ASSESSMENT OF NEGATIVE IMPACT OF AGRICULTURAL MOBILE ENERGY MEANS AND EURO-5 STANDARD

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Abstract: Environmental problems today are one of the most important and global indicators of human development. One of the consequences of the impact of agricultural machinery on natural resources is their pollution due to loss of fuel and lubricants and engine waste. The purpose of the research is to develop scientific and methodological bases for the selection of criteria for assessing the environmental safety of the diesel engine of an energy vehicle with the creation of an environmental safety management system. The scientific and methodological basis for assessing these factors is a systematic approach to solving environmental problems that arise during the operation of machine-tractor units and other agricultural energy resources. Estimation of the level of emissions of the main pollutants and toxic substances in exhaust gases can be defined by means of the regulatory characteristic of the engine depending on an operating mode of this engine. The optimal mode of operation of the engine YaMZ-236M2, from an environmental point of view, adopted 1450…1850 rpm. In this case, fuel consumption does not increase in this mode. It is possible to reduce the emissions of the most significant NOx exhaust element by limiting the engine speed to 90% of the nominal. CO and CH emissions at a given engine speed have not reached their maximum value.
KEY WORDS**:** *MACHINE-TRACTOR UNIT, EXHAUST GASES, POLLUTION, ENGINE, OPTIMUM, TRACTION CHARACTERISTICS, ECOLOGICAL SAFETY*

1. Introduction

Environmental problems today are one of the most important and global indicators of human development. Modern scientists and practitioners note that human impact on the ecosystem has reached such a scale that natural regulatory mechanisms are no longer able to independently neutralize this negative impact.

Objects of agricultural production have a negative chemical, biological, physical and mechanical impact on all major components of the environment: soil, water and air.

Thus, agricultural production in ecological terms causes the manifestation of some processes, which are expressed in the pollution of surface and groundwater, soil erosion and degradation of natural landscapes. Agricultural facilities are livestock farms, agricultural lands, technologies, technical means used in the production and processing of products, transport, warehouses, storage facilities, energy facilities, repair and storage sites. The cause of environmental pollution is emissions of harmful substances from mobile sources and stationary facilities of the agro-industrial complex, including livestock, processing and repair and maintenance enterprises.

Intensive technologies are increasingly used in agricultural production, which include multiple passes through the field of powerful and heavy machine-tractor units (MTU), combine harvesters, technological trucks and mobile vehicles. All this leads to an imbalance of the natural environment.

At the same time, the negative impact of MTU occurs in the following areas: exhaust emissions of internal combustion engines, soil compaction and destruction of its structure as a result of the impact of the running systems of mobile energy resources and tillage implements.

In the twentieth century, the degradation of the fertility of the land fund became an objective factor. The amount of humus decreased by 25%. At present, the amount of humus in the soils of Ukraine varies from 3.5% to 3.%, which is 1…2% below the optimum. All the above leads to a decrease in crop yields by 15…20%.

There is a real danger of disturbing the natural and ecological balance (ecosystem) from the deterioration of soil structure, wind and water erosion, pollution of water bodies (water sources) with toxic substances, residues of mineral fertilizers and pesticides.

High density leads to deterioration of physical and biological properties of the soil, it complicates the penetration of roots into the lower horizons and moisture, nutrients remain inaccessible to plants, deteriorating living conditions of microorganisms.

One of the biggest factors of environmental pollution is the tractor fleet [2].

One of the consequences of the impact of agricultural machinery on natural resources is their pollution due to loss of fuel and lubricants and engine waste.

To prevent this negative impact, it is necessary to equip machine yards with washing machines, oil filters for wastewater treatment from oil impurities; timely and at a high technical level to conduct technical inspections, current and major repairs that would prevent the leakage of oils and fuels; correctly regulate fuel equipment and ignition of technical means, tanks with oil products to be installed underground, which in comparison with ground placement significantly reduces losses due to evaporation. Control over engines and fuel systems should be strengthened by regulating the supply of fuel and lubricants, preventing it from leaking.

Table 1. Exhaust gas components and their content [2]

Component	Chemical formula	Amount, %
Nitrogen	N_2	74
Oxygen	O_2	10
Carbon dioxide	CO_2	7
Water vapor	H_2O	5
Benzapyrene	C_2OH_{12}	1.771
Soot	PM	1
Nitrogen oxides	NO_x	0.5
Carbon oxides	CO	0.4
Hydrocarbons	CH_x	0.3
Sulfur oxide	SO_2	0.02
Aldehyds	R_xCHO	0.009

All this requires a comprehensive consideration and solution of this economic problem [5, 6]. However, its implementation is almost impossible without solving the relevant scientific and technical problem. Its essence is a comprehensive study and assessment of the impact of MTU on the environment and the development of environmental criteria to manage environmental safety in the operation of MTU.

