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IMPROVEMENT OF THE ECOLOGICAL SAFETY OF ROAD TRANSPORT IN THE USE OF ALTERNATIVE FUEL AND EXHAUST CONVERTERS

Volodymyr Shmandiy, Olena Kharlamova, Tetyana Rigas

Kremenchuk Mykhailo Ostohradskyi National University, Kremenchuk, Ukraine
ecol4207@mail.ru

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Abstract The aim of the research was to reduce ecological danger caused by vehicles through the use of combined fuel and improved designs converters of exhaust gases.

The use of obsolete structures of a catalytic analyzer on cars and the provision of periodic purging of catalytic units can significantly reduce soot emissions without making changes to the design of the engine.

It was established that the use of a mixture of diesel fuel with biofuels (made involving waste) reduces the toxicity of exhaust gases by 30–35 % and saves hydrocarbons.

Key words: ecological danger, road transport, exhaust, converter, biofuels, ecological safety, carbon black

1. Introduction

In Ukraine, as in the whole world, in recent years there is an increase in the number of cars. That exhaust gases of vehicles currently provide 80 % to 90 % of air pollution in large cities and metropolises [1].

The problem of environmental pollution by exhaust gases of vehicles is global. The analysis of harmful components that are a part of the exhaust gases and methods of their disposal allows to choose the most effective way to solve the problem of environmental pollution. Spent gases are a complex mixture of substances that depend on many factors, including structural features and mode of operation of the car and its engine.

One of the most toxic compounds that affect the health of humans, animals and plants is carbon black. It can cause irreversible changes and even loss of flora and fauna. Soot particles are small enough to penetrate deep into the lungs during breathing while being the sorbent.

In addition to soot, the exhaust gases of a diesel vehicle contain impurities of fuel oil aerosol, products of engine wear, mineral substances fed into the engine cylinder with fuel and air, and other substances that can be detained by a filtering material. However, the amount of these substances is negligible compared to the mass content of soot particles in the exhaust gases. Particularly acute is the issue in relation to cars equipped with outdated engines.

The main areas of reduction of toxicity of harmful emissions of internal combustion engines are [2]:

– improving the design and workflow of internal combustion engines;

– the use of alternative fuels;

– exhaust gas cleaning in the release.

Let's consider in more detail the second of these methods. Alternative fuels must meet the following requirements: have the necessary raw materials, low cost, not hamper the operation of the ICE, integrate into the existing fuel supply system, etc. Authors [3] to alternative motor fuel include: gas fuel of natural origin; synthetic fuel; secondary resources (by-products of recycling of liquid and solid fuels).

The distribution of the above types of fuels is limited by storage problems, toxicity; significant deterioration of technical and economic indicators [2].

Based on the analysis of literary sources, it was found that one of the effective methods of ensuring the environmental safety of motor transport is the catalytic neutralization of exhaust gases of engines.

2. Material and methods

Engine and performance tests of the prototype of the catalytic converter were carried out according to standard techniques. A special engine stand was used (Fig. 1) [4]. The latter has two parallel channels with catalytic blocks. This ensures that the exhaust gases pass through each block equal to identical costs and similar

gas distribution through the intersection of the blocks. The purification properties of the neutralizer, their stability under operating conditions, the impact of the neutralizer on the gas-dynamic resistance of the exhaust system and the external noise of the vehicle were studied.

In order to assess the level of ecological danger of diesel vehicles equipped with catalytic neutralizer, measurements of concentrations of harmful components in its input and output were conducted. The purification ratio for the i-ingredient was defined as the ratio of these parameters.

Before the tests, such parameters as fuel density, kinematic viscosity, flash temperature and fuel fractional composition were set by the techniques of relevant standards. The elemental composition and lower calorific value of diesel fuel and its blends were determined by gas-liquid chromatography [5].

