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OXYGEN SENSORS IN DETERMINING THE TECHNICAL CONDITION OF THE CATALYTIC CONVERTER USING ON-BOARD DIAGNOSTICS SYSTEMS

To reduce the toxicity of exhaust gases through the reduction of nitrogen oxides and the use of oxygen to burn carbon monoxide and unburned hydrocarbons in modern internal combustion engines uses a catalytic converter. It is installed in the exhaust system of the engine and the main requirement for its successful operation is to ensure the stoichiometric ratio of fuel and oxygen in the fuel-air mixture [1].

The stoichiometric mixture is a mixture, the composition of which ensures complete combustion of fuel without residual oxygen. For gasoline internal combustion engines with spark ignition, the stoichiometric ratio is air / fuel, equal to 14.7: 1 (mass parts). For propane, this ratio is 15.6: 1. The coefficient of excess air for the stoichiometric combustible mixture is equal to one [2].

In contemporary engines, the maintenance of the air-fuel ratio close to the optimal is carried out by means of an automatic control system. The main sensor in such systems is a sensor of the concentration of free oxygen in the exhaust gases of the engine - oxygen sensor (or lambda sensor) [3].

Three-way catalytic converters (TWC) to neutralize carbon monoxide (CO), hydrocarbons (CxHy) and nitrous oxide (NO and NO_2) use two different types of catalysts: reducing and oxidizing. Both types of catalytic converter are made in the form of a ceramic structure (carrier block) coated with a metal catalyst (usually platinum or its alloy with iridium, rhodium and / or palladium). The ceramic base has a honeycomb structure, which provides an increase in the contact area of the exhaust gases with the surface on which a thin layer of metal is applied. Unburned residues (CO, hydrocarbons) in contact with the surface of the catalytic layer are oxidized by oxygen released during the NO reduction reaction and also, partially contained in the exhaust gases. As a result of the reaction, heat is released, which heats the catalyst and, thus, the oxidation reaction is activated [1].

The engine control system monitors the content of the exhaust gas flow and uses this information to control the fuel injection system. One oxygen concentration sensor is installed in front of the car catalyst (Fig. 1, it.2), ie closer to the engine than the catalytic converter itself (Fig. 1, it.1). This sensor provides the engine control unit (ECU) with information on the amount of oxygen in the exhaust. The engine control unit reduces or increases the oxygen content of the exhaust gases by regulating the amount of air entering the fuel. The second sensor (Fig. 1, it.3) is installed after the catalytic converter and provides control over the efficiency of its operation. This scheme allows you to maintain the operation of the engine on the fuel mixture with a ratio close to the stoichiometric, as well as to control the amount of oxygen in the exhaust gases required for the operation of the catalytic converter.

As a result, at the exit of the catalytic converter (serviceable) exhaust gases contain mainly N2 and CO2 - more or less harmless gases (we are not talking about greenhouse effects here).

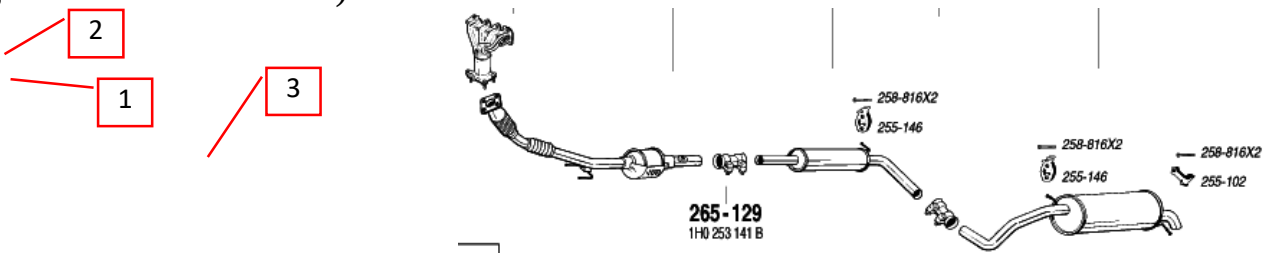

Fig. 1. Installation of catalytic converter (1) and oxygen sensors (2), (3) on Skoda Fabia, Volkswagen Polo 1.4.

The ECU in the control process compares the signals of the 1st and 2nd sensors for a given time interval, calculating the duration of the voltage signal, and if it exceeds a given threshold, the ECU of the car, interprets this as a malfunction of the converter. The limit value of the difference between the amplitudes of the front S1 (taken as a reference) and the rear S2 oxygen sensors is more than 0.7 times per minute. But the check light, which signals the error in the memory of the ECU, does not light up instantly, but only when the reduction in the efficiency of the catalytic converter occurs within 100 seconds, and the load on the engine should be from 21 to 63% when the crankshaft rotates 1,720 - 2,800 rpm, and the temperature of the catalyst exceeds 500 degrees Celsius.

As the catalyst wears (throughput), the readings of the rear sensor approach the readings of the front oxygen sensor. During the normal operation of the catalytic converter, the signal heated by the oxygen sensor at the output, switches slowly between the values of the enriched and depleted states. Frequent switching of the lambda probe between these states also indicates a decrease in the efficiency of the catalytic converter. As a result, its ability to accumulate oxygen is reduced.

The ECU will issue error code P0420, which stands for "efficiency of the catalytic converter system below the threshold level". If the vehicle is equipped with two converters at once, this error may also have the code P0430 Catalyst System Efficiency Below Threshold (Bank 1) or (Bank 2). Fault code P0420 appears when oxygen and residues of unburned fuel are detected in the exhaust gases.

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