The purpose of the research is to develop scientific and methodological bases for the selection of criteria for assessing the environmental safety of the diesel engine of an energy vehicle with the creation of an environmental safety management system.

2. Preconditions and means for resolving the problem

When performing mechanized technological processes in agricultural production, agricultural units are one of the main

objects of negative impact on the environment. At operation of cars distinguish the following indicators of ecological safety:

a) exhaust emissions through the exhaust pipe of a tractor or agricultural machinery. Exhaust gases (or exhaust gases) - the main source of toxic substances in the internal combustion engine - is an inhomogeneous mixture of various gaseous substances with different chemical and physical properties, consisting of products of complete and incomplete combustion of fuel, excess air, aerosols and various micro-impurities (as gaseous, and in the form of liquid and solid particles) coming from the engine cylinders into its exhaust system. They contain about 300 substances, most of which are toxic. The main normalized toxic components of engine exhaust gases are oxides of carbon, nitrogen and hydrocarbons. In addition, with exhaust gases into the atmosphere enter the limiting and non-limiting hydrocarbons, aldehydes, carcinogens, soot and other components.

b) acoustic effects (external and internal noise (in the driver's cab) generated by the tractor (agricultural machine). High noise load not only causes functional disorders of individual body systems, but also leads to an increase in the incidence of cardiovascular, nervous and other diseases. Prolonged noise adversely affects a person, causing headaches, dizziness, diseases of the nervous and cardiovascular systems, dysfunction of the gastrointestinal tract and metabolic processes in the body.

c) specific pressure on the ground of the machine engines. The problem of soil compaction in recent decades has been put forward as one of the first places in a number of anthropogenic impacts on the environment. Overcompaction leads to the strengthening of the main anthropogenic factor of soil and landscape degradation - water and wind erosion. Soil compactions containing little organic matter are most prone. During irrigation, high-humus chernozems will be compacted. The main reason for soil compaction is the high man-made load on them against the background of intensive degumification of the arable horizon. Agrotechnical, organizational-technological and technological measures are used to reduce the negative consequences of overcompaction [4].

d) vibrations on the steering wheel and on the seat of the tractor operator (machine). In agricultural production, the sources of vibration are mobile units used in the repair of technological equipment, as well as mechanized tools. Prolonged exposure to vibration on the body leads to disorders of the nervous system, changes in blood vessels and the vestibular apparatus. Local vibration affects the neuromuscular and musculoskeletal system, leads to spasms of peripheral blood vessels [7].

e) leakage of engine, transmission and hydraulic oil, diesel fuel, coolant;

f) *CO* content in the air of the working area of the tractor operator or agricultural machine (cab tightness).

Introduction of the environmental safety factor of MTU operation. The scientific and methodological basis for assessing these factors is a systematic approach to solving environmental problems arising from the operation of MTU and other agricultural energy resources.

Currently known [1, 2, 3] studies that consider the impact of technology on soil degradation, as well as work [1] that studies the deterioration of environmental safety from harmful emissions of internal combustion engines.

The generalized environmental safety factor (GF_{es}) [1] from the impact of MTU can be assessed by five categories of environmental safety (ES) of tractors and agricultural machinery:

1) Higher or promising. Environmental safety factor (GF_{es} <0.90). MTU on the basic or on the majority of indicators satisfies values of perspective or international norms. Suitable for use;

2) Good (GF_{es} <0.95). MTU meets all environmental requirements of domestic standards. Promising for internal use;

3) Satisfactory (GF_{es} <1.2). MTU can be used in the production of agricultural products. In the future it is subject to modernization;

4) Unsatisfactory (GF_{es} = 1.2). MTU is not to be used. Urgent modernization or its removal from work is required, after emergence of the corresponding replacement for this unit;

5) Inadmissible (GF_{es} > 1.2). Urgent exclusion of MTU from production is required.

When designing an MTU, it may be necessary, only for environmental indicators, to determine the possibility of implementing or not new technical solutions for this unit. To do this, it will be necessary to use a comprehensive environmental assessment for five categories of environmental safety.

Environmental Euro standards for harmful emissions of exhaust gases from internal combustion engines.

