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POLLUTION OF AIR WITH EXHAUST GASES OF INTERNAL COMBUSTION ENGINE (ICE) VEHICLES AND ACTIONS TO REDUCE THEIR TOXICITY

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Abstract

Growing number of vehicles and other means of transportations causes serious negative effect. Air pollution refers to the contamination of atmospheric air due to the presence of some substances and gases (from anthropogenic or natural sources) which have harmful and poisonous effects. It is one of the most dangerous forms of pollution.

Clean vehicle and fuel technologies provide us with an affordable, available means of reducing transportation-related air pollution and climate change emissions. These include fuel-efficient vehicles that use less oil; cleaner fuels that produce fewer emissions; and electric cars and trucks that can entirely remove tailpipe emissions.

Keywords: Air pollution, exhaust gasses, ICE, hydrocarbons, fuel, environment, vehicles, toxicity, nitrogen oxide

ЗАГРЯЗНЕНИЕ ВОЗДУХА ОТРАБОТАННЫМИ ГАЗАМИ ДВС АВТОМОБИЛЕЙ И МЕРОПРИЯТИЙ ПО СНИЖЕНИЮ ИХ ТОКСИЧНОСТИ

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Аннотация

Рост числа транспортных средств и других транспортов вызывает серьезный негативный эффект. Загрязнение воздуха относится к загрязнению атмосферного воздуха из-за присутствия некоторых веществ и газов (из антропогенных или природных источников), которые оказывают вредное и ядовитое действие. Это одна из самых опасных форм загрязнения.

Технологии экологически чистых транспортных средств и топлива обеспечивают нам доступное средство для снижения загрязнения воздуха, связанного с транспортировкой, и выбросов в результате изменения климата. К ним относятся экономичные автомобили, которые используют меньше масла; более чистые виды топлива, которые производят меньше выбросов; и электрические автомобили, и грузовики, которые могут полностью удалить выбросы выхлопной трубы.

Ключевые слова: Загрязнение воздуха, выхлопные газы, ДВС, углеводороды, топливо, окружающая среда, автомобили, токсичность, оксид азота

Introduction

The main cause of air pollution is incomplete and uneven combustion of fuel (gasoline, diesel fuel, engine oil) in the combustion chamber of internal combustion engines.

Only 15% of it is spent on car movement, and 85% is useless, i.e. **"Flies to the wind."**

In addition, the combustion chamber of an ICE is a kind of chemical reactor that synthesizes toxic substances and re-

leases them into the atmosphere.

Even **innocent nitrogen** from the atmosphere, entering the combustion chamber of the ICE, is converted into toxic nitrogen oxides.

The exhaust gases of the internal combustion engine contain over 170 harmful components, of which about 160 are derived hydrocarbons, with the appearance of which incomplete combustion of fuel (gasoline, diesel fuel, etc.) occurs in the ICE.

The presence in the exhaust gases of harmful substances associated with the type and conditions of combustion.

Table 1 shows the indicators of the consumption of motor fuels and emissions of exhaust gases (EG) by various types of internal combustion engines.

Table 1. Consumption of motor fuels and exhaust emissions by various types of internal combustion engines [2]

№	Types of vehicles	Total power %	Fuel consumption		Exhaust emissions to the atmosphere	
			%	million tons	%	million tons
1.	Automobiles	50	56,5	65,0	71,3	21,7
2.	Agricultural and forestry machines	20	23,5	27,0	17,8	5,4
3.	Railway	16	11,0	12,6	6,3	1,9
4.	River	8	5,9	6,8	2,6	0,8
5.	Road construction	4	1,9	2,2	1,3	0,4
6.	Aviation	2	1,2	1,4	0,7	0,2
Total:		**100**	**100**	**115,0**	**100**	**30,4**

Exhaust gases, wear products of mechanical parts and tires of automobiles, as well as road surface compose about half of atmospheric emissions of anthropogenic ***(atmosphere pollution*** - *compounds of organic origin entering the atmosphere mainly from anthropogenic sources (land vehicles, internal combustion engines, fuel combustion, etc.))* sources.

The most investigated are emissions of exhaust gases of the internal combustion engine (both gasoline and diesel).

The composition of these emissions, in addition to nitrogen, oxygen, carbon dioxide and water, includes such harmful components as carbon monoxide, hydrocarbons, oxides of nitrogen and sulfur, oil and gas soot, solid nanoparticles.

