Investigation of environmental indicators of diesel engine when working on methanol

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Abstract. The increasing negative impact of internal combustion engines on the environment has given rise to a number of global problems, which in recent years have become a serious problem for humanity. The problem of reducing the toxicity of engine exhaust gases has become global and has become common to all countries. Toxic components of engine exhaust gases, entering the atmosphere, are transported by air currents over long distances, so reducing the content of toxic components of diesel engines is an urgent and urgent task, considered at the Federal level. The article presents an analysis of the main toxic components and an overview of the main ways of using methanol in engines, the application of the most effective method of using methyl alcohol for a diesel engine is considered. According to the results of laboratory and bench studies of various load and speed modes of a diesel engine running on methanol and diesel fuel, data on the content of the main components in the exhaust gases were obtained, and a conclusion was made about the efficiency of using methanol as a motor fuel.

The exhaust gases of internal combustion engines contain more than two hundred different individual hydrocarbons. Of particular importance are the emissions of benzene, toluene, polycyclic aromatic hydrocarbons. This group of highly toxic substances is formed as a result of pyrolysis of light and medium fractions of fuel at high temperature. Such conditions occur during the working stroke near the cold surfaces of the cylinder with a lack of oxygen. These hydrocarbons belong to the group of carcinogenic substances [1].

The next element that is formed in the exhaust gases is soot. Soot is a solid carbon particle with a size of 0.4...5 microns with low water content. Being in the exhaust gases, soot adsorbs on its surface hydrocarbons, including carcinogenic, and becomes toxic. Soot is formed as a result of pyrolysis of fuel molecules at high temperatures (over 1500 K) in conditions of a strong lack of oxidizer. The content of soot in the exhaust gases of the spark-ignition engine is insignificant. The problem of soot formation is most inherent in diesel. The combustible mixture formed in the cylinder of a diesel engine, in which the rate of combustion is mainly limited not by the rate of chemical reactions, but by the rate of mixing is limited by the diffusion of fuel vapors and air. As a result, zones with rich, stoichiometric and poor mixture are formed in the diesel cylinder [2].

Soot is not the only solid found in exhaust gases. Other solids are formed from sulfur contained in fuel, petroleum aerosols, and unburned fuel oil. In addition, exhaust gases may contain products of wear of the cylinder. All these substances have received the General name "solid particles".

Nitrogen oxides are formed from nitrogen and oxygen in the air, which begin to react with each other at high temperatures (over 2000 K). The composition of engine exhaust gases depends on the type of engine (diesel or spark ignition...
Considering the toxicity of exhaust gases, it should be noted that the toxic components are carbon oxides CO, nitrogen oxides, hydrocarbons, aldehydes. Soot, which carries on its surface toxic substances, in particular carcinogenic ones, can be conditionally referred to the category of toxic [3].

Carbon monoxide CO. It affects the nervous and cardiovascular systems, causes suffocation (it binds to hemoglobin in the blood and makes it difficult to transfer oxygen to the tissues). Carbon monoxide is a colorless and odorless gas, making it particularly dangerous. The primary symptoms of carbon monoxide poisoning (the appearance of headaches) occur at a concentration of 200 mg/m$^3$ with a duration of exposure for 2 hours. With several large concentrations of CO, there is a feeling of pulse in the temples, dizziness. At the next stage of poisoning comes drowsiness, leading to loss of consciousness. In the presence of nitrogen oxides in the air, CO toxicity increases. Special attention should be paid to the phenomenon of chronic poisoning with small doses of carbon monoxide, which can occur at a volume concentration of about 0.0194. Poisoning of this kind are subject to drivers. Chronic poisoning is expressed in the appearance of frequent headaches, ringing in the ears, difficulty breathing and General depression. The CO content in spark-ignition engines is maximum at idle. Therefore, special care should be taken when starting the engine indoors. In the absence of ventilation, lethal concentrations of CO can occur within a few minutes. Being a long time in the cabin of a car, the engine of which is idling, is also dangerous.

The next most dangerous product in exhaust gases is nitric oxide. Nitric oxide is colorless and odorless, very toxic, irritating to the human respiratory system. Nitrogen oxides are especially dangerous in cities, where they interact with the hydrocarbons of car exhaust gases under the influence of sunlight and form photo-oxidants, the toxicity of which is several times higher than that of the original components. Photochemical fog-smog can occur under certain weather conditions. Nitrogen oxide poisoning begins with a mild cough. With increased concentration, there is a strong cough, vomiting and headache. When nitrogen oxides come into contact with the moist surface of the lungs, nitric acid is formed, which destroys the lung tissue, which leads to chronic diseases, the respiratory tract and the mucous membranes of the eyes are also irritated. At significant concentrations, symptoms of poisoning may increase even after the removal of the victim from the poisoned zone [4].

