ISSN: 1231-4005
e-ISSN: 2354-0133
DOI: 10.5604/12314005.1216387

DIAGNOSTICS OF MODERN DIESEL ENGINES ON THE EXAMPLE OF FIAT 1.3 JTD MULTIJET ENGINE

Konrad Prajwowski

West Pomeranian University of Technology in Szczecin
Faculty of Mechanical Engineering and Mechatronics
Department of Automotive Engineering
Piastów Avenue 19, 70-310 Szczecin, Poland
tel.: +48 914494045, fax: +48 914494820
e-mail: kprajwowski@zut.edu.pl

Abstract

Initially, electronic components replaced the mechanical ones to make various systems more reliable. Mechanical control systems, due to the wear of movable parts and imprecise adjustment, were affected by large errors, which are not shown by electronic circuits operating according to constant set-points. Then, a sharp increase in electronisation was associated with the tightening of exhaust gas emission regulations. Progress in some cases is forced by environmental protection, in other ones by market competition. Modern motor vehicles, slow moving vehicles, military vehicles, etc., are the technical systems being constructed using the latest developments in many fields of science, first of all in mechanics and machine engineering, electrical engineering, electronics, information technology, and chemistry. The rapid development of electronics has led to an increase in the number of electronic components in motor vehicles in all systems, starting with an engine, which has been modified first, to comfort and infotainment systems.

The paper presents example measurements of sensors and actuators of an engine with Common Rail fuel supply system on the example of Fiat 1.3 JTD MultiJet engine. The measurements were made using various diagnostic instruments, such as a diagnostic tester, a multimeter or an oscilloscope. Sometimes, the reading of error codes with a diagnostic tester itself is not enough and it is necessary to check the signal waveform with an oscilloscope, which has been presented in this paper.

Keywords: *engine diagnostics, sensor system, actuator system, oscilloscope signal waveforms*

1. Introduction

A modern car is the technical system being constructed using the latest developments in many fields of science, first of all mechanics and mechanical engineering, electric engineering, electronics, information technology, and chemistry [6].

An increase in the requirements for internal combustion engines and a dynamic development of electronics favour more and more extensive introduction of electronic control systems that use microprocessors. The availability of ever more powerful electronic processors resulted in the application of these systems in the systems that control various engine-operating parameters. An opportunity has developed to store the characteristics of changes in individual parameters according to many input data, and thus a multi-parameter optimisation of engine operation is possible. The implementation of numerous sensors in combination with high computing power of the on-board computer has allowed constant monitoring of engine operation and very early detection of possible failures [4].

2. Test object

As the test object, a Fiat 1.3 JTD MultiJet engine was chosen; it is an-in-line, four-cylinder, turbocharged, charge air cooled engine. The engine is equipped with high-pressure Common Rail electronic fuel injection system and is fully controlled by the control unit MJD 6JF. This test object is part of the equipment of the Department of Motor Vehicles Operation of the West Pomeranian University of Technology in Szczecin.

In order to carry out the tests in their adopted scope, the following diagnostic instruments were used:

- Multimeter – Brymen BM 338,
- Oscilloscope – Escort 328, Finest 1006,
- Diagnostic tester – Mega Macs 66.

The objective of this study was to present the methods and problems of diagnosing electronic devices using various instruments and, based on test results, to determine correct operation or malfunction of a given component, and to evaluate the capabilities of diagnostic instruments.

Fig. 1. A test object – 1.3 JTD MultiJet engine

3. Engine sensor and actuator systems

In the 1.3 JTD engine with Common Rail fuel injection system, its electronic control system underwent complexification. The controller collects information from a number of sensors, which refer, among others, to crankshaft speed, camshaft position, accelerator pedal position, intake air temperature, coolant temperature, etc., and, based on them, controls all engine parameters, optimising its performance and fuel consumption by responding in the real time to engine operation conditions.

The sensors being used in motor vehicles are to collect information about engine operation parameters and process this information into an electronic signal and provide it to the control unit. During the processing of physical quantities ϕ and chemical quantities into electrical quantities E, interference Y is being taken into account. As electrical quantities, not only current and voltage should be understood but also current and voltage amplitudes, electric oscillation pulse period, frequency and duration, inductance, resistance and capacitance [3].