The composition of the exhaust gases depends on the type of applied fuel lubricants (gasoline, diesel fuel, engine oil, etc.), added additives (quinones, quinolines, etc.) and the operation mode of the internal combustion engine, its technical condition, traffic conditions of cars, etc.

The toxicity of waste (exhaust) gases in gasoline internal combustion engines is determined mainly by the content of carbon monoxide and nitrogen oxides, and diesel ICE is caused by nitrogen oxides and soot (see Table 2).

Among the harmful components are solid emissions containing lead and soot, on the surface of which cyclic hydrocarbons are adsorbed (some of them have carcinogenic properties).

The pattern of distribution in the environment of solid emissions differs from the pattern characteristic of gaseous emissions.

Large fractions (with a diameter of more than 1 μm), settling near the center of emission on the surface of plants and soil, ultimately accumulate in the upper soil layer.

Small fractions (with a diameter of less than 1 μm) form aerosols and spread with air masses over longer distances.

If, to imagine **more in details**, the composition of the basic chemical elements of the **exhaust** (waste) gases of the ICE as [2]:

1. **"Inorganic gaseous compounds"** - H_2O, CO, NH_3, CO_2, NO_x, H_2S, H_2, SO_x, HCN, O_2, and etc...,

2. **"Dispersed particles" -** carbon, fuel aerosols, SiO_2, FeO_X, H_2SO_4, connections Pb, connections Ca, Ba, Mg, Cr, Al and etc...,

3. **"Organic compounds" -** alkanes, aldehydes, alkenes, alcohols, cyclins, ketones, polyaromatic hydrocarbons, ethers, phenols, organic acids, organic amines, organic amides, etc.

It is not difficult to make sure that all these chemical (poisonous) elements and compounds invariably settle on the ground, plants, trees, irrigation water for irrigation of plants, vegetables (radishes, tomatoes, cucumbers, melons and gourds, etc.) and others.

Table 2. Composition of exhaust (waste) gases of ICE, % (by volume) [1]

№	Components	Engines	
		Petrol	Diesel
1.	Nitrogen	74 ÷ 77	76 ÷ 78
2.	Aldehydes	0 ÷ 0,2	0,001 ÷ 0,009
3.	Benzo-a-pyrene, mgcal/m^3	10 ÷ 20	up to 10
4.	Carbon dioxide	5 ÷ 12	1 ÷ 10
5.	Oxygen	0,3 ÷ 8	2 ÷ 18
6.	Nitric oxide	0 ÷ 0,8	0,0002 ÷ 0,5
7.	Carbon monoxide	5 ÷ 10	0,01 ÷ 0,5
8.	Water vapor	3 ÷ 5,5	0,6 ÷ 4
9.	Soot, gr/m^3	0 ÷ 0,4	0,01 ÷ 1
10.	Hydrocarbons	0,2 ÷ 3	0,009 ÷ 0,5

And the animal world, of course, consumes water, grass, vegetables, fruits, etc. from those deposited by chemical (poisonous) elements.

Of course, the animal world gives people milk, meat - which are saturated with all these toxic chemical elements, harmful gases of gasoline and diesel ICE of automobiles and other land vehicles.

Undoubtedly, we ourselves also, sometimes without observing sanitary hygiene, consume fruits (cherries, apples, pears, grapes, etc.), vegetables (radishes, tomatoes, cucumbers, melons and others, etc.).

Of course, we - people (adults and children) consciously and with love use the various dairy and meat products of these animals.

Meat products might be boiled, fried, smoked, etc. Who will guarantee that these milk and dairy products, meat and meat products are environmentally friendly products for the peaceful use of people?

This chain can still be continued, as far as the above-mentioned composition of harmful exhaust gases of internal combustion engines of cars pollute the world around us, and how seriously they affect the health of people and the animal world.

If we take into account the **annual growth in the number of cars** that will continue to grow and grow, the ecology (toxicity and carcinogenicity) of the city and the republic as a whole will be catastrophically dangerous to the health of the population and wildlife in the near future.

Because of such changes occurring in the environment, specialists and employees of automobile enterprises began to get sick more often (especially drivers, mechanics, electricians, etc.) with "**professional**" diseases, which are currently difficult to treat.

Therefore, we all need to **strictly comply** with the established requirements and standards to limit the use of exhaust gases of ICE of automobiles, etc.

