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Analysis of Electrical Parameters of an Internal Combustion Engine to Determine the State of Its Efficiency and Ecological Level

P. Olszowiec, M. Luft & Z. Łukasik
University of Technology and Humanities in Radom, Radom, Poland

ABSTRACT: The article presents an analysis of research on a series of passenger vehicles equipped with diesel and spark-ignition engines of modern generation. These studies show the attempt to determine the consistency of the measurement results presented by the electrical motor with respect to the external direct measurements determining the level ecological driving unit such as a gas analyzer. The premise of this material is to assess the suitability of the read actual parameters sent by the ECU as the data source the level of organic vehicle, for example. The test for diagnostic station with annual regular reviews. The inspiration for the material was the attempt to determine the sensitivity of the self-diagnosis system of the propulsion unit, which correctness of the diagnosis itself is one of the criteria of the positive periodic test guidelines.

1 INTRODUCTION

Computer diagnostics is a field used to assess the technical condition of a vehicle. Using dedicated as well as universal diagnostic testers, it is possible to view the actual parameters of elements such as various types of sensors monitoring and supervising vehicle operation in various operating conditions. This allows you to collect a huge amount of information that makes detection possible and diagnosing potential faults and their elimination. Computer diagnostics has a wide range of applications. The paper attempts to use computer diagnostics to determine the ecological level of the vehicle. The environmental level consists of many factors, the main is the emission of toxic fumes emitted during the operation of the car, as well as elements affecting their reduction implemented in the vehicle [4]. Other factors that are important for the natural environment, and hence the ecological level, are: the impact of the car use process, the growing demand for new means of transport and the impact of alternative drive solutions.

2 EMISSION STANDARDS

Reducing transport emissions is one of the most important EU policy objectives. Emitted in this sector, carbon dioxide accounts for over 20% of released greenhouse gases. The latest data shows that approximately 71% of the carbon dioxide emissions in the transport sector come from from road transport. The reason for such a large share of CO2 emissions is that road transport is the most frequently used form of transport. The passenger car industry, on the other hand, is the source of around 65% of CO2 (fig.1) emissions in road transport. For comparison, maritime transport is responsible for about 14% of pollution, an additional 2% comes from emissions from inland waterways, air transport is 13%. The railway transport is responsible for the smallest percentage share, as only 1% of the emission of pollutants. The first European standard to limit the emission of harmful components contained in exhaust gases was the regulation of 1972 bearing the designation ECE15 / 01 (ECE - European Economic Commission - ECE). In 1982 ECE Standard 15/04 entered into force. The first of the EURO standards was created in 1991, in force since 1992 requiring the use of catalysts in the vehicle outlet system, introducing unleaded petrol for spark ignition engines and a carbon dioxide limit below 3g / km. The ECG normalized and introduced a new European driving cycle (NEDC), ie a measurement cycle, which can be used to assess the toxicity of exhaust gases and fuel consumption, including measurements in urban traffic and the extra-urban movement. Passenger cars were tested for the NEDC measurement cycle. The tests allowed to determine compliance with the requirements for the Euro 1 standard.

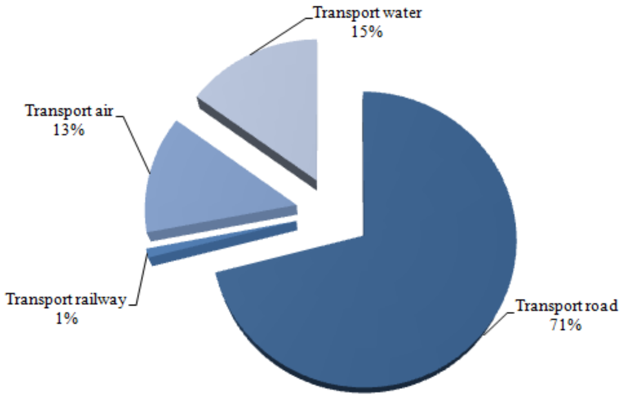

Figure 1. Emission of greenhouse gases within the European Union, broken down by means of transport [3]

The latest from Euro 6 standards was introduced by the Regulation of the European Union Commission No. 459/2012. It began to be in effect in 2014. Includes light passenger and utility vehicles. The introduction of restrictions resulted in a reduction of particulate matter (PM) by 66%, nitrogen oxides (NOx) by 80% compared to Euro 5.