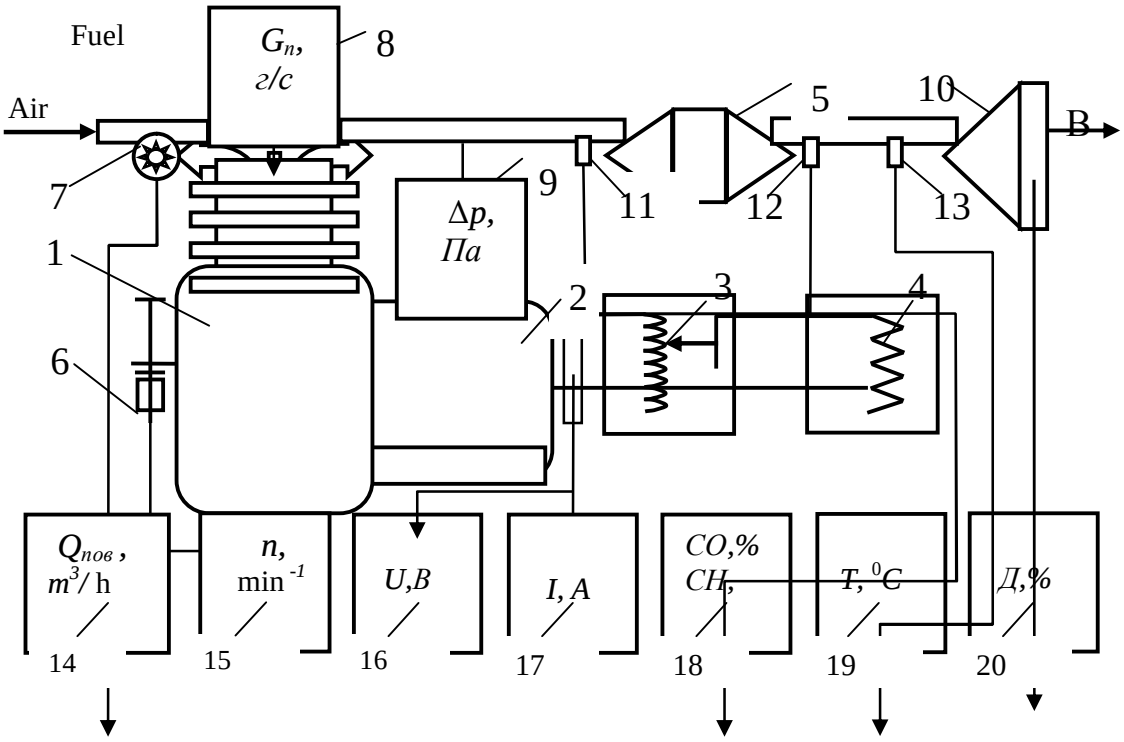

Fig. 1. Scheme of engine stand: 1 – studied engine; 2 – pull-generator; 3 – autotransformer; 4 – pull-up resistor; 5 – catalytic converter; 6 – the gauge of frequency of rotation of the engine shaft; 7 – air flow sensor; 8 – counters of fuel; 9 – gauge system exhaust; 10 – smokescopes probe; 11 i 12 – exhaust selection tubes; 13 – thermocouple; 14 – air flow sensor; 15 – tachometer; 16 – voltmeter; 17 – ammeter; 18 – gas analyzer; 19 – measuring the temperature of the exhaust gas; 20 – smokemeters

3. Results and discussion

The results of experimental research both on an engine stand and on a car that worked under real conditions of operation showed an increase in emissions of harmful substances due to contamination of channels of catalytic blocks with carbon black. The feasibility of periodic purges of catalytic blocks of diesel exhaust system neutralizers in order to release their channels from soot is proved, which makes it possible to provide an effective cleaning after the implementation of the regulatory procedure. The neutralizer includes a device that allows purging of some of its sections.

It was proved that diesel vehicles equiped with a catalytic neutralizer makes it possible to provide exhaust gas emission standards that meet ecological safety standards. All the received results were compared to standards DSTU4276: 2004.

In previous studies [6] the composition of vehicles and the standards of technogenic safety of vehicles were analyzed. In 2015, nearly 7.000 vehicles with diesel internal combustion engines were registered on the territory of Kremenchug industrial region, 2300 of which were truck. Also an anthropogenic impact of soot contained in exhaust gases of cars was analysed, and harmful substances adsorbed on the surface of soot particles. were determined. Negative impact on humans, animals, plants and the environment was found, which determines the relevance of our research.

