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ARTICLE

JUSTIFICATION OF DIRECTIONS OF RESEARCH FOR ENSURING ENVIRONMENTAL INDICATORS OF ENERGY INSTALLATIONS OF TRANSPORT PURPOSE

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ABSTRACT

Energy installations of transport purpose for toxic emissions occupy the first place among all types of transport. In total there are over 650 million cars with internal combustion engines (ICE). Tighter environmental legislation on emissions of harmful substances with exhaust gases (OG) forces developers and engine manufacturers to look for new solutions to the organization of an effective workflow (RP). The complexity of the solution of this problem lies in a multitude of factors influencing the course of intra cameral processes, automobile diesel engines are operated in a wide range of load variations and the rotational speed of the crankshaft (CV), which significantly affect the course of the processes of mixture formation and fuel combustion in the cylinder. The use of multiphase fuel injection is one of the effective means of reducing emissions of toxic substances in diesel. The organization of a uniform distribution of fuel in the combustion chamber (CS) increases the self-ignition and combustion centers, thereby reducing the unevenness of the temperature field and reducing the number of high-temperature zones in the CS. Reducing the toxicity of diesel engines with direct injection of fuel is one of the most acute problems of engine building. Therefore, work is needed aimed at a more in-depth study of work processes that could meet environmental standards without significantly increasing the cost of diesel.

KEY WORDS
toxic substances, exhaust gas of diesel engines, engine parameters, environmental

INTRODUCTION

Emissions from road transport in Russia are about 20 million tons per year. The exhaust gases of ICE contain more than 200 names of harmful substances, including carcinogenic ones. Obviously, while there is fuel of oil origin, the growth of a car park with traditional engines will continue. Such an amount of harmful substances harms the health of mankind and the entire environment.

The purpose of the study is to justify the direction of research to ensure the environmental performance of power plants for transport purposes.

The objectives of the study are:

1. To conduct an analysis of ways to ensure the regulatory requirements of environmental indicators.
2. Substantiate the directions of research to ensure the environmental performance of automotive tractor diesels.
3. Systematize the main indicators of power plants for transport purposes, taking into account the requirements of the standard for toxicity and customer requirements.

METHODS

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Theoretical method of research directions to ensure environmental indicators of power plants for transport purposes. In the work, analytical studies of technical, economic and environmental indicators of serial and new vehicle designs were made with the aim of reducing emissions of harmful substances with exhaust gases.

Scientific novelty. Generalization of research directions to ensure legislative requirements for toxicity, taking into account the consumer characteristics of power plants for transport purposes.

The practical importance of the work is to justify the use of systems to ensure environmental quality indicators in power plants. The proposed recommendations can be implemented in the design of new, as well as currently produced power plants for transport purposes.

RESULTS AND DISCUSSION

The validity of the theoretical positions of the work is confirmed by experimental studies, reflected in the works of other authors on this topic.

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The use of motor transport in human life has become an integral part of social development. However, with motorization of society, such a serious social problem as pollution of the environment by harmful emissions of exhaust gases is associated [1]. In recent years, as a result of a significant increase in the car

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fleet, gross emissions of harmful substances by motor vehicles have increased significantly, which adversely affects the environment and human health. Therefore, environmental protection is one of the priority activities of governments of different countries [2].

A couple of decades ago, the purchase of diesel cars was positioned in Europe as an environmentally sound choice and was even encouraged in some countries by tax preferences. As a result of state policy, the share of such vehicles now in the car fleet of France reaches 80%, Spain 70%, in Britain exceeds 50%. The average in the EU is 55%. This is due to the higher efficiency and environmental safety of such engines, as well as the fact that more raw-materials (gas oil, fuel oil) are produced from oil for the production of diesel fuel than gasoline [3].

In some major cities with the largest number of vehicles per unit area, the content of harmful substances in the atmosphere has reached or is approaching a concentration dangerous to human health.
Scientists are trying to find a compromise between reducing the toxicity of exhaust gases and fuel consumption. The costly-ness of design decisions on these issues and their inherent shortcomings hinder their universal distribution.

According to experts, emissions of road transport to the atmosphere are up to 90% for carbon monoxide and 70% for nitrogen oxide.