There are two types of sensors – passive sensors and active ones. Passive sensors transmit an unchanged signal to the controller; therefore, they have only two electrical contacts. An example of such a sensor can be a rotational speed inductive sensor or a temperature sensor. On the other hand, a signal of active sensor is being transformed in the electronic system before it reaches the controller.

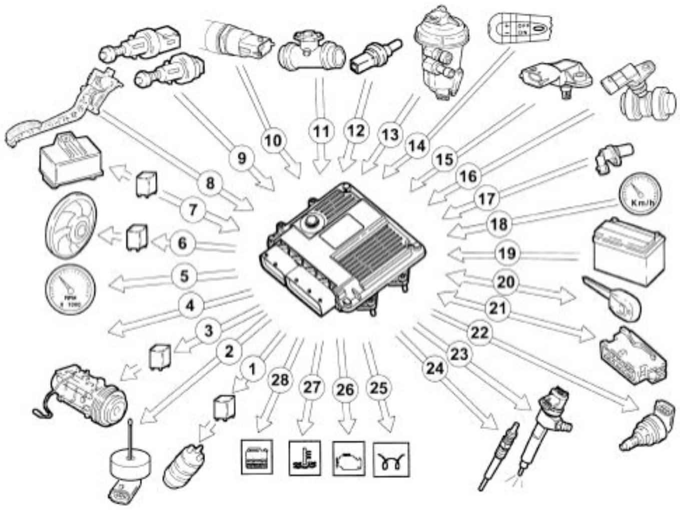

Fig. 2. Controller input / output information flow [8]: 1 – Additional electric fuel pump; 2 – Water in fuel sensor; 3 – Air conditioning compressor; 4 – EGR solenoid valve.; 5 – Revolution counter; 6 – Electric fan; 7 – Pre-heating glow plug control unit; 8 – Dual-path accelerator pedal potentiometer; 9 – Double brake pedal switch-clutch pedal switch; 10 – Fuel pressure sensor; 11 – Air flow sensor; 12 – Coolant temperature sensor; 13 – Fuel temperature sensor; 14 – Cruise control system; 15 – Turbo boost sensor; 16 – Phase sensor; 17 – RPM sensor; 18 – Speedometer; 19 – Battery; 20 – Fiat CODE (body computer); 21 – Diagnostic port socket; 22 – Fuel pressure regulator; 23 – Solenoid-controlled fuel injectors; 24 – Pre-heating glow plugs; 25 – Pre-heating glow plugs ON indicator light; 26 – Fuel injection indicator light; 27 – Maximum coolant temperature indicator light; 28 – Water in fuel indicator light

The sensors must provide high measuring accuracy and, besides, must be durable and be characterised by low costs of manufacture and operation. The required durability results from operation conditions, such as high and low temperature in the range of -40 to +140ºC, dirt, such as sand, dust, salt, water and operating liquids, vibration acceleration to 30 g, and high level of electromagnetic interference [5].

Based on the signals obtained from numerous sensors, the control unit controls the actuators being connected to it, running the following systems:
- fuel supply system,
- air supply system,
- glow plug pre-heating system,
- engine cooling system,
- fuel pre-heating system.

4. Diagnostics of electronic elements

The sensors and actuators in the controller surrounding are composed, among others, from resistors and inductors, which, from a measuring technique point of view, are well measurable by means of a universal meter, while in more difficult cases by means of an oscilloscope.

During the testing of a pre-heating glow plug, the resistance between the connection terminal and the metal housing should be measured as in the figure below. Prior to measurement, the pre-heating glow plugs should be thoroughly cleaned of rust, dirt, oil and paint.

The diagnostics of coolant temperature consists in the first place in checking the list of current parameters and comparing it with thermometer indications. If the sensor gives a false temperature, while a fault has not been recorded in the diagnostic memory, the voltages on the inserted sensor plug should be measured.

The measured value 0V means breaking the cable to the controller or the controller damage. The sensor and the cables to the controller can be also measured by measuring the resistance.

a) b)

Fig. 3. Measurement result: a – engine temperature, b – engine temperature sensor resistance

Often, the measurement of current or voltage, even with a high-class multimeter, is not sufficient and does not give a clear answer to the question about the status and operation of a tested device. With rapid changes in voltage and current, a multimeter is helpless because it makes only two to three measurements per second. To measure quick-changing signals or short-term interruptions being caused by loose contacts, an oscilloscope is needed. This is the more that there may be a pulse, alternating, deformed current. Then, there will be a need to observe the signal waveform using an oscilloscope.