The analysis of the auto park in. Kremenchug revealed the inadequacy of of technogenic safety standards of cars because a significant percentage of outdated cars.

The analysis of the literature on the problems of reduction of carbon black in the exhaust gases of vehicles equipped with diesel engines showed that a rational method is the catalytic one. Experimental studies were carried on an engine stand to identify patterns of carbon black content in the exhaust gases depending on the engine and determine the concentrations of carbon black in the exhaust. It was established that the use of catalyst based on platinum salts can reduce carbon black content by 30 % and reduce CO emissions by 90 %. Thus, there is a reduction of ecological danger without significant changes in car design.

For comparison of ecological danger of vehicles with different masses and different capacity engines, it makes sense to use a dimensionless index that is obtained by referring the release of the i-component to fuel consumption:

$$g_{i/n} = \frac{G_i}{G_n}. \quad (1)$$

This allows to estimate the amount of harmful emissions in SH for each component relative to fuel consumption and allows to combine the determination of ecological car safety with its fuel economy.

We studied the different modes of the diesel internal combustion engine, which were simulated by a generator load. The data characterize the ndicators of man-made components of the the ecological and economic dangers of diesel internal combustion engine running on different fuels and their mixtures.

We [7] found that the use of a mixture of diesel fuel with biofuels can significantly reduce the total toxicity of exhaust gases of diesel cars, especially when internal combustion engines work on idling and partial loads. The largest decrease in the total toxicity is about 30–35 %, corresponding to binary content of biofuels in the fuel mix of 45–50 %. As a feedstock for biogas different biological components are used. Quite promising is the use of blue-green algae, which is massively reproduced in the waters of artificial reservoirs or waste food industry.

In [8], the process of complex processing of cyanobacteria for the production of technical oil suitable for the production of biodiesel has been investigated; the prospect of the application of hydrodynamic cavitation for increasing the efficiency of the process is shown.

We investigated Soap stock (alkaline refining waste of sunflower oil) to produce biodiesel as food industry waste [9]. The essence of our method is to reduce the viscosity of Soap stock which can be achieved in various ways. Glycerin, which is a part of Soap stock provides its viscosity and density. So to get biodiesel, glycerol must be removed and replaced by alcohol. When useing soapstock as a basis for making biodiesel, preliminary filtration to remove impurities and water is needed. If the water is not removed, triglyceride hydrolysis will occur instead of transesterification reactions and salts of fatty acids will be obtained instead of biodiesel [10]. In the reaction, after processing with sorbent, soapstock was first heated to 60˚S (to speed up the reaction), and then catalyst and alcohol (butanol) were added. To accelerate the reaction Iron (III) sulphate was used. As a result of settling, mixture is stratified to form biodiesel and then a layer of soap in the upper layer, and glycerin is lef on the bottom. Then glycerin and soap layer were separated and biodiesel was waswashed to remove residual soap, catalyst and other possible contaminants. The yield of esters of fatty acids is about 95 %, which exceeds the value of this parameter (85–91) in the absence of coabstock purification. Obtaining biodiesel from fat-containing waste from the food industry allows to reduce oil consumption in the traditional way of its production. Moreover, the addition of biodiesel components can significantly reduce engine exhaust emissions.

Using the above data on motor structure based on simple calculations we make a conclusion that the use of B-50 mixture enables saving of 10.450 m^3 of diesel fuel at 7000 Auto Vehicle a year.

4. Conclusion

1. Thus the use of a catalyst can significantly reduce the emission of carbon black in the exhaust gases of diesel cars, especially when internal combustion engines work on idling and partial load without making major changes to engine design that is cost-effective.

2. The feasibility of periodic purging of catalytic converters blocks of exhaust gases of diesel vehicles is confirmed

3. It is established that the use of the mixture of diesel fuel with biofuels (B-50) can reduce the total toxicity of exhaust gases by 30–35 % and save hydrocarbons.

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