Primary weighted particles (WP) are those that are emitted directly into the atmosphere, meanwhile secondary WPs are formed in the atmosphere after oxidation and transformation of precursor gases (mainly SO_x, NO_x, NH_3 and some volatile organic compounds (VOC).

Table 2 lists the ten components of the main air pollutants of the petrol and diesel engines of the United Nations, carbon monoxide, marked with the silhouette of the car, ranks second.

Diesel engine is more economical than gasoline by 20 ÷ 30%. Moreover, the production of diesel fuel requires 2.5 times less energy than for the production of gasoline. It turns out as if double energy savings.

This explains the rapid growth in the number of cars operating on diesel fuel.

Moving at a speed of 80 ÷ 90 km/h on average, the car turns into carbon dioxide as much oxygen as 300 ÷ 350 people. But it's not just carbon dioxide.

The annual exhaust of a car's ICE is 800 kg of carbon monoxide, 40 kg of nitric oxide and more than 200 kg of various hydrocarbons. In this set **carbon monoxide** is highly insidious.

Due to its high toxicity, its permissible concentration in ambient air should not exceed 1 mg/m3.

There have been cases of the tragic death of people who started the cars with the garage door closed. In a single-seat-

er garage, a lethal concentration of carbon monoxide occurs as early as 2 - 3 minutes after the starter is switched on [1].

In the cold season, stopping to stay overnight on the side of the road, inexperienced drivers sometimes turn on the engine for heating the car. Due to the penetration of carbon monoxide into the cabin of the car, this overnight stay may be the last.

Carbon monoxide is one of the products of incomplete combustion of fuel (benzene, diesel fuel).

Nitric oxide is formed as a result of nitrogen oxidation at high temperatures and pressures developed in the combustion engine of the internal combustion engine.

Hydrocarbons are mainly represented by unburned components of fuel and motor oils (MO), as well as compounds formed during the combustion of the air-fuel mixture in the combustion chamber of the ICE.

Dispersed particles (DP) - are represented by the entire set of compounds that are in the condensed state in the exhaust path of the engine. The basis of DP is soot, on the surface of which carcinogenic substances may be present.

Nitrogen oxides are toxic to humans and, in addition, they are irritating.

Particularly dangerous component of exhaust gases are carcinogenic hydrocarbons, which are detected primarily at intersections at traffic lights (up to 6.4 μg/100 m3, which is 3 times more than in the middle of the quarter).

When using leaded gasoline, the automobile ICE releases lead compounds. Lead is dangerous because it can accumulate both in the external environment and in the human body.

The level of gas content in highways and in main areas depends on the intensity of traffic (with ICE operating on gasoline and on diesel fuel, etc.), the width and topography of the street, wind speed, the share of freight transport and buses in the general flow and other factors.

When the intensity of movement of 500 transport units per hour, the concentration of carbon monoxide in an open area at a distance of 30 ÷ 40 meters from the highway decreases 3 times and reaches the norm [1].

Difficult to disperse harmful emissions of cars on cramped streets with tall trees and buildings. As a result, almost all city residents experience the harmful effects of polluted air.

Temperature inversions (reflection) significantly affect the speed of pollution and concentration in certain areas of the city. In general, they are typical, as a rule, in calm weather (75% of cases) or in light winds (from 1 to 4 m/s). The inversion layer acts as a screen, from which harmful substances are reflected on the earth as a torch, with the result that their surface concentrations increase several times.

Of the metal compounds that make up solid car emissions (ICE), the most studied are lead compounds.

Lead compounds, entering the human and warm-blooded animals with water, air and food, have the most harmful effect on it. Up to 50% of the daily intake of lead in the body falls on the air, in which a significant proportion of the exhaust gases of internal combustion engines of cars.

Every motorist knows: it is almost impossible to pour out all gasoline into the tank of a car, some part of it from the barrel of the "pistol" hose always splashes to the ground. Little amount.

But how many cars do we have today? And every year their number grows and will continue to grow, and the harmful evaporation into the atmosphere will also increase.

Only 300 gr of gasoline spilled during careless refueling of a car pollutes 200 thousand m^3 of air.

Proposals to reduce the toxicity of exhaust gases of ice cars

Of great importance to reduce air pollution from exhaust gases is the daily technical monitoring of the state of the engine ICE.

