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Dependence of Reliability of Operation and Environmental Safety of Automotive Engines on Fuel Quality

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ABSTRACT: The results of work on a comparative assessment of the influence of fuel quality on the reliability of operation and the toxicity of exhaust of motor vehicles during its operation in different climatic zones are given. It is noted that the higher the quality of the fuel, the better the combustion process and the less harmful components in the exhaust gases and the quality of the fuel is a factor that has a decisive influence on the reliability of operation and the toxicity of a vehicle's emissions, regardless of which climatic zones it is in operation.

KEY WORDS: road transport, fuel quality, standards, Euro, environmental safety, operational reliability, emission toxicity, climatic conditions, air pollution.

I.INTRODUCTION

One of the most important characteristics of modern internal combustion engines is their reliability, which allows a quantitative assessment of changes in the quality of the engine by its operating time. Such an assessment greatly facilitates the development of comprehensive measures for the further improvement of existing and creation of new engine designs, contributes to an increase in environmental safety and the efficiency of their operation.

Over the past decade, a significant increase in the reliability and environmental safety of motor vehicle engines has been achieved, which is due to a significant increase in the quality of structural and fuel lubricants (FL) [1, 2, 6,].

There is a complex relationship between the FL, the engine and its operation [2,6], therefore, for organizations that produce and operate internal combustion engines (ICE), it is necessary to know the FLchemotology: working conditions and processes of its qualitative and quantitative changes in the engine; identification of regularities linking the quality of FL with operational and environmental safety, as well as engine efficiency; establishing optimal requirements for the quality of FL and determining the conditions for its rational use, etc.

Internal combustion engines are the most massive consumers of FL. The total costs calculated only for fuel during engine operation are several times higher than the cost of the engine itself [5,6]. Consequently, irrational consumption and a decrease in the quality of FLcauses enormous damage to the country's economy.

Thus, fuel is one of the important functional elements of the engine, largely determining its reliability, environmental friendliness and efficiency. As noted above, fuel quality and engine design are interconnected, therefore, issues of improving fuel quality, reliability, environmental safety and engine efficiency should be considered in close relationship with each other. This formulation of the problem allows not only to increase the reliability of the engines, reduce the toxicity of emissions, but also serves as the basis for their further improvement and reduction of fuel consumption.

II. DISSCUSSION

The environmental safety of road transport is an integral part of the environmental problem of the whole world. In this regard, the problem of atmospheric air pollution by harmful emissions is becoming especially urgent. At the same time, the share of road transport in the total emission of harmful substances is: in the USA - 60.5%, in England - 34%, in France - 32%, in Russia - more than 80 % [7.8], and in the CIS countries - up to 85%.

The volume of emissions of harmful substances around the world is about 22 million tons. [8]. At the same time, the pollutants have different origins, i.e. oxides and carbon dioxide (CO and CO2), nitrogen oxides (NOx), hydrocarbons, compounds of lead, sulfur, particulate matter, etc. These compounds, polluting the air, have a harmful effect on human, animal and plant health. The volume of emissions of harmful substances around the world is about 22 million tons. [8]. At the same time, the pollutants have different origins, i.e. oxides and carbon dioxide (CO and CO2),

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nitrogen oxides (NOx), hydrocarbons, compounds of lead, sulfur, particulate matter, etc. These compounds, polluting the air, have a harmful effect on human, animal and plant health.

The main determinants of the quality of fuels are their purity, i.e. the absence of various pollutants of organic and inorganic origin in them and the compliance of their environmental characteristics with the requirements of Euro standards for elemental composition.

Many consumers believe that the octane rating of gasoline reflects its quality and purity. However, the octane number (RON) shows only the resistance of gasoline to spontaneous combustion during compression [11], and the name of the standard to which the fuel corresponds indicates its environmental friendliness and purity. It follows from this that the Euro standard does not affect the PM, but regulates the quantitative composition of harmful compounds in the exhaust gases of cars and other technical equipment.

Europe has pioneered environmental protection for the first time, with a policy aimed at reducing the content of harmful substances in exhaust gases. The first Euro standard for fuel appeared in the EU countries in 1992, in Russia in 2005, and in Uzbekistan in 2010. Since then, there has been a constant tightening of environmental requirements for fuels and cars.

III. EXPERIMENTAL RESULTS

Since 2015, Euro-6 standards have been in effect in Europe. According to these requirements, the following standards of permissible emissions of harmful substances have been established for gasoline and diesel fuels (Table 1).