In the 1990s, European environmentalists sounded the alarm. In the cities of the old world, the content of harmful substances emitted by cars rose sharply, which became more and more every day. Europeans have become hostages of urbanization, and their futures have become increasingly hazy, as has the air in cities. The UN was forced to act, and set up a commission to assess the situation and find a way out. The results of the commission's assessment were not encouraging: emissions of hydrocarbons, nitrous oxide, carbon dioxide and heavy substances threatened to lead to very sad consequences in the near future.

"Euro" is an environmental standard that regulates the content of harmful substances in the exhaust gases of vehicles with diesel and gasoline engines. After all, car emissions include more than 200 different chemicals (carbon dioxide, sulfur dioxide, aldehydes, soot, lead compounds) that enter the environment. Some of them have a toxic effect.

The development, organization of production and introduction of new automotive fuel have always been the result of a compromise between motorists and refiners. Motorists formulated requirements for fuel performance based on the parameters of work processes developed by engines, and refiners tried to correlate the possibility of meeting these requirements with the technical capabilities of plants, the need to ensure fuel efficiency and complete use of hydrocarbons. To ensure the proper operation of car engines, gasoline and diesel fuels must meet a set of requirements based on their purpose, environmental safety and sustainability. Environmental requirements for the mobile vehicle and its engine are currently a priority. Ecological purity of an exhaust is put in a design of the engine and mobile means as a whole at design. Further in operation, the toxicity characteristics must remain stable. Toxicity regulation in modern car engines is in most cases either not required or severely limited. At the same time, in car engines of previous years of production, especially with carburetors, the toxicity of the exhaust is directly related to the technical condition of the power supply and ignition system and their regulation. Therefore, currently the repair of the engine, no matter how complex it may be, can not be considered qualified and high quality, if the toxicity of the engine exhaust after the repair exceeds the established permissible limits.

Until recently, Ukraine had a Euro-1 system that limited emissions of mobile substances from mobile vehicles. This has significantly strengthened environmental safety, although over time the number of vehicles on state roads has increased, and this has required stricter regulations. Ukraine's transition to the new Euro-2 standards has been implemented since January 1, 2006 in accordance with the Law of Ukraine "On Some Issues of Importing Vehicles into the Customs Territory of Ukraine". Euro-2 standards have tightened the requirements for the quality of fuel consumed by a mobile vehicle and for the content of harmful impurities in exhaust gases. According to the current legislation from 2010, all mobile vehicles at the first registration must comply with the environmental standards of "Euro-3", which will reduce emissions of carbon oxides and nitrogen oxides - by 40%, and carcinogenic solids - by 50%. From January 1, 2012, the requirements for vehicles have intensified, and imported and manufactured in Ukraine vehicles under commodity codes 8701 20, 8702, 8703, 8704, 8705 must comply with environmental standards not lower than the level of "Euro-4".

State Committee for Technical Regulation and Consumer Policy (№ 244 of October 3, 2007) new national standards "Gasoline for high-quality cars" and "High-quality diesel fuel" came into force in Ukraine on January 1, 2008, which fully meet the

requirements "Euro-3" and "Euro-4". These standards regulate fuel standards, namely standard fuels contain five times less benzene, which is a strong toxic solvent, half the concentration of actual resins, which causes engine wear, and five times less sulfur, which causes corrosion of metals. . But only a few domestic refineries are able to produce fuel of appropriate quality, so it is mainly imported.

With the signing of the agreement with the EU, Ukraine has committed itself that from January 1, 2016 in Ukraine will be banned the use of fuels that do not meet Euro-5 environmental standards.

This standard was introduced in Europe in 2009 and it prohibits import of cars that have been in use for more than 5 years.

Euro-4 is an environmental standard that regulates the content of harmful substances in the exhaust gases of cars, introduced in the European Union in 2005.

The Euro-4 certificate confirms the compliance of a car or any other vehicle with European environmental standards, the main indicator of which is the level of emissions of harmful substances - carbon dioxide, nitrogen oxides and hydrocarbons, etc. (Table 2).

Table 2. Toxicity standards for heavy-duty diesel engines, g/m^3

Stantard	Content in exhaust gases, g/m^3		
	NOx	CH	CO
Euro - 0	15.8	2.6	12.3
Euro - 1	8.0	1.1	4.45
Euro - 2	7.0	1.1	4
Euro - 3	5.0	0.66	2.1
Euro - 4	3.5	0.46	1.5
Euro - 5	2.0	0.46	1.5

In 2018, Euro-6 environmental norms should come into force in our country, which is provided by the latest version of the Law of Ukraine "On some issues of importation into the customs territory of Ukraine and registration of vehicles."

