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OXYGEN SENSOR ADAPTER FOR MECHATRONIC INTERNAL ENGINE CONTROL COMBUSTION CARS

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Abstract– The use of mechatronic control systems in internal combustion engines of automobiles optimizes the control processes and the operation of all complex vehicle systems. Therefore, the use of modern mechatronic systems in cars is one of the factors that improve the performance of cars and allow us to offer the client a new level of car control. The paper presents the development of an oxygen sensor adapter for an internal combustion engine with a mechatronic vehicle control system, which allows the mechatronic control system to be adapted to the use of various Euro standard systems and catalyst models.

Key words– Automobile, mechatronics, diagnostics, catalyst testing, driving cycle, performance of internal combustion engines and automobiles.

I Introduction

The mechatronic engine management system is based on a complex control of the parameters of the power unit, that is, torque, revolutions. The engine torque is controlled by supplying air and also by adjusting the ignition timing. All this is adjusted for one of the possible engine operating modes: starting mode of the internal combustion engine, engine warming up, idling, driving under load, transient modes, engine braking, activation of additional equipment. The electronic control unit affects the actuators, depending on the analysis of the data received from various sensors of the internal combustion engine and the car, including one of the most important are sensors for determining oxygen in the composition of the exhaust gases at the outlet[1].

II Main part

Fuel injection systems have a number of advantages. The main benefit is accurate metering of fuel and, as a result, more economical fuel consumption. Also, we must not forget about reducing the toxicity of exhaust gases and increasing throttle response.

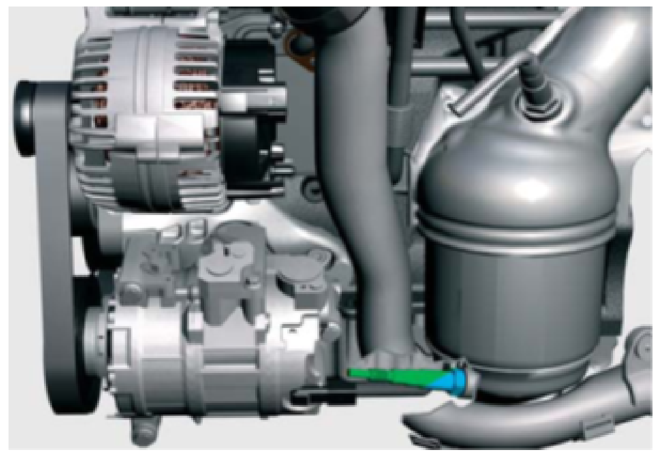

Fig. 1: The location of the oxygen sensors (lambda probe) on internal combustion engine

As standard in modern cars, two oxygen sensors are used to adjust the fuel-air mixture at the intake. One in front of the catalyst (upper lambda probe), and the second after it (lower lambda probe). There are no differences in the design of the upper and lower sensors, they may be the same, but they perform different functions. The upper or front oxygen sensor detects the remaining oxygen in the exhaust gas.

Oxygen sensor is a device designed to record the amount of oxygen remaining in the exhaust gases of a car engine.

In the theory of the operation of an internal combustion engine, there is such a concept as a stoichiometric ratio - this is the ideal proportion of air and fuel at which complete combustion of fuel occurs in the combustion chamber of the engine cylinder.

Based on a signal from this sensor, the engine control unit determines on what type of air-fuel mixture the engine is operating (stoichiometric, rich or lean). Depending on the oxy-