Table 1

Environmental emission standards for Euro-6 fuel, g / km

Composition of the emission	Engines	
	gasoline (petrol)	diesel
Carbon monoxide (CO)	1,0	0,5
Hydrocarbon (CH)	0,1	
Nitric oxide (NOx)	0,06	0,08
Particulate matter (PM)	0,005	0,005
Carbon and nitrogen oxides (HC + NOx)	-	0,17

Gasolines of different markings differ in composition and amount of impurities, which, when burned, emit harmful gases and substances into the atmosphere. The higher the serial number (3,4,5, etc.), the higher the quality of the fuel and its use causes less damage to the environment, engine, fuel and exhaust systems of the car. For example, in Euro-5 gasoline, compared to Euro-4, the sulfur content in exhaust gases has been reduced by 3 times. The Euro-6 standard established 5-10 times lower norms for the content of aromatic hydrocarbons, nitrogen oxide in the exhaust.

In Russia, fuels that meet Euro standards are designated by a class, i.e. fuel Euro 4 has the designation of class 4, Euro 5-class 5 and Euro 6-class 6.

The requirements for the quality of diesel fuels are also becoming more stringent. Undesirable elements in diesel fuel are sulfur, nitrogen-containing compounds, aromatic hydrocarbons, etc. In this regard, special attention is paid to tightening requirements specifically to the content of sulfur, polycyclic aromatic hydrocarbons in diesel fuel. Table 2 shows the environmental requirements of Euro for various types of diesel fuel.

Fuel manufactured according to European standards has better characteristics compared to conventional fuel, for example, when it is used, the smoke of exhaust gases and the level of emissions in combustion products are reduced [3].

The permissible content of sulfur-containing substances in diesel fuel is strictly limited, since their presence in the fuel has a negative impact on the environmental situation and reduces the engine resource [3,7].

Table 2

Environmental standards Euro for diesel fuels [9,10].

Indicators	Euro -2	Euro -3	Euro -4	Euro -5
Cetane number, not less	53	55	55	55

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The content of sulfur compounds, mg / kg	500	350	50	10
CO content in exhaust, g / kW * h	4,0	2,1	1,5	<1,5
Share of polycyclic hydrocarbons,%	5	2	2	2
Flash point, o C	55			

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The increased sulfur content in the fuel leads to the following consequences: intensive corrosive wear of the parts of the cylinder-piston group (Fig. 1) and reduced engine durability; carbon formation and the appearance of deposits in the combustion chambers; a general decrease in the efficiency of the fuel equipment and the exhaust system; severe environmental pollution.

However, the complete removal of sulfur-containing compounds from the fuel is not effective, because with a decrease in sulfur less than 0.35%, the lubricity of diesel fuel deteriorates, and this leads to an increase in plunger wear and a decrease in the failure-free operation of fuel equipment (Fig. 1).