3. Results and discussion

Research of influence of a mode of work of the diesel engine on an example of the regulatory characteristic on indicators of ecological safety.

Ensuring environmental safety in agricultural production becomes especially important in connection with the constant development of the agro-industrial complex and, as a consequence, the strengthening of harmful effects on the environment. The technical condition of the internal combustion engine has an extremely strong influence on the carcinogenic hazard of the exhaust gases of mobile vehicles.

Also, the coefficient of ecological safety of mobile energy means is significantly influenced by the quantitative and qualitative composition of combustion products of the working fuel-air mixture, which is determined by the processes of fuel supply, mixing, evaporation, combustion, compression and expansion, and well-organized workflow. Each of the components of the exhaust gases has its own characteristics of the physical and chemical processes of formation and decomposition. Knowing the composition of exhaust gases, you can with a high degree of probability to analyze the nature of the combustion process. At the same time, CH emission characterizes the size of the flame extinguishing zones and the amount of fuel not involved in combustion, CO emission - the amount that did not fully react due to lack of oxygen in the oxidation zone, NOx emission - the volume of the combustion products zone with high temperatures. It should take into account not only the absolute values of the concentration of harmful substances in the exhaust gases, but also the nature of their changes depending on the mode of operation or regulation. For example, a decrease in NOx emissions with increasing load characterizes the moment of a sharp improvement in the mixture, which leads to a decrease in temperature in the combustion zone due to the intensification of the soot formation process, and to a lack of oxygen in the combustion products zone.

As we have defined earlier, the main pollutants and toxic substances that are subject to the strictest control include:

- Carbon monoxide (CO);
- Nitric oxide (NOx);
- Carbohydrates (CH).

To determine the amount of harmful substances in the environment, we accepted for analysis one of the most common in the south of Ukraine tractor series HTZ-170 with YaMZ-236M2 engine.

Estimation of the level of emissions of the main pollutants and toxic substances in exhaust gases can be defined by means of the regulatory characteristic of the engine depending on an operating mode of this engine. For clarity, you need to build a regulatory characteristic of the engine YaMZ-236M2. The corresponding required calculation parameters are presented in table. 3.

Table 3. Parameters for construction of the regulatory characteristic

n_d / n_n,	1.06	1.03	1	0.9	0.8	0.7	0.6	0.5
Engine speed n_d, rpm	2226	2163	2100	1890	1680	1470	1260	1050
Engine power N_e, kW	0	60.75	121.5	124.74	116.75	105.4	91.7	76.25
Torque moment M, N·m	0	276.2	552.5	630.3	663.70	685.3	695.3	693.5
Fuel consumption G, kg/h	6.38	13.8	21.26	21.06	19.41	17.63	15.73	13.67
Specific fuel consumption g_e, g/kWh	455	227.5	175.00	168.87	166.25	167.125	171.5	179.37

Since we in the second section by approximation found the theoretical dependences of the change in the amount of CO, NOx and CH depending on the engine load, the total emissions are presented in table 4.

Table 4. Dependence of diesel engine emissions on its power

Engine power, kW	0	47.2	94.4	96.9	90.7	82.0	71.3	59.3
CO, g/m^3	1.110	1.288	1.823	1.862	1.768	1.648	1.516	1.391
CH, g/m^3	0.523	0.620	1.230	1.272	1.171	1.036	0.885	0.738
NOx, g/m^3	0.250	2.539	2.278	2.103	2.496	2.852	3.014	2.898

Using a computer and Excel, you can present the control characteristics of the diesel engine with graphs of CO, NOx and CH emissions (Fig. 3.1 - 3.4).

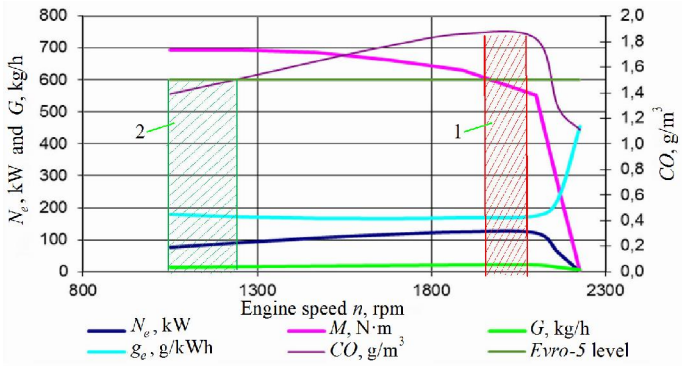

Fig.1. Dependence of CO emissions on engine operation mode: 1 - the range of maximum CO emissions; 2 - the range of permissible CO emissions according to the environmental safety standards of Euro-5