The first stage of using an oscilloscope consists in the checking if a given component sends a correct signal. An example can be the Hall Effect sensor that operates as a sensor of camshaft speed and position. A square waveform of signal, with an amplitude similar to sensor supply voltage, should be expected. No such signal waveform is evidence of its damage. The engine with a damaged sensor cannot be started. On the other hand, if a damage occurs during engine operation, this will not stop it but it will not be possible to start it again [2].

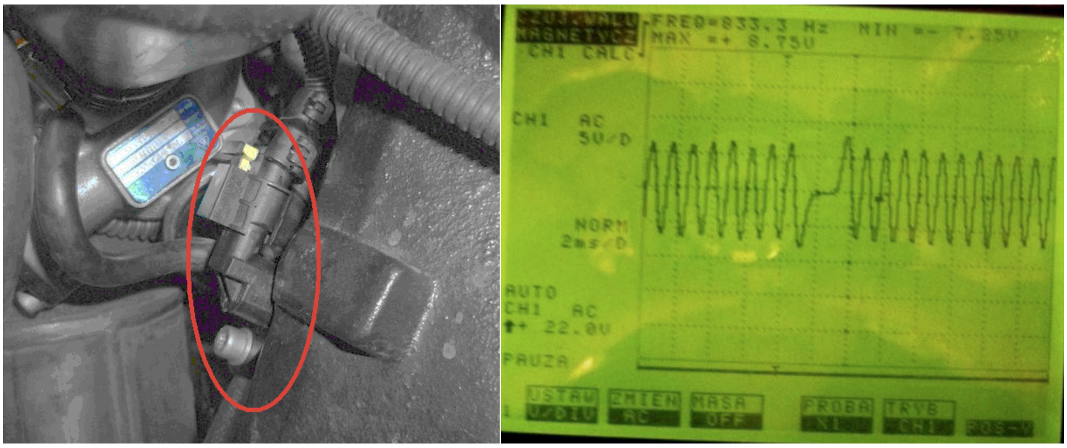

Fig. 4. A waveform of inductive sensor signal being obtained during test at idling

In order to verify the proper operation of the inductive sensor of crankshaft rotational speed, the following steps would be necessary to perform:

- checking the shape of teeth and air gap,
- visual control of the shape of sensor,

- measurement of the resistance of a sensor coil on the disconnected and switched off engine and then comparing the results with the manufacturer's data,
- checking the induced signal using an oscilloscope with the started engine at different ranges of its operation by measuring the frequency, voltage amplitude and signal stability and observing the shape of waveform and comparing them with the manufacturer's data.

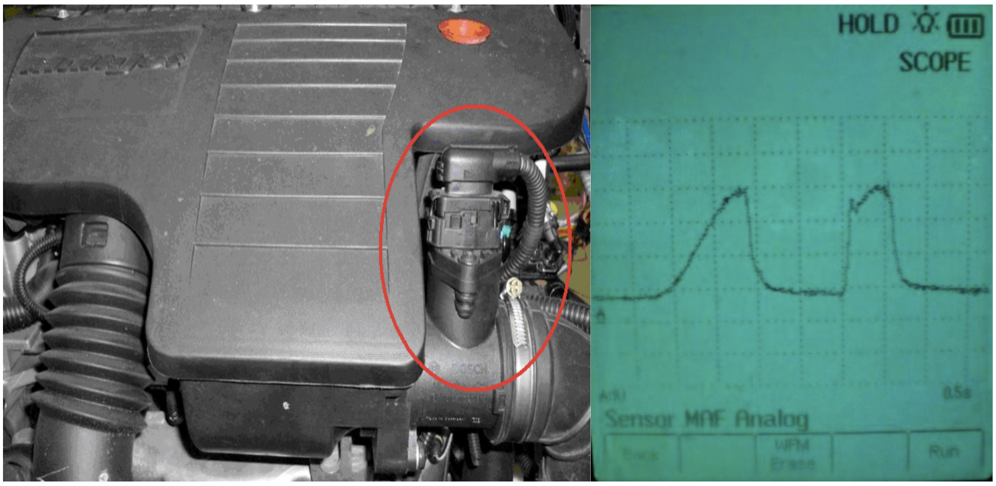

Fig. 5. An airflow sensor and its signal waveform during acceleration

The first test to which Common Rail fuel injectors are being subjected is the test of their electrical parameters. This can be done by using a multimeter with which the resistance or inductance of fuel injector can be measured.