The first legislative requirements for limiting emissions of toxic substances by diesel engines were issued in 1973 in California, and in all other US states - since 1974. These requirements limited the emissions of carbon monoxide and the sum of hydrocarbons and nitrogen oxides. Smoke rates were calculated when operating in diesel overclocking modes by external characteristic and the maximum value, respectively, 15, 20 and 50% on the Hartridge scale [5]. In 1990, the USA adopted the "Clean Air Act", which verifies the environmental performance of vehicles (ATS). It uses two basic test procedures: checking the concentration of carbon monoxide and hydrocarbons at idling speed; load tests to estimate emissions of nitrogen oxides and carbon black. The US legislation in the field of the environment from the harmful effects of motor vehicles has three main functional blocks: regulatory (standardization of environmental indicators of automatic telephone exchanges during their production and operation), administrative (organizational mechanisms for access, control and prohibition of ATS operation by environmental indicators) and economic sanctions and benefits that stimulate the production and use of more environmentally friendly automatic telephone exchanges) [6]. Since 1972, Regulations No. 24 of the United Nations Economic Commission for Evrope (ECE) have been in force in many Evropean countries, setting limits on the smokiness of exhaust gas for diesel engines. Prior to 1988, there were regulations that limit the emission of hazardous substances by trucks, established in accordance with the recommendations of the UNECE document - Regulation No. 49. The standards for emissions of harmful substances in accordance with the requirements of ECE Regulation No. 49 are presented in [Table 1].

Later these norms were called Evro-1. The Evro norms are periodically reviewed and tightened. Also, tougher requirements are imposed on diesel fuels. For example, the sulfur content of Evro-4 fuel is reduced by 40 times compared to fuel in accordance with GOST 305-82 [7].

The first technical regulation in the Russian Federation adopted in accordance with the Federal Law "On Technical Regulation" was a special technical regulation "On Requirements for Emissions of Harmful (Pollutant) Substances by Automotive Equipment Issued for Use in the Territory of the Russian Federation" approved by the Government of the Russian Federation from October 12, 2005 No. 609.

The technical regulation establishes mandatory emission requirements depending on the ecological class of automotive equipment. The fulfillment of these requirements must be ensured at the production stage. Assessment of compliance with the established requirements is carried out at the stage of issuance of vehicles, that is before their operation in the territory of the Russian Federation.

Table 1: Standards for emissions of harmful substances

EEHK OON №49	Specific emission of harmful substances, g / (kW • h)			
	NO_x	CO	C_mH_n	PM, (solid particles)
Evro-1 (before 01.10.1995 y.)	8,0	4,5	1,1	0,61
Evro -2 (after 01.10.1995 y.)	7,0	4,0	1,1	0,15
vro -3 (after 01.10.2000 y.) ESC ETC	5,0 5,0	2,1 5,45	0,66 0,78	0,1 0,1

Evro -4 (after 01.01.2005 y.) ESC ETC	 3,5 3,5	 1,5 4,0	 0,46 0,55	 0,02 0,03
Evro -5 (after 01.09.2009 y.) ESC ETC	 2,0 2,0	 1,5 1,5	 0,25 0,25	 0,02 0,03
Evro -6 (after 2015 y.)	0,5	1,5	0,13	0,01

One ESC – European Steady Cycle – steady-state tests;
ETC – European Transient Cycle – transient testing

The UNECE Regulations No. 24, 83, 49 and 96, as amended by various levels of amendments, referred to in paragraph 8 of the Technical Regulations, and which the Russian Federation is obliged to apply as a member country of the Geneva The 1958 Agreement. The establishment of requirements for different environmental classes through the UNECE Regulations harmonizes national Russian legislation with the legislation of the European Union, however, taking into account the current level of development of the domestic economy, the technical regulation provides for a phased transition to compliance with international standards for emissions of harmful substances. In particular, it is stipulated that the release of 100% of the automotive equipment of the ecological class (Evro-3) takes place from January 1, 2008, from January 1, 2010, the entry into force of the ecological class (Evro-4), from January 1, 2014 - ecological class (Evro-5).