Euro norm for petrol engine			
	Limit values		
	CO	NOx	HC
Euro 1	3,16	1,13	
Euro 2	2,2	0,5	
Euro 3	2,3	0,15	0,2
Euro 4	1	0,08	0,1
Euro 5	1	0,06	0,1
Euro 6	1	0,06	0,1
Values in g/km			

Figure 2. Emission norms for gasoline engines [3]

The reduction of particulate matter emissions from Euro 1 to Euro 6 is about 97%. CO2 (fig.2) emissions were reduced by more than 6-fold, while in gasoline engines there was more than 11-fold reduction of hydrocarbons [8].

Euro norm for Diesla engine				
	Limit values			
	CO	NOx	HC+NOx	PM
Euro 1	3,16	-	1,13	0,18
Euro 2	1	-	0,7	0,08
Euro 3	0,64	0,5	0,56	0,05
Euro 4	0,5	0,25	0,3	0,025
Euro 5	0,5	0,18	0,23	0,005
Euro 6	0,5	0,08	0,17	0,005
Values in g/km				

Figure 3. Emission standards for diesel engines [3]

3 METHODS FOR DETERMINING THE ECOLOGICAL LEVEL

There are many ways to determine the ecological status of the vehicle. One of them is a direct method mainly involving the examination of smoke and the composition of the exhaust emissions emitted by the vehicle under appropriate operating conditions. Smoke opacity measurement provides information on the presence of solid particles (soot), efficiency of the dpf filter, and is carried out using various types of opacimeters. The measurement of the exhaust gas composition with analyzers guarantees detailed information on the components contained in exhaust gases such as hydrocarbons, nitrogen oxides, carbon monoxide or carbon dioxide. We distinguish two basic types of exhaust gas analyzers: laboratory and workshop. Both in the laboratory analyzer and in the workshop analyzer measurements are made for the content of the same components present in the exhaust gas. The advantage of the laboratory analyzer is the additional possibility of measuring other components with a significant impact on living organisms and the natural environment. Another way to determine the ecological state of the vehicle is to use the indirect method, which is computer diagnostics. It consists in checking and analysis of real parameters and waveforms from sensors affecting the fuel and air mixture dosage, the functioning of components responsible for the exhaust gas filtration, and as a result the quality of the exhaust gases emitted. Computer diagnostics can be divided into a self-diagnosis performed in a vehicle and for diagnostics using external tools such as an appropriate interface to connect with the tested object and an information platform. Computer diagnostics in the article was carried out using universal diagnostic testers such as kts 540 from bosch in combination with the use of the esi tronic 2.0 platform, delphi, cdif 2 and cdif 3 offering connection and cooperation with almost all brands and vehicle models. With their help, it is possible to obtain information on the technical condition of components responsible for maintaining the ecological status of the tested vehicle, such as a particulate filter, catalytic converter, lambda sensors. They enable reading error codes, obtaining detailed information on eg equipment versions, part numbers, controller data.

4 THE CASE STUDIES

One of the main elements affecting the ecological condition of a diesel vehicle is the proper operation of the particulate filter responsible for the exhaust gas filtration. Using the diagnostic tester, it is possible to check many filter parameters such as its filling, consisting of the amount of ash and soot contained, the time since the last regeneration. In the case of Volkswagen vehicles, special attention should be paid to the actual values of the degree of particulate filter pollution. Using the KTS 540 interface (fig.4), which was used to diagnose a Volkswagen Jet-ta 2.0 TDI, it is possible to read these messages.

Figure 4. Measurement of the degree of particulate filter contamination

In the above case, the obtained filter pollution degree values are given in grams. It consists of the amount of soot and ash deposited in the element responsible for filtering and flue gas flow of the particulate filter component. These values are calculated by the motor controller. The desired value for the degree of contamination is from 0 to 100 grams. This means that the filter is theoretically able to work up to full filling, but based on service practice when the component is full 70-80% (fig.5), the vehicle enters emergency mode, and the filter itself is unable to work which has an impact on the emission of poisonous exhaust components into the atmosphere and is unconditionally replaced with a new component or regeneration in a specialized service.

Using the diagnostic interface, it is possible to check the consumption of engine oil in the tested vehicle.

Figure 5. Oil consumption parameter – universal soft

This parameter is readable only on vehicles with a particulate filter. In the above example, the oil consumption is 80%, which means that the current fluid is heavily used up, as well as the necessary replacement in the near future. Oil consumption adversely affects the lubrication of moving engine parts to remove heat from them.