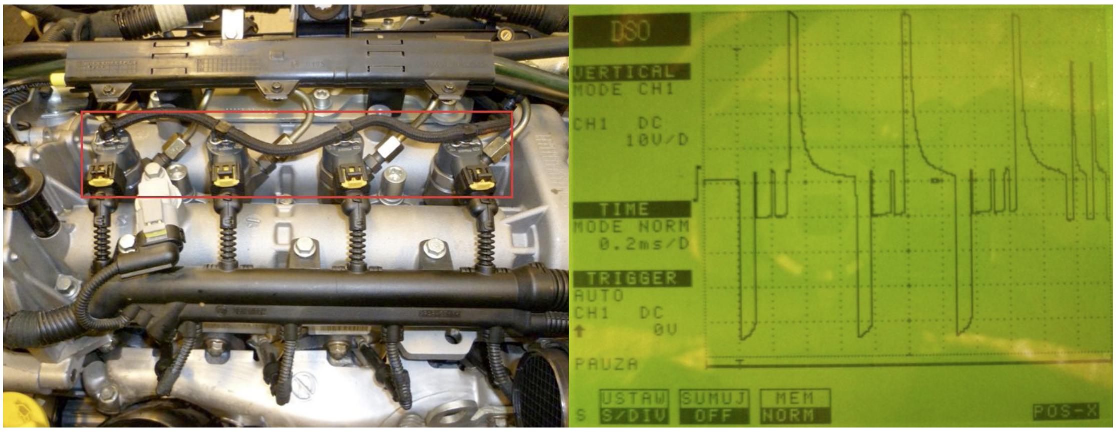

Fig. 6. Fuel injectors and their signal waveform

Regardless of the type of fuel injector, the resistance between electrical contacts and its casing should be infinitely high. Then, electric cables from the fuel injector to the controller are being checked whether they are not shorted to each other or are not shorted to ground. If the electrical parameters of fuel injector are appropriate and the electrical cables are in working order, there is only the controller left to be a possible cause of malfunction [7].

The diagnosing of a fuel pressure regulator can take place by connecting an oscilloscope to the regulator contacts and reading the value of its opening degree. During engine idling, it should amount to approximately 18-20%, while with engine being switched off to approximately 25%. Due to the fact that the fuel pressure sensor and the pressure regulator are in located in the fuel accumulator, they share a common parameter. Based on this, their values, in a certain range, should correspond to each other. To verify this, one can rely on the current parameters of engine operation [1].

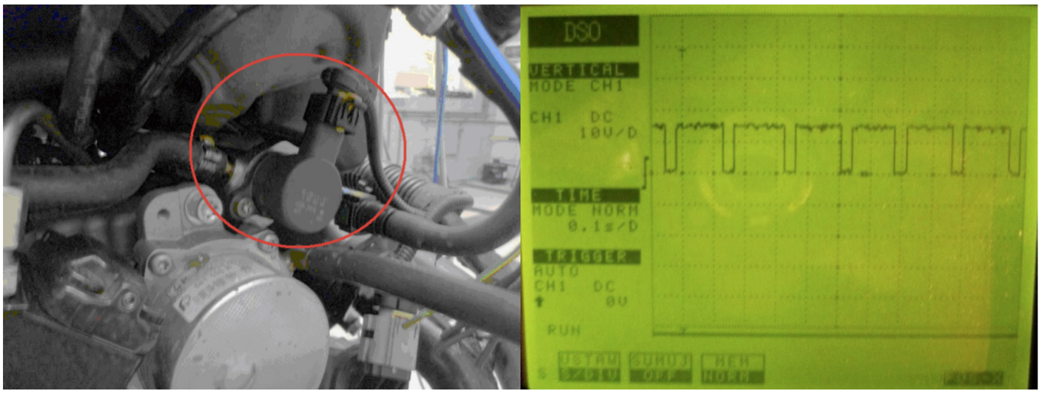

Fig. 7. A fuel pressure regulator and its signal waveform

The diagnostics of fuel pressure sensor was performed using an oscilloscope to illustrate the signal waveform under free acceleration while observing the pressure on a manometer with simultaneous monitoring of the current parameters of engine operation by means of a diagnostic tester. As a result, it is possible to check if the pressure being read by the engine controller from the fuel pressure sensor in the Common Rail accumulator is adequate to the actual one.