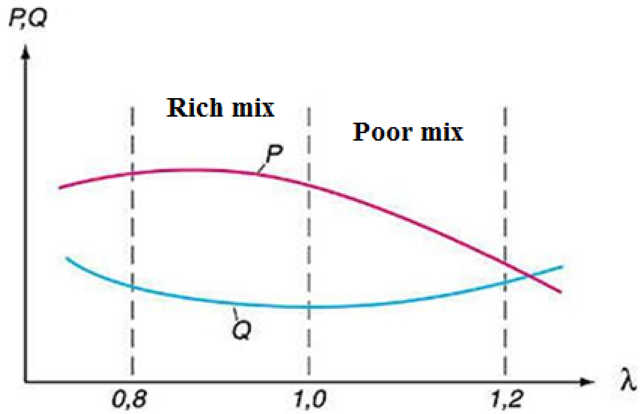

Fig. 2: Power (P) and fuel consumption (Q) versus excess air ratio

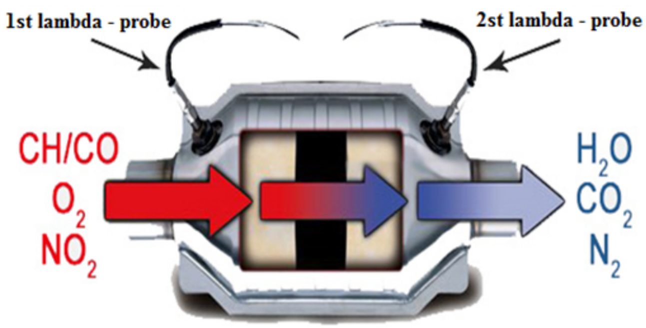

Fig. 3: Determination of oxygen in the substance of the composition of the exhaust gases by oxygen sensors (lambda probe) on an internal combustion engine

gen readings and the required operating mode, the electronic control unit adjusts the amount of fuel supplied to the cylinders. Typically, the fuel delivery is adjusted towards the stoichiometric mixture. It should be noted that when the engine is warming up, the signals from the sensor are ignored by the electronic engine control unit until it reaches the operating temperature. The lower or rear lambda probe is used to further adjust the composition of the mixture and monitor the serviceability of the catalytic converter.

There are several types of lambda probes used in modern cars. The most used of them which is an oxygen sensor based on zirconium dioxide (ZrO2) will be considered from the design and the operation principle point of view. The sensor consists of the following main elements: the outer electrode - contacts the exhaust gases, the inner electrode - contacts the atmosphere, the heating element - is used to heat the oxygen sensor and bring it to the operating temperature more quickly (about 300 ° C), solid electrolyte - located between the two electrodes (zirconium dioxide), the body, the tip guard - has special holes (perforations) for the penetration of exhaust gases.

The outer and inner electrodes are platinum-coated. The principle of operation of such a lambda probe is based on the occurrence of a potential difference between platinum layers (electrodes), which are sensitive to oxygen. It occurs when the electrolyte is heated, when oxygen ions move through it from atmospheric air and exhaust gases. The voltage at the sensor electrodes depends on the oxygen concentration in the exhaust gases. The higher it is, the lower the voltage. The oxygen sensor signal voltage range is 100 to 900 mV. The signal has a sinusoidal shape, in which three regions are distinguished: from 100 to 450 mV - lean mixture, from 450 to 900 mV - rich mixture, 450 mV corresponds to the stoichiometric composition of the air-fuel mixture.

Lambda probe life and its malfunctions The lambda probe is one of the most quickly worn out sensors. This is due to the fact that it is constantly in contact with exhaust gases and its resource directly depends on the quality of the fuel and the serviceability of the engine. For example, a zirconium oxygen sensor has a resource of about 70-130 thousand kilometers. Since the operation of both oxygen sensors (upper and lower) is monitored by the OBD-II on-board diagnostics system, if any of them fails, a corresponding error will be recorded, and the "Check Engine" indicator lamp on the instrument panel will light up. In this case, you can diagnose a malfunction using a special diagnostic scanner.

When the oxygen sensor is working properly, the signal characteristic is a regular sinusoid, showing a switching frequency of at least 8 times within 10 seconds. If the sensor is out of order, then the signal shape will differ from the reference one, or its response to a change in the mixture composition will be significantly slowed down.

Oxygen sensors, in addition to zirconia, are also used titanium and broadband.

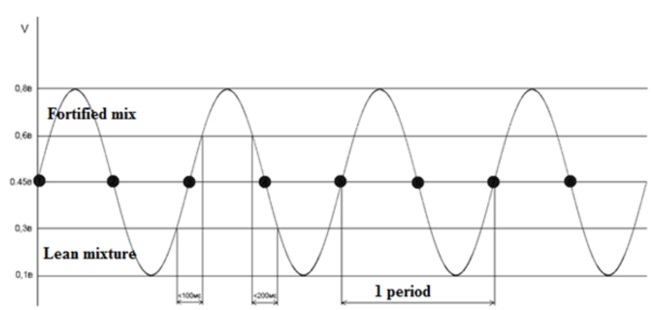

Fig. 4: Proper oxygen sensor signal

Titanium lambda probe, has a titanium dioxide sensing element. The operating temperature of such a sensor starts from 700 ° C. Titanium lambda probes do not require atmospheric air, since their principle of operation is based on a change in the output voltage, depending on the concentration of oxygen in the exhaust.