Another element affecting the quality of exhaust emissions subject to computer diagnostics is the oxygen sensor or lambda probe. This the element exists in both Diesel and I units spark ignition. Important parameters to pay attention to are the value of the lambda excess air coefficient. The element exists in both Diesel and I units spark ignition. Important parameters to pay attention to are the value of the lambda excess air coefficient.

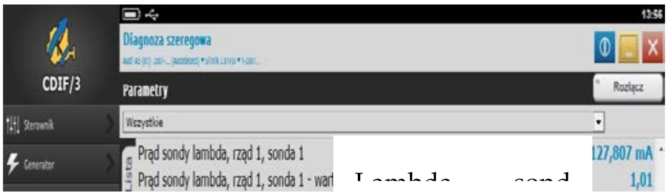

Figure 6. Lambda probe work parameter

From the above measurements it is possible to obtain information on the value of the lambda coefficient. In the test vehicle of the Audi A5 2.0 TFSI brand, the lambda probe is a broadband probe, this coefficient oscillates within 1. The engine controller converts the current consumption into a lambda value, trying to achieve a stoichiometric mixture. Only the combustion of the stoichiometric mixture guarantees low emission levels of toxic compounds emitted in the exhaust (fig.6).

Another parameter affecting the ecological level of the unit is the measurement of fuel injection dose correction on each cylinder provides information on the difference in the amount of fuel delivered to individual cylinders. Depending on the size of the correction, it is possible to determine the efficiency of the injectors. The above measurement shows the difference in the injection dose in milligrams at the stroke of the engine, and the average value of the injection dose. The values measured in the tested vehicle are stable and are within the standards set by the manufacturer. In the event of damage to the injector or injectors, it is possible to excessively add the corrective dose by the engine controller to damaged injectors and negative corrective (fig.7) doses to the injectors, which may lead to fuel failure.

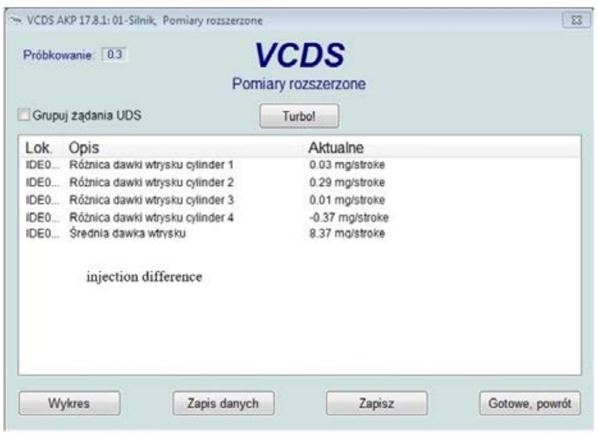

Figure 7. Measurement of the injection dose difference to individual cylinders in the vehicle – soft dedication for VW group

The result of this situation will be excessive emission of toxins contained in the exhaust, increased smoke, and in extreme cases, the arrival of oil in the engine compartment which may lead to engine seizure. The examples presented in this article are the result of our own tests carried out with various diagnostic testers on 15 vehicles equipped with various drive units.

5 CONCLUSIONS

This article is devoted to the use of computer diagnostics to determine ecological parameters, and thus the ecological level of the vehicle.

In the case of motor vehicles, the efficiency of the exhaust system including the components responsible for filtering the emitted exhaust gases, such as the diesel particulate filter or three-way catalyst, plays a significant role. Supervision over the mentioned elements is carried out by means of various types of sensors, such as lambda sensors, differential pressure sensors, and exhaust temperature sensors.

Filtering components along with the course of the vehicle undergo the process of exploitation, their effectiveness decreases. It is necessary to control their consumption process as well as the state in which they lose their nominal parameters. Computer diagnostics using the appropriate interface and information platform allows to determine the ecological level of the vehicle.

The aim of the work was achieved through the research presented in the sixth chapter. Diagnostics of the relevant parameters shown on the example of vehicles of different makes and models provides information on the technical condition of the measuring object. It allows to determine the ecological level of the tested vehicle.

The current increase in environmental pollution and increasingly restrictive emission standards have an impact on the development of motoring. More weight is attached to the ecological level of motor vehicles. Computer diagnostics are therefore a great tool to supervise the responsible elements.This article is devoted to the use of computer diagnostics to determine ecological parameters, and thus the ecological level of the vehicle.

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