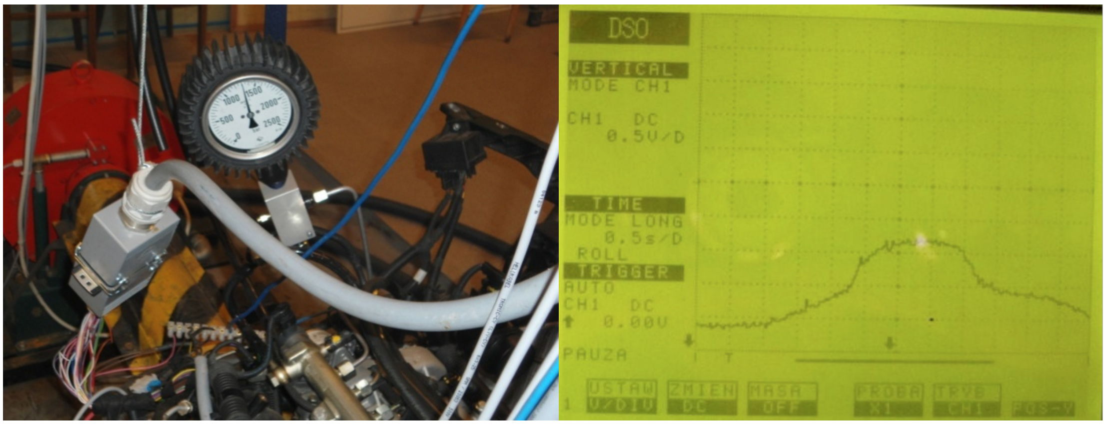

Fig. 8. Measurement of CR fuel pressure and a waveform of fuel pressure sensor signal

5. Conclusions

The main objective of the tests being presented in this paper was to present the methods of diagnostics and measurements of the sensor and actuator systems in order to look for their defects. Additionally, interpretation of some results of the tests was undertaken.

A multimeter was used only to measure the resistance of pre-heating glow plugs, engine temperature sensor, fuel temperature sensor and fuel heater sensor. In the case of pre-heating glow plugs ad fuel heater sensors, it was a sufficient measurement to determine their performance status. On the other hand, in the case of engine and fuel temperature sensors, it would be necessary to make several measurements at different temperatures. This would allow observing whether the resistance changes with temperature and whether this change is similar to the characteristics of a given sensor. An oscilloscope was used to diagnose the inductive sensor, Hall effect sensor, fuel pressure sensor, and intake manifold pressure sensor. It was also used to diagnose three actuators, i.e. an EGR valve, fuel pressure regulator and fuel injectors.

Using the Mega Macs 66 interface, it was checked whether error codes had been recorded in the controller's memory. Then, current parameters were observed. This function allows specifying whether the sensors generate correct signals. Finally, the test of actuators was performed which, in the case of the engine being tested, was limited to an EGR valve and a fan motor. During the test, the operation of these components was audible.

References

[1] Chmiel, D., *Diagnostyka układu zasilania common rail w silnikach ZS*, Auto Moto Serwis, 6, 2009.
[2] Bosch, *Czujniki w pojazdach samochodowych*, WKiŁ, Warszawa 2002.
[3] Dziubiński, M., *Elektroniczne układy pojazdów samochodowych*, Lublin 2003.
[4] Gajek, A., Juda, Z., *Czujniki*, WKiŁ, Warszawa 2009.
[5] Günther, H., *Układy wtryskowe Common Rail w praktyce warsztatowej*, WKiŁ, Warszawa 2010.
[6] Merkisz, J., Mazurek, S., *Pokładowe systemy diagnostyczne pojazdów samochodowych*, WKiŁ, Warszawa 2007.
[7] Myszkowski, S., *Diagnostyka czujnika ciśnienia absolutnego w kolektorze dolotowym silnika – cz. 1,* Auto Elektro, No. 100/02, 2009.
[8] Zembowicz, J., *Fiat Panda*, WKiŁ, Warszawa 2008.