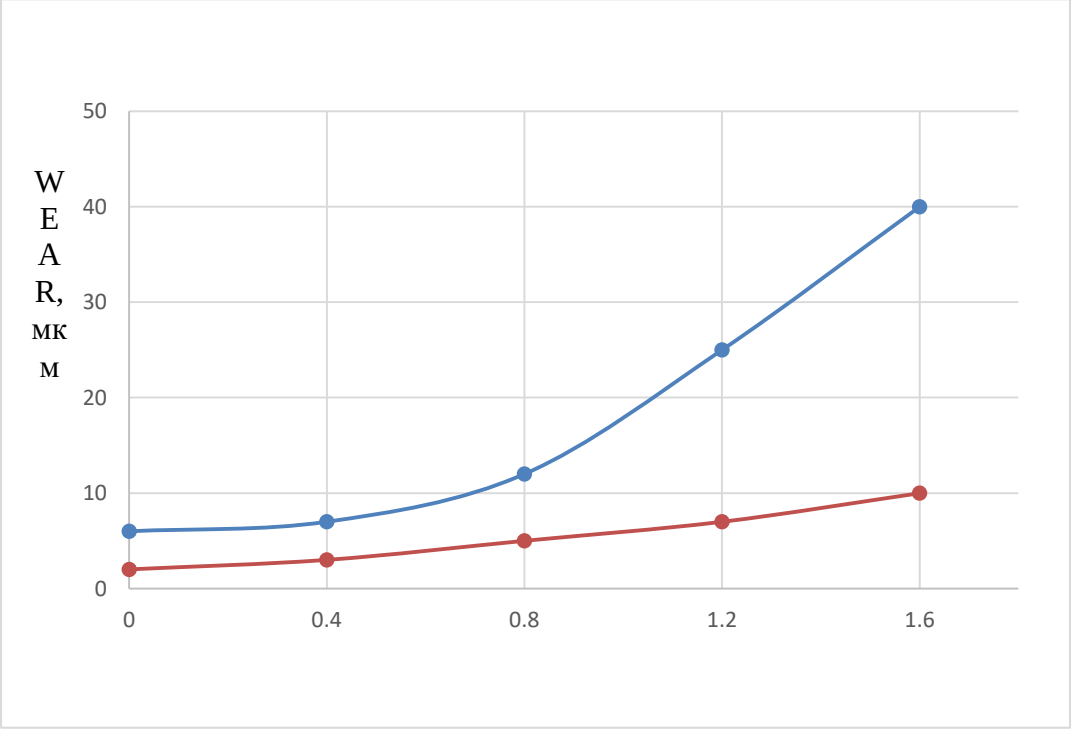

Fig. 1. The wear of the cylinder liners of a diesel engine depending on the sulfur content in the fuel [6]:
- at a coolant temperature of 75 - 95 ° C;
- the same at a temperature of 33-35 ° C.

In work [3] it is noted that when using diesel fuels of the Euro standard, in comparison with fuel GOST 305-82, weighted average emissions of NOx - by 9%, CO - by 23%, CO2 - by 12% and soot - by 9% are reduced.

The reliability of operation, power, efficiency and environmental friendliness of gasoline engines also largely depend on the quality of the fuel used. When using low quality gasoline, engine starting and warming up deteriorate; increased fuel consumption and wear of parts of the cylinder-piston group, etc.

The problem of environmental safety is also acute in Uzbekistan. The amount of atmospheric air pollutants on a national scale in 2019 amounted to more than 2.5 million tons, of which motor transport accounts for over 65%, which is more than 3 times higher than the standards set for the level of air pollution in developed countries. Figure 2 shows the results of processing data on the state of air pollution in several regions of the republic. It can be seen that the main share of environmental pollution with harmful emissions falls on road transport. It should be noted that over the past 10 years, constant background air pollution with dust particles in the human inhalation zone is characteristic due to the climatic features of the republic's terrain.

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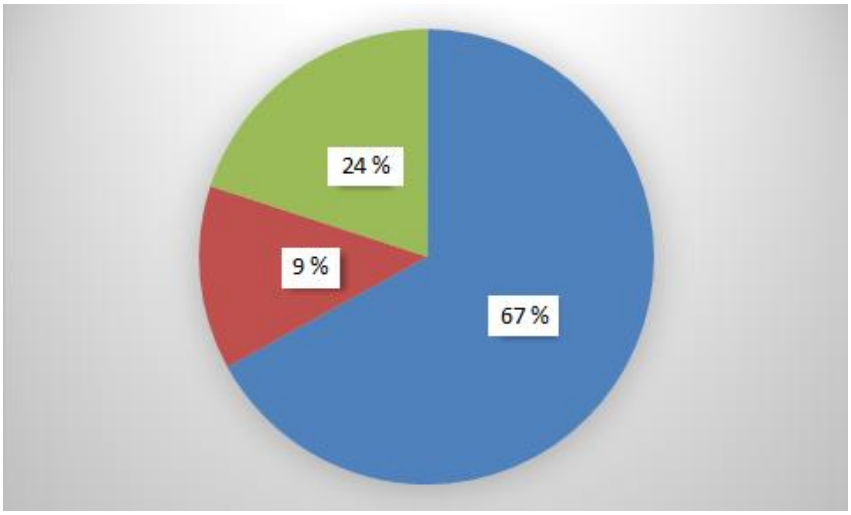

Fig. 2. Averaged structural components of air pollution by harmful substances in the republic:

- by car;
- dust curtain;
- industry.

Effective work is being carried out to solve this problem at the government level. The relevant strategic documents defining the goals in the field of combating air pollution and improving its quality were the National Action Plan for Environmental Protection and Health, a strategy for the sustainable development of work to reduce the share of harmful emissions from road transport into the atmosphere.