Aldehydes (mainly formaldehyde). They are formed during the period when the process of oxidation of fuel occurs at low temperatures (when starting the engine, in the layers of walls, in diesels - during the preliminary reactions that occur when preparing the fuel-air mixture for combustion). Have an irritating effect on the mucous membranes of the eyes and respiratory tract. The smell of formaldehyde is observed at a concentration of 0.2 mg/m$^3$, and at a concentration of 20...70 mg/m$^3$ appears headache, weakness, loss of appetite, insomnia, severe irritation of the mucous membranes.

Sulfur contained in the fuel is released into the atmosphere in the form of sulfur dioxide. Sulfur dioxide is a colorless gas with a pungent odor. It has an irritating effect on the respiratory system, in contact with moisture acids are formed.

Carbon dioxide (CO$_2$), fuel type, additives and oils, engine operating mode, its technical condition, driving conditions and other factors.
times, and aluminum is destroyed 100 times faster than in rural areas. The main role in the formation of acid rain is played by emissions from industrial enterprises, as they are discharged into the atmosphere through high pipes.

To reduce the damage caused to nature by the use of petroleum fuels, it is necessary to actively use alternative options such as fuel. One of the most effective alternative fuels for diesels are alcohols. It is primarily methyl (methanol) and ethyl (ethanol) alcohol. The most promising of them is methanol. Its production is possible from almost any raw material containing carbon (natural gas, coal, biomass, urban waste). Methanol production has rich resources and its cost is relatively low.

In addition, methanol as a fuel for diesels can solve the problem of reducing emissions of nitrogen oxides and, especially, particulate matter. This is due to the fact that the combustion of methanol does not release intermediates, from which aromatic and acetylene hydrocarbons are then formed, contributing to the generation and growth of soot particles. There are practically no sulfur compounds in the combustion products of methanol. The simpler structure as well as the smaller size of the molecules contribute to cleaner combustion of the fuel.

But the widespread use of alcohols and, in particular, methanol is constrained by the fact that they differ significantly from diesel fuels in a number of physical and chemical properties.

The main disadvantage of methanol is a large-4.4 times-the heat of evaporation (1115 kJ / kg against 250 Kj / kg of diesel fuel) at a low boiling point. Excessive cooling of the air charge during the evaporation of alcohol and low cetane number of alcohol (high self-ignition temperatures) lead to its poor ignition in the diesel. To eliminate this disadvantage requires the use of special measures and is the cause of the complexity of the design, increasing the cost of manufacturing and operation of the diesel engine. The poor solubility of alcohols, especially those containing water, in diesel fuel is also negative. The effect of this property is naturally characterized by a good solubility of water in alcohol, whereby water accumulates in the alcohol.

Currently, there are two main groups of ways to use alcohols as fuel for diesels. The first group includes methods based on the use of two or more types of fuel, it is [5]:

- solutions of alcohols in diesel fuel and fuel mixtures;
- carburetor or alcohol injection into the intake system and diesel fuel injection into the cylinder;
- emulsions of alcohols in diesel fuel;
- alcohol injection and ignition of fuel in the cylinder.

The second group-methods based on the supply of alcohol to the engine and alcohol with an additive, it is:

- convert the diesel into the engine with external mixing and forced ignition;
- using a glow plug;
- injection of alcohol with an additive that increases the cetane number;
- charge stratification during internal mixture formation and spark ignition;
- ignition from hot surfaces.

When choosing a method of using alcohol, it is necessary to take into account that alcohols have less lubricity, greater corrosion resistance, as well as a greater propensity of methanol to ignite from hot surfaces.

In Vyatka State Agricultural Academy, at the Department of heat engines, cars and tractors, tests were carried out diesel engine 2H 10.5 / 12.0 when working on methanol with the supply of alcohol through a multi-jet nozzle and ignition of methanol from the ignition portion of diesel fuel.

The graphs show data on the content of the main toxic components in the exhaust gases. Analyzing these data, we can draw the following conclusions. The content of nitrogen oxides (figure 1) in
exhaust gases when working on methanol is significantly lower than when working on diesel fuel in the entire load range. This is obviously primarily due to the fact that when operating on methanol, following the peculiarities of the chemical composition of methanol than from diesel fuel and, according to the chemistry of the combustion process, dominated by rapid formation of oxides of nitrogen, the main contribution to the formation of nitrogen oxides receive a thermal mechanism, or so-called thermal nitrogen oxides, which contribute to an overall reduction in the content of nitrogen oxides in the exhaust gases.

![Figure 1](https://example.com/figure1.png)

Figure 1. Nitrogen oxides content in diesel exhaust gases: – diesel fuel; – methanol.

The content of soot in the exhaust gases is significantly reduced when working on methanol throughout the studied load range (figure 2).

![Figure 2](https://example.com/figure2.png)

Figure 2. Soot content in diesel exhaust gases: – diesel fuel; – methanol.

The presented results of studies to improve the environmental performance of diesel 2H 10.5 / 12.0 when working on methanol with a dual fuel supply system by reducing the content of the main toxic components in the exhaust gases show a high efficiency of methanol when used as motor fuel.

References
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