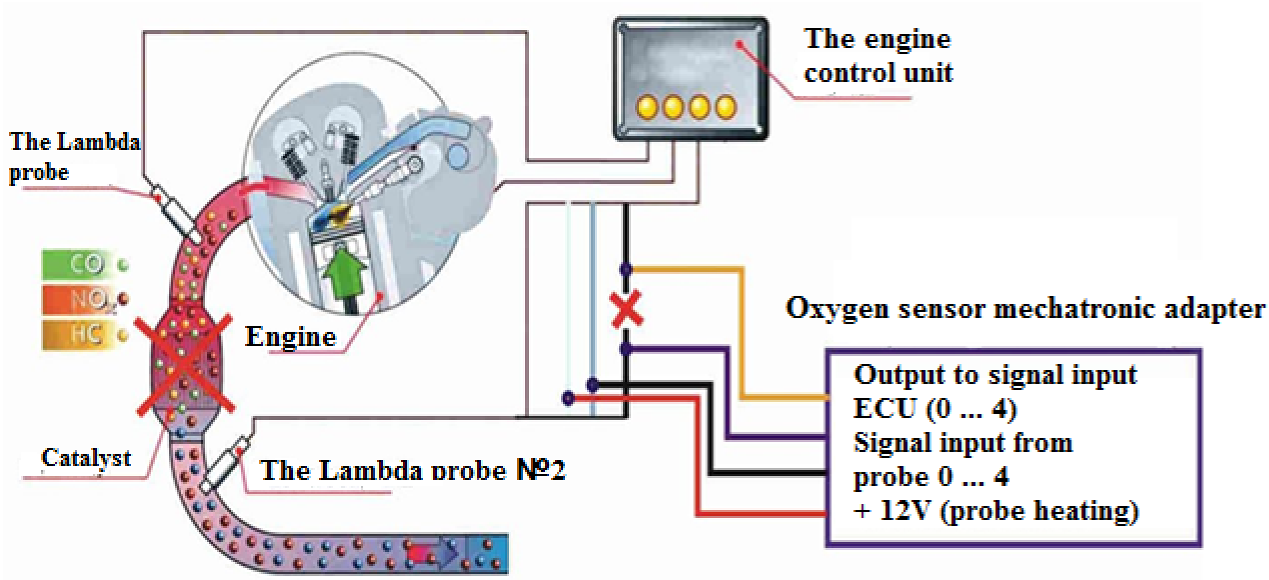

Fig. 5: Connecting the oxygen sensor adapter to the oxygen sensor

The broadband lambda probe is an improved model. It consists of a zirconium sensor and an injection element. The first measures the concentration of oxygen in the exhaust gas, recording the voltage caused by the potential difference. Next, the reading is compared with the reference value (450 mV), and, in the event of a deviation, a current is applied, provoking the injection of oxygen ions from the exhaust. This happens until the voltage becomes equal to the given one.

Fig. 6: Oxygen sensor adapter installed on the car

The oxygen sensor is a very important element of the engine management system, and its malfunction can lead to difficulties in mechatronic vehicle control and cause increased wear of the rest of the engine parts.

To optimize the operation of the mechatronic control system of an internal combustion engine of a car, as well as to use catalysts of various types of Euro standards to improve the environmental performance of internal combustion engines on a specific vehicle platform, an additional mechatronic oxygen sensor adapter can be used.

When developing an oxygen sensor adapter for internal combustion engines of automobiles, we resort to the basic control methods and principles of operation of standard sensors for determining oxygen in the composition of exhaust gases. Also, to determine the correct control and adaptation of the mechatronic control system of the internal combustion engine of cars when using the oxygen sensor adapter, we carry out road tests of the car and work to determine the composition of the exhaust gases[1,2,4].

The purpose of the oxygen sensor adapter is to adapt the mechatronic control system of a car when using catalysts of various Euro standards in place of standard catalysts on cars.

Installation of a Euro catalyst of one type in place of a Euro catalyst of another type, on a vehicle of the T250 platform (Nexia R3), requires adaptation of the second oxygen sensor for the correct operation of the mechatronic control system of the internal combustion engine, which is achieved by adapting the second oxygen sensor using an oxygen sensor adapter.

When replacing a catalyst of one Euro type in place of a catalyst of the Euro standard of another type, on a car of the T250 platform (Nexia R3), the second oxygen sensor registers a greater value of the composition of the exhaust gases, thus - the check engine will burn, the power may decrease, the acceleration characteristics of the car will worsen.

