic processes of Common Rail unit based on computer systems. Diagnostics, Vol. 27, 11-16.
3. **Bosch R., 2009.** Common Rail injection system, Transport and Communication Publishers. Warsaw.
4. **Bosch R., 2009**. Common Rail accumulated injection system. Transport and Communication Publishers. Warsaw.
5. **Brzezanski M., 2010.** New standards for emissions in self-ignition engine – VW 2.0 TDI engine. Combustion Engines, No. 1, 57-63.
6. **Czech P., 2013.** Application of probabilistic neural network and vibration signals for diesel car engine fuel injectors damage. Scientific Papers of Silesian University of Technology, Transport Series. Vol. 81, 25-30.
7. **Dziubinski M., 2004.** Examination of Automobile Electronic Equipment, Scientific Publishing Gabriel Borkowski, Lublin.
8. **Dziubinski M., 2003.** Automobile electronic systems. Scientific Publishing Gabriel Borkowski, Lublin.
9. **Gautier C., Sename O, Dugard L., Meissonnier G., 2007.** An LFT Approach to H Control Design for Diesel Engine Common Rail Injection System, Oil & Gas Science and Technology, Rev. IFP. Vol. 62, No. 4, 513-522.
10. **Gladysek J., Gladysek M., 2009.** Repair of Common Rail injectors. Auto Moto Service. No. 10.
11. **Gladysek J., Gladysek M., 2009.** Evaluation of Common Rail injector. Auto Moto Service. No. 9.
12. **Gunther H., 2014.** Common Rail injections system in practice workshop. Transport and Communication Publishers, Warsaw.
13. **Gunther H., 2009.** Diagnostics of Diesel engine. Transport and Communication Publishers, Warsaw.
14. **Idzior R., Borowczyk T., Karpiuk W., Stobnicki P., 2011.** The feasibility research of a technical condition of modern injectors for compression ignition. Logistics. N3.
15. **Ignaciuk P., L. Gil., 2014.** Damages to injectors in Diesel engines. Advances in Science and Technology Research Journal. Vol. 21, No. 8, 58-61.
16. **Janiszewski T., 2010.** Mavrantzas Spiros, Electronics injection systems of Diesel engines. Transport and Communication Publishers, Warsaw.
17. **Karczewski M., Koliński K., 2011.** Diagnosis of injectors through common rail pressure measurement, Scientific Papers of the General Tadeusz Kościuszko Military Academy of Land Forces in Wroclaw, No. 1.
18. **Kech J., Willmann M., Gorse P., Boog M., 2011.** Common Rail fuel injection, key technology for clean and economical combustion.
19. **Konieczny Ł., Adamczyk B., Adamczyk G., 2015.** Diagnostics and regeneration of Common Rail injectors. Scientific Papers of Silesian University of Technology, Transport Series, Vol. 86, 65-73.
20. **Kovalyshyn O., Gabriel Yu., 2014.** Development of management systems model of automatic control by using fuzzy logic. ECONTECHMOD. An international quarterly journal, Vol. 3. No. 4, 87-90.
21. **Kuszewski H., Lejda K., Ustrzycki A., 2008.** Determinants of the fuel dosage accuracy in a dispenser supply system Common Rail, Technical magazine. Mechanics, Cracow University of Technology Publisher.
22. **Kuszewski H., Ustrzycki A., 2007.** The influence of working parameters of common rail system on a real fuel injection beginning. Combustion Engines, Vol. 46, 107-117.
23. **Lino P., Maione B., Pizzo A., 2007.** Nonlinear modelling and control of a common rail injection system for diesel engines. Applied Mathematical Modelling, Vol. 31, 1770–1784.
24. **Łukasiewicz M., Dobek S., Kałaczyński T., 2014.** The study of selected elements of the common-rail Diesel engine. Proceedings of Polish Association for Knowledge Management, No. 69, 141-155.
25. **Merkisz J., Mazurek ST., 2004.** Automobile on-board diagnostic systems. Transport and Communication Publishers, Warsaw.
26. **Osipowicz T., Abramek K., 2014.** Catalytic processing of the fuel injectors in the diesel engine, Szczecin.
27. **Osipowicz T., T. Stoeck., 2013.** Repair contemporary Diesel engine injectors. Buses: technology, exploitation, transport systems, Vol. 14, No. 10, 210-212.
28. **Stoeck T., T. Osipowicz, K.F. Abramek., 2014.** Methodology for the repair of Denso common rail solenoid injectors. Maintenance and Reliability, Vol. 16, No. 2.
29. **Ustrzycki A., Kuszewski H., 2006.** The study beginning fuel injection in Common Rail injection system. Materials XVII International Conference on. Computational Methods and Research in Development of Motor Vehicle and Heavy Machinery Self-propelled. Management and Marketing in the Automotive Industry. SAKON 2006, Rzeszow.
30. **Ustrzycki A., Kuszewski H., 2007.** The effect of temperature on fuel injected dose in the tank fuel injection Common Rail. Materials XVIII International Conference on. Computational Methods and Research in Development of Motor Vehicle and Heavy Machinery Self-propelled. Management and Marketing in the Automotive Industry. SAKON 2007, Rzeszow.
31. **Wierzbicki S., Smieja M., 2014.** Controlling the fuel feeding system in a self-ignition engine under fast-prototyping conditions using LabView, Measurement Automation Control, Vol. 60, No. 11, 1049-1052.
32. **Lut M., Mrachkovskyy A., Taran V., 2012.** Measuring equipment and software products in vibrodiagnostics. ECONTECHMOD. An international quarterly journal, Vol. 1, No. 1. 67-70.