The European Union pays special attention to the requirements of environmental safety of vehicles. Currently, three EU Directives No. 72/306, 88/77, 2005/55 in various versions are in effect in the European Union regarding environmental safety, which establish requirements for emissions of harmful substances with exhaust gases from engines of vehicles of categories N2, N3, M2, M3, as well as the ecological classification of vehicles by class - EVRO-3, EVRO-4, EVRO-5. In addition, these EU Directives set the time frame for the introduction of requirements for an environmental class. In particular, EVRO-3 standards have been established in Europe as mandatory since 2002 for vehicles of categories M2, M3, N2, N3, EVRO-4 standards have been introduced simultaneously for all vehicle categories since 2005. Currently, for vehicles of categories M2, M3, N2, N3, the EVRO-5 requirements are mandatory, which entered into force in 2008. These Directives, like many others operating in the EU, were prepared as a result of work similar to the one, which is carried out at the World Forum for Harmonization of Vehicle Regulations (WP.29) of the United Nations Economic Commission for Europe (UNECE), which resulted in the adoption of more than 120 Regulations annexed to the Geneva Agreement.

The working processes of engines, the problems of the formation of toxic substances in general and in OW DVS, in particular, have been and are being studied by many scientists: Bolotov AK, Brozet DD, Voinov AN, Gayvoronsky AI, Grekhov L. V., Zvonov VA, Zeldovich Ya.B., Zlenko M.A., Ivaschenko N.A. and others.

The products of combustion of hydrocarbon fuels, under normal conditions (atmospheric pressure, temperature) and complete oxidation, are water, carbon dioxide. Substances are not toxic. They account for 99 – 99,8% of the volume of exhaust gas [8]. The chemical formula of oxidation thus looks as:

$$C_mH_n + (m + n/4)O_2 = mCO_2 + (n/2)H_2O \quad (1)$$

Combustion of fuel in the actual working cycle of ICE differs from normal conditions in the first place:
- the time of the process, when the combustion of the fuel-air mixture (FA) occurs in a short period of time;
- the thermodynamics of the process, that is, the presence of high temperatures and pressures in the cycle;
- the amount of fuel and air involved in the combustion.

As a result, toxic components appear in the exhaust gases of the ICE, the content of which in the exhaust gas is 0,02-1% by volume. The main pollutants of the environment are products of incomplete combustion (carbon monoxide CO, hydrocarbons CH) and nitrogen oxides NOx. There are various options for assessing the severity of these substances on the environment [9]. What unites them is that nitrogen oxides are more toxic than unburned hydrocarbons, and CnHm is more harmful than carbon monoxide.

The change in the total toxicity of the engine from the composition of the mixture and the relative values of individual components in it is shown in [Fig. 1].

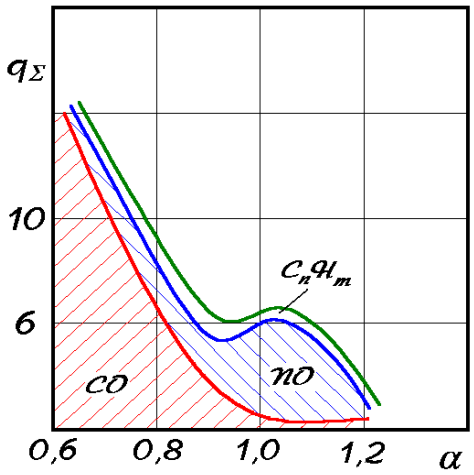

Fig. 1: Total toxicity of exhaust gases.

For α <0,85, the toxicity is mainly determined by the CO content.
For α> 1.0, the toxicity is determined by the NOx content.
At α = 0,90 ÷ 0,95 - the value of CO and NOx in the total toxicity is approximately the same.

The toxicity of diesel engines when operating at medium loads is practically determined by NOx. At high loads, soot is added to them. At low loads, NOx decreases, but CnHm increases.

In diesel engines normalized emissions of carbon monoxide CO, unburned hydrocarbons CnHm, nitrogen oxides NOx and PM solid particles (soot). Approximate composition of exhaust gases of diesel engines is presented in [Table 2]. When combustion of 1 kg of diesel fuel, about 80 ... 100 g of toxic components are released (20 ... 30 g of carbon monoxide, 4 ... 10 g of hydrocarbons, 20 ... 40 g of nitrogen oxides and other.) [9].