A second oxygen sensor, downstream of the catalyst, monitors the efficiency of the catalyst by measuring the oxygen content in the exhaust gas at the outlet. If all of the oxygen is absorbed by the chemical reaction between the oxygen and the pollutants, the sensor generates a high voltage signal.

The connection of the oxygen sensor adapter of the mechatronic control system of the internal combustion engine of the car is shown in Fig. 5.

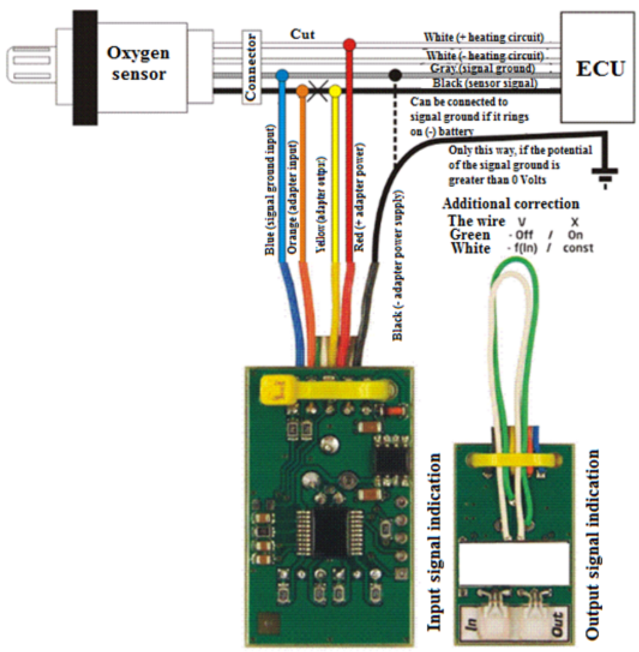

Fig. 7: Connecting the oxygen sensor adapter to the oxygen sensor

III Results and Discussions

Application of the adapter of the second oxygen sensor is connected to the network of the electronic control unit. This adapter improves the information processing system by starting to analyze it. Thus, the controller performs much better and optimally. The oxygen sensor adapter circuit includes a capacitor and a resistor.The oxygen sensor adapter installed on the vehicle is shown in fig. 6.

The connection circuit of the oxygen sensor adapter with the oxygen sensor of an internal combustion engine with a mechatronic vehicle control system is shown in fig. 7.

IV Conclusion

The oxygen sensor adapter for internal combustion engines of cars allows the adaptation of the mechatronic control system of the car when catalysts of various Euro standards are used instead of standard catalysts on cars. To adapt the mechatronic control system of an internal combustion engine using a new type of catalyst, an adapter is integrated on the oxygen sensor after the catalyst.

The main novelty of this development is to improve the operability and adaptation of the mechatronic control system of an internal combustion engine of a car, as well as to optimize the performance of a car:

1. Developed and substantiated a model of the oxygen sensor mechatronic adapter for the exhaust gas neutralization system;
2. A model of car engine control using an oxygen sensor adapter as an additional element has been developed;
3. An adaptive control algorithm for the mechatronic system has been created using an oxygen sensor adapter for the use of various Euro standards and the selection of optimal modes for cars with a different class of mechatronic elements;
4. A new element has been proposed and its efficiency has been substantiated for adaptation, calibration and data transmission to the engine controls (oxygen sensor adapter);
5. The performance indicators of engines of vehicles with a mechatronic control system when using an oxygen sensor adapter have been substantiated;
6. The methodology for selecting the characteristics of the oxygen sensor adapter in the mechatronic control system of the car engine has been determined.

The practical significance of the work lies in creating a technology for adapting a mechatronic control system for a car engine using various catalytic converters on cars of a certain platform for car manufacturers:

1. A technology has been developed for adapting the mechatronic control system of a car engine with the use of various catalytic converters on cars of a certain platform for car manufacturers;
2. The use of an oxygen sensor adapter for propulsion production, flexible re-equipment and the introduction of catalytic converters has been substantiated;
3. An improved control system for the mechatronic elements of the vehicle has increased fuel efficiency by 8% and improved the environmental performance of engines with Euro 3, Euro 4 and Euro 5 systems.

This development provides the adaptation of the mechatronic vehicle control system when using catalysts of various Euro standards instead of standard catalysts on cars.

This oxygen sensor adapter can be used on internal combustion engines of cars. Its use gives significant economic efficiency, depending on the type of catalyst used and the Euro standard.

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