In fig. 1 shows the area in which the engine operation mode is shown: its power, speed, fuel consumption, which meets the environmental standard Euro-5 for CO, also shows the range of maximum carbon monoxide emissions. Received a mode of operation of the tractor engine up to 1250 rpm, where its carbon monoxide emissions meet the standard of environmental safety.

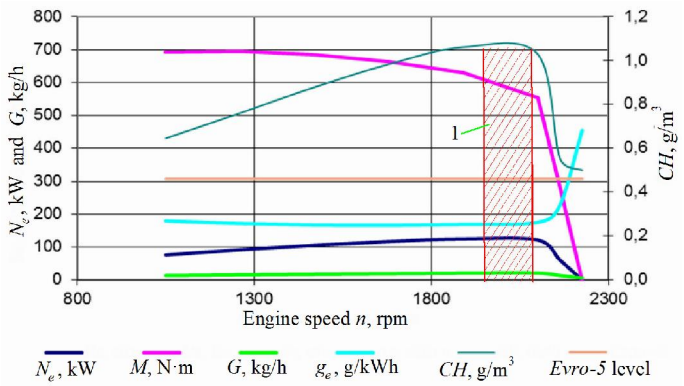

Fig. 2. Dependence of CH emissions on the engine operation mode: 1 - range of maximum CH emissions

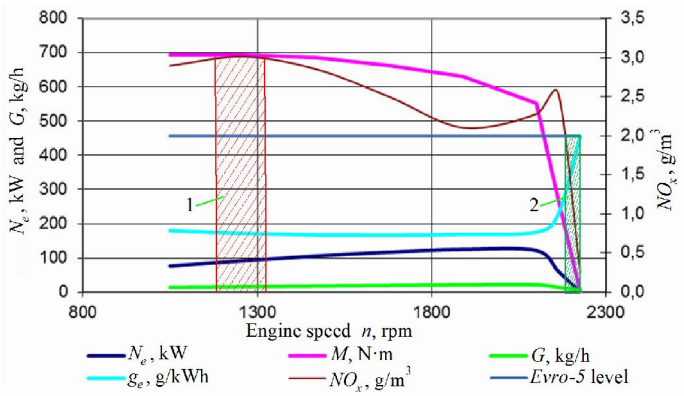

Fig. 3. Dependence of NOx emissions on the engine operation mode: 1 - the range of maximum emissions; 2 - range of permissible NOx emissions according to Euro - 5 environmental safety standards

In fig. 2 - 3 we see that the standards of Euro-5 CH and NOx are quite high, and we can not meet them in those modes of operation of mobile vehicles that are acceptable for environmental safety.

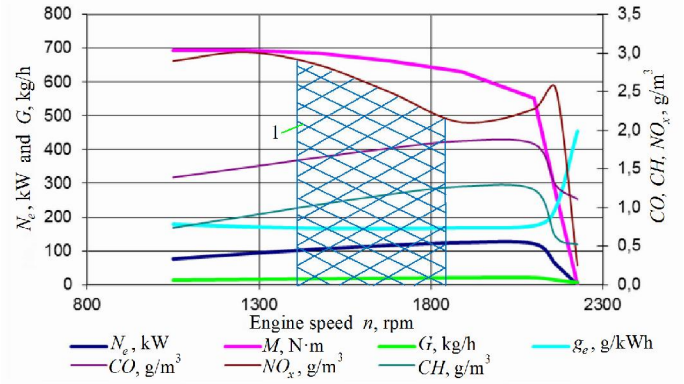

Fig. 4. The general dependence of CO, CH, NOx emissions on the engine operation mode: 1 - the range of optimal operation of the mobile vehicle in terms of the amount of CO, CH, NOx emissions

In fig. 4 shows the area that we accept as optimal for the operation of the tractor from an environmental point of view. As the indicators of carbon monoxide and hydrocarbons begin to increase, while slightly exceeding their parameters, and the rate of nitric oxide decreases, thereby compensating for the growth of other components of exhaust gases.

It follows that the accepted mode of operation of the engine in terms of speed can be considered 1450…1850 rpm, at average power and average load of the mobile vehicle, while fuel consumption does not increase in this mode.