These strategic documents set the following main goals: reducing air pollution from transport and other mobile energy sources; improving the quality of various types of motor fuel; modernization and replacement of old vehicles, including trucks; improving the road network in major cities and other areas; replacement of leaded gasoline with unleaded gasoline, wider and later full use of natural gas as a motor fuel; increasing the role of technical inspections and strengthening control over the norms and standards for exhaust gases, as well as improving the work of auto repair services for public and private vehicles; introduction of state monitoring of the natural environment, including the state of air pollution in the surface layer of the atmosphere and at sources of emissions of pollutants. Motor fuels produced in the republic must also comply with Euro-3 environmental standards, in particular, for diesel fuel, the sulfur content should not exceed 0.035% by weight. However, today the fuel produced meets the environmental standards only Euro-2.

According to the draft resolution of the Cabinet of Ministers of the Republic of Uzbekistan "On strengthening measures to protect the environment in terms of reducing emissions of pollutants from vehicles", developed by JSC "Uzavtosanoat", the latter provides for the production and supply to the domestic market of the Republic of Uzbekistan of vehicles that meet the requirements of the ecological class " Euro-3 "by December 1, 2014 for subsequent circulation in the domestic market of the republic.

To improve the environmental performance of manufactured vehicles and limit pollutant emissions, national standards have been developed:

O'zDst - 35.49.11 "Uniform regulations concerning the measures to be taken to control the emission of pollutants gaseous substances and particulate matter from compression-ignition engines intended for use in vehicles, as well as the emission of gaseous pollutants from engines with positive ignition, fueled by natural gas or liquefied petroleum gas and intended for use in vehicles "(identical to UNECE Regulation No. 49 Revision 4 (document E / ECE / 324 - E / ECE / TRANS / 505 / Rev.1 / Add.48 / Rev.4 dated August 13, 2008);

-O'zDst -35.83.11 "Uniform provisions concerning the approval of vehicles with regard to emissions of pollutants depending on the fuel quality required for engines" (identical to UNECE Regulation: No. 83 Revision 3 (document E / ECE / 324 - E / ECE / TRANS / 505 / Rev.1 / Add.82 / Rev.3 dated 14 June 2005).

-In Uzbekistan, the phase-out of fuel of a class below Euro-4 begins [12];

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-From January 1, 2022, it is prohibited to import motor fuel of an ecological class below Euro-3, and from January 1, 2023 - motor fuel of an ecological class below Euro-4.

This is stated in the presidential decree "On approval of the concept of environmental protection of the Republic of Uzbekistan until 2030."

According to the document, it is prohibited:

• from January 1, 2020, the commissioning of new capacities for the production of motor fuel of an ecological class below Euro-4;

• from January 1, 2022, premises under the customs regime "temporary import" and "release for free circulation (import)" of motor fuel of ecological class below "Euro-3", and from 1 January 2023 - motor fuel of ecological class below "Euro-3" 4";

- there is no regulatory and legal framework in the republic based on specific rates of emission of pollutants into the atmosphere by emission sources; about 2% of leaded gasoline continues to be produced and used, which does not allow the use of catalytic converters of exhaust gases. The use of the latter, as the experience of developed foreign countries shows, would reduce emissions of pollutants by more than 50%;

- until now, the production of diesel fuel with a sulfur content of up to 1.2% continues, which ultimately leads not only to premature engine wear, but also to high concentrations of pollutants in the exhaust gases of cars.

Today, the European Union sets the next task to tighten environmental requirements for road transport, i.e., to completely eliminate harmful emissions from road transport by 2050, for which new regulations and rules, new standards and new sanctions for non-compliance are being introduced.

IV. CONCLUSION

The above data allow us to draw the following conclusions:

1. The problem of environmental safety of road transport and the reduction of harmful emissions is the most important task of our time, the solution of which is possible both by improving the engine design and improving the quality of the fuel.

2. The quality of the fuel used has a decisive influence on both the reliability of operation and the environmental performance of road transport.

3. When using fuel that meets Euro requirements instead of standard domestically produced fuels, the amount of weighted average harmful emissions is significantly reduced.

4. The volume of harmful emissions in Uzbekistan in 2019 amounted to more than 2.5 million tons, in which the share of road transport was more than 65%. The amount of pollutant emissions from cars from year to year remains unchanged. The Government of Uzbekistan is carrying out effective programs to reduce air pollution by harmful emissions from road transport.

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