Table 2: Composition of exhaust gases of diesel engines

Components	Toxicity	Diesel
Nitrogen, %	-	76…78
Oxygen, %	-	2…18
Water vapor, %	-	0,5…4
Carbon dioxide, %	creates a greenhouse effect	1…10
Carbon monoxide, %	+	0,01…0,5
Nitrogen oxides, %	+	0,001…0,4
Hydrocarbons, %	+	0,01…0,5
Soot, г/м^3	can carry carcinogens	0,01…1,1

Emissions of carbon monoxide CO depending on the composition of the mixture are shown in [Fig.2]. The minimum CO emission is observed at Gm / Gb = 0.03, which corresponds to the air excess ratio α = 2,3.

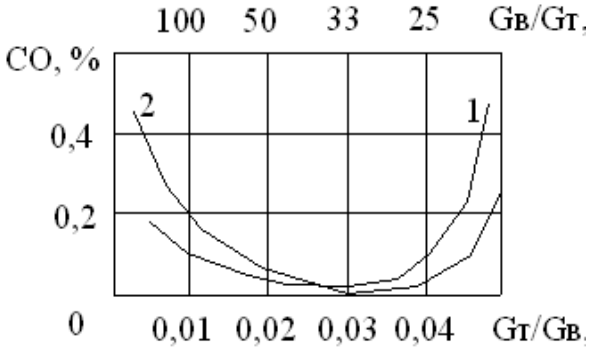

Fig. 2: Influence of mixture composition on CO emissions in direct injection diesel engines: 1 – supercharged diesel; 2 - diesel with free inlet.

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Thus, the main factors that determine the toxicity of diesel engines is the presence in their exhaust gases of nitrogen oxides and soot. The total share of these components in the total resulted emission of harmful substances is more than 95% (NOx accounts for 49,8%, for the Republic of Moldova – 44,9%) [9]. Consequently, the main task of reducing the toxicity of exhaust gasoline engines is to reduce the release of NOx and soot.

SUMMARY

As a result of the studies, the following conclusions can be drawn:

1. The analysis of ways of maintenance of normative requirements of ecological indicators of power installations of transport purpose, as a result of which it is revealed that the majority of them lead to complication of the engine systems demanding significant financial and time expenses.
2. The directions of the research are substantiated for ensuring the environmental performance of auto tractor diesel engines, which are solved in a complex manner and depend on constructive, regulating, regime and technological factors.
3. The main indicators of power plants for transport purposes are systematized taking into account the requirements of the toxicity standard and customer requirements that allow rational development of combined and hybrid power units based on internal combustion engines with original design solutions.

CONCLUSION

The paper summarizes the main directions of scientific research to ensure legislative requirements for toxicity, taking into account the consumer characteristics of power plants for transport purposes.

The review of the literature made it possible to draw the following conclusions:

1. The analysis of the stages of standardizing the values of the release of major explosives by international UNECE Regulation No. 49 (diesel engines for trucks and buses) and No. 83 (cars and commercial vehicles weighing up to 3,5 tons) was conducted.
2. The review of software complexes for modeling the working process of a diesel engine, which have the optimal capabilities for solving the tasks, has been reviewed.
3. It is established that the transition to higher environmental standards leads to a complication of the engine systems and its rise in price.
4. It is revealed that the task of increasing the technical and economic and environmental indicators is solved in a comprehensive manner. the engine performance depends on many factors: constructive, adjusting, regime, technological. It is accepted that it is necessary to carry out studies of the influence of each factor on the engine performance separately.

Also, analytical studies of technical, economic and environmental indicators of serial and new vehicle designs were made to reduce emissions of explosives from exhaust gases; The analysis of numerous studies on the operating modes of transport ICE in operation shows that they are characterized by frequent regime changes and a significant proportion of the idle and low load operation time; The analysis of factors determining the importance of ecological and economic parameters of internal combustion engines is carried out; Technical solutions aimed at achieving the required quality indicators, which allow to reduce the amount of harmful emissions, with simultaneous improvement of economic indicators are proposed; Priority directions for the conditions for preserving the urban air environment without pollution of explosives should develop the production of electric vehicles and vehicles with power plants operating on compressed air, cryogenic nitrogen and hydrogen [10].

To reduce air pollution, it is necessary to develop works on the development and creation of new technologies for obtaining energy carriers through renewable sources, combined and hybrid power units with original design solutions.

General conclusions and recommendations on further research for creating environmentally safe and energy efficient engines are formulated.

CONFLICT OF INTEREST
There is no conflict of interest.

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