All fleets are obliged to monitor the good condition of cars produced on the line. With proper, well-regulated internal combustion engine in the exhaust gases carbon monoxide should contain no more than the permissible rate.

The low level of maintenance and the complete absence in many countries of compulsory technical control over the condition of motor vehicles lead to a breakdown of vehicle components and systems.

As a result, the emissions of harmful substances from such vehicles are much higher than the norm established for this type of car. All this leads to the fact that the effective measures taken by the automotive industry to ensure and require standards are reduced, and often even reduced to nothing.

At this time, an urgent task is to improve the design of a car with limited toxicity, as well as to increase the level of maintenance and improve systems and methods for monitoring the technical condition.

The causes of the "**smoke**" of cars are different - a malfunction of the engine, the inadequate power system or ignition.

If all car ICE is properly regulated, then the emission of harmful substances into the atmosphere will decrease at least 3 - 5 times.

Violation of technological discipline, unwillingness to conduct an inspection of the internal combustion engine in time leads to the fact that the car for weeks or even months carries poison (carbon monoxide) through the streets. And badly inflated tires not only wear out faster, but also increase the resistance to movement, which means that more fuel is burned.

For quick and effective monitoring of the technical condition of cars, compliance with regulatory requirements for the protection of atmospheric air, traffic police (State Automobile Inspection) are equipped with diagnostic stations, modern devices that can **diagnose** many cars.

Many fleets have their own diagnostic equipment, the use of which allows you to quickly assess the technical condition of cars and not to produce defective cars on the line. As a result, the average content of carbon monoxide in the exhaust gases of the internal combustion engines of vehicles belonging to this department can be reduced by more than 2 times.

In our country there are two types of standards for norms and methods for the determination of harmful substances in exhaust gases of internal combustion engines of automobiles.

The first of these includes state standards that apply to vehicles in use, i.e. on the whole car park of the republic. This is GOST 17.2.2.03-77 “Nature Protection. Atmosphere. Carbon monoxide content in exhaust gases of cars with gasoline engines. Norms and method of definition” and GOST 17.2.2.01-84 “Nature Protection. Atmosphere. Diesel cars. Exhaust fumes. Norms and methods of measurement”.

The second type is the industry standards “Uzavtosanoat” for new products, which include testing the toxicity of exhaust gases of internal combustion engines of vehicles with spark ignition weighing from 400 to 3,500 kg, of internal combustion engines of trucks and buses during acceptance and control tests at manufacturers. The number of cars (ICE and others) for control tests is established by the manufacturer with guaranteed compliance of all products with established standards.

Meeting environmental requirements is achieved through the implementation of comprehensive measures related to design changes, as well as regulation of the composition of fuels and motor oils.

For example, constructive measures are associated with a change in the exhaust gas recirculation system, their neutralization system, air supply system, etc. At the same time, consider switching to motor fuels with a lower content of sulfur and aromatic hydrocarbons (see Table 1).

Table 3. General requirements for the quality of motor fuels to ensure environmental safety [2]

№	Indicator	Standards for class			
		Euro - 2	**Euro - 3**	**Euro - 4**	**Euro - 5**
1.	Mass fraction of sulfur, mg/kg, not more than	500 (AB)	150 (AB)	50 (AB)	10 (AB)
2.	Volume fraction of benzene, %, not more than	500 (DF)	350 (DF)	50 (DF)	10 (DF)
3.	Volume fraction of aromatic hydrocarbons, %, not more than	5,0 (AB)	1,0 (AB)	1,0 (AB)	1,0 (AB)
4.	Mass fraction of polycyclic and aromatic hydrocarbons, %, not more	- -	42 (AB) 11 (DF)	35 (AB) 11 (DF)	35 (АБ) 11 (ДТ)

Note: AB – Automobile benzene; DF – Diesel fuel.

Similar requirements are imposed on the ecological properties of MO, realized through an immediate danger to living organisms and manifested in the form of toxicity and carcinogenicity.

Thus, FLM (gasoline, diesel fuel, motor oil) in the course of their work in ICE have a negative impact on the ecology of the atmosphere, polluting the environment in various ways. Harm can be minimized with proper organization of their production and use.

Meanwhile, not all drivers and individual car owners know that compliance with the standards for permissible emission of carbon monoxide in exhaust gases of internal combustion engines of cars with gasoline engines, as well as smoke standards for diesel cars, not only reduces air pollution, but also significantly saves fuel.

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