Analysis of the dependence of CO, CH, NOx emissions on the traction characteristic of the tractor.

The main indicators of the tractor in gears are usually presented in the form of traction characteristics.

Traction characteristic is a set of dependences of traction power, speed, fuel consumption, engine shaft speed, and others. characteristics of the traction or transport machine from the traction force. Traction characteristics allow you to assess the dynamic, economic, etc. performance of machines and is determined by calculation or traction tests. It depends on the engine power, the type of engine, the weight of the vehicle and the physical and mechanical properties of the surface on which the movement takes place. Based on the characteristics, calculations are also made on the rational combination of traction machines with various agricultural and industrial implements.

Analyzing the obtained graphs (Fig. 1-3) in the light of the current implementation of new standards for emissions of harmful gases CO, NOx and CH, we can see that with increasing load and speed of the engine YaMZ-236M2 there is an increase in CO and CH emissions, up to nominal mode engine. At the same time, the content of NOx compounds in the exhaust gases, under the same conditions, decreases to 1890 rpm, in this mode the engine can develop a maximum power of 124.7 kW (Fig. 5), which is 96.93% of the nominal value of 128.7 kW (Fig. 5). .

Since the use of a tractor at a certain optimum involves a corresponding reduction in engine power, it will change the traction properties of the tractor. To compare the obtained new characteristics of the tractor with the nominal operating mode *Ne*, respectively, we will build a traction characteristic for the nominal and new operating modes.

Since the limitation of engine power will also change the performance of the tractor, it is advisable to compare them at different levels of power developed by the engine.

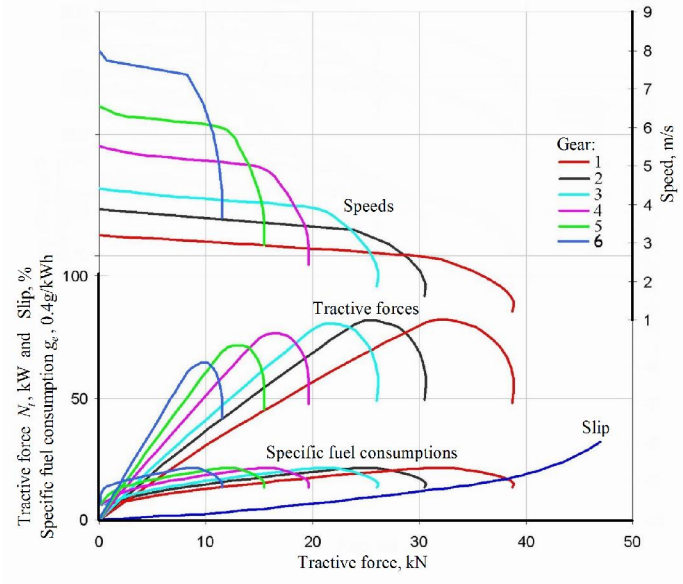

Fig. 5. Traction characteristics of the engine at rated power N_e = 124.7 kW

Thus, there is a possibility of a significant reduction in emissions of the most significant volume and weight of the NOx exhaust element, if you limit the engine speed to 90% of the nominal. There will also be a reduction in CO and CH emissions, because at this value their volumetric amount has not reached its maximum value..

4. Conclusions

1. It is proved that the assessment of the level of emissions of major pollutants and toxic substances in exhaust gases can be performed using the regulatory characteristics of the engine depending on the mode of operation.

2. To comply with the Euro-5 standard, the mode of operation of the YaMZ-236M2 engine for CO emissions should not exceed 1250 rpm.

3. Euro-5 standards for CH and NOx emissions are quite high, so the engine YaMZ-236M2 can not meet them in any mode of operation of mobile vehicles.

4. The optimal mode of operation of the engine YaMZ-236M2, from an environmental point of view, adopted 1450…1850 rpm. In this case, fuel consumption does not increase in this mode.

5. With increasing load and speed of the engine YaMZ-236M2 there is an increase in emissions of CO and CH, up to the nominal mode of operation of the engine. The amount of NOx compounds in the exhaust gases, under the same conditions, decreases to 1890 rpm. At such speeds, the engine can develop a maximum power of 124.7 kW, which is 96.93% of the nominal value of 128.7 kW.

6. It is possible to reduce the emissions of the most significant NOx exhaust element in terms of volume and weight by limiting the engine speed to 90% of the nominal. CO and CH emissions at a given engine speed have not reached their maximum value.

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