Prospects for the use of alcohol fuels at the present stage

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Abstract. To solve the problems of environmental pollution from road transport, it is proposed to use bioethanol fuel. It significantly reduces both toxic compounds in exhaust gases and carbon dioxide emissions CO_2, which is a greenhouse gas. The advantages and problems associated with the use of alcohol fuels are considered.

Keywords: Bioethanol, alcohol fuel, motor vehicles, EURO standards.

Today, the problem of atmospheric air pollution by harmful components of exhaust gases from cars is becoming more and more acute. It is typical for large megalopolises that the main share of pollution is accounted for by road transport. If in the mid-90s of the 20th century, 50% of pollution accounted for industrial enterprises and 50% for road transport, today the share of pollution from road transport already exceeds 80%. At the same time, the number of cars in the world has increased from 400 million units in the 90s to 1 billion 400 million today.

Much is being done today to reduce pollution. So back in the 90s, the EURO standards were adopted, which established the requirements for emissions up to the present time. Certain compositional requirements were adopted for fuel, in particular, sulfur almost completely disappeared from the fuel, the aromatics content was limited to 30%, and benzene to 1%. The injector is firmly incorporated into the design of the car, paired with a catalytic converter, which made it possible to reach the level of EURO-3 and higher in emissions, but the measures taken are not enough. So, if you look at the EURO numbers, you can see that, in particular, for gasoline cars, the CO content decreased by 2.72 times. From 2.72 g/km for EURO-1 to 1 g/km for EURO-6. At the same time, since 1992, when the EURO-1 standards were adopted, until today, the number of cars has increased by 3.5 times. Despite the toughness of the EURO norms, they are really, at best, only able to freeze emissions at the level of the 90s.

Obviously, in these conditions, the requirements for emissions should be tightened, but the manufacturers of automotive equipment today have already reached the limit beyond which it is impossible to reduce toxicity by traditional means. Therefore, the next step on the part of legislators may be limiting the content of carbon dioxide CO_2. This compound is not toxic, but it belongs to greenhouse gases that destroy the azone layer of the planet and lead to climate change. Today, CO_2 emissions are already limited for individual countries that have entered the Kyoto Protocol. In these conditions, limiting carbon dioxide in car emissions seems to be very real.

The end products of combustion of any heat engine are CO_2 and H_2O, and the better the combustion process is organized, the more of these compounds will be. Any conventional fuel (gasoline, diesel, compressed and liquefied gas) will invariably emit CO_2 and H_2O.

According to the authors, the solution may be to use bioethanol as a fuel. It is believed that when burned in an engine, bioethanol releases about the same amount of CO_2 as was absorbed by the plants from which alcohol was produced during their growth. Thus, the CO_2 balance will be zero.

The idea of using ethanol as a fuel or fuel component dates back to the 19th century. As a result, the use of alcohol began almost before the use of gasoline. It is believed that the idea of using alcohol as a motor fuel was first announced in Paris in 1902, when 70 ethyl alcohol-fueled engines were introduced. Since then, this idea has been regularly discussed. In practice, this was realized in 1906, when the addition of alcohol to gasoline became the basis for the operation of public transport in Paris. Many were immediately attracted by the cheapness of the novelty and its reduced fire hazard. Later, ethanol began to be used in Germany for conventional cars [1]. Since 1908, the Ford-T car has been produced for about 20 years - the first mass-produced car in history, while it could run on gasoline, ethanol and a mixture of both types of fuel. Henry Ford considered the use of ethanol a promising direction for American farmers, since the raw materials for alcohol were mainly agricultural products and waste products [2].

Ethanol-containing fuels can be divided into 3 groups according to the concentration of ethyl alcohol: standard gasoline containing up to 5-15% (E5-E15), medium ethanol fuels - from 20 to 40% (E20, E30, E40) and high ethanol fuels for special vehicles - from 50 to 100% alcohol (E85, E100, ED95).

The first option, when the alcohol concentration is up to 15%, is interesting in that it does not require any changes in the design and engine adjustments. Moreover, the Technical Regulations of the Russian Federation for Gasoline [3] and the Technical Regulations of the Customs Union [4], which are, as it were, receivers of GOST R 51866 - 2002, also provide for the addition of ethanol up to 5%. It is believed that the higher the ethanol concentration, the higher the octane number of the fuel and the lower the toxicity of the exhaust gases. The next step in increasing the concentration of ethanol in our country was benzene according to GOST R 52201 [5]. It provides for a 10% alcohol content. From a formal point of view, this is no longer gasoline, but it can be used as a motor fuel without any design changes or adjustments. In the US, they went further and started using 15% ethanol. This fuel is recommended for those cars, the production of which was started after 2001 [6]. Today, 15% ethanol is the limit for alcohol that does not require redesign and engine adjustments.

The third option is of greatest interest from the point of view of realizing the potential advantages of alcohol - these are high-ethanol fuels with an alcohol content of 50 to 100% (E85, E100, ED95). The most important competitive advantage of ethanol over fossil fuels is its renewability and availability of raw materials. Bioethanol at this stage can be produced from any plant material. The world leaders in the production of bioethanol are the USA and Brazil. In the United States, bioethanol is produced from corn, and in Brazil from sugar cane. Bioethanol has a positive energy balance, which, depending on the type of raw material, can vary from 1.24 to 8. That is, when ethanol is burned, several times more energy is released than is expended in its production. In this sense, it is an order of magnitude superior to gasoline or diesel fuel. Huge sums are spent on exploration, production, transportation, oil refining, so the fuel balance of petroleum fuels is less than one [1,7]. This feature predetermines the relatively low cost of alcohol in comparison with petroleum fuels.

An important advantage of alcohol fuel is its high octane number, which reaches 129.5 according to the research method and 101.3 according to the motor method, respectively [8]. It is clear that these characteristics will be realized as fully as possible when using 100% alcohol, as it actually happens in Brazil, where E100 alcohol fuel is widely used. In more northern latitudes, the use of E100 fuel becomes problematic, since alcohol evaporates worse than motor gasoline, then already at a temperature of +10°C, problems with starting the engine may arise. This problem is solved by adding gasoline or low-boiling hydrocarbon fractions to alcohol, as a result, such a "starting fraction" ensures engine start at low temperatures. The most famous alcoholic composition is E85 alcohol fuel (in Russia it is labeled as Ed75-Ed85 according to GOST R 54290-2010) [9]. This alcohol fuel is subdivided into summer and winter. Summer contains 74% ethanol and 17 - 26% hydrocarbons and aliphatic ethers as a "starting fraction". Winter contains 70% ethanol and 17 - 30% hydrocarbons and simple aliphatic ethers as a "starting fraction".

Poor volatility is not the only drawback of alcohol fuels. So alcohol has a calorific value of 30.6 MJ/kg versus 43.6 MJ/kg for gasoline, which means, other things being equal, the engine on alcohol fuel will develop less power with higher fuel consumption. This problem can be solved by stronger compression of the mixture, since alcohol has a much higher octane number than gasoline, it is able to withstand greater compression without detonation. The compression ratio when using alcohol can be 19 units [1] versus 10 for gasoline. If the antiknock potential of alcohol is fully realized, then the fuel consumption will be lower and the power will be higher than with gasoline, which leads to a higher efficiency when the engine is running on alcohol. It is possible to increase the compression by increasing the ignition timing, but this is unlikely to allow you to get the maximum output from the engine. It must be borne in mind that alcohol is corrosive to metals, especially in the presence of water, as well as corrosive to rubber and plastic. It is hardly possible to solve all these issues by changing the adjustments and alterations of universal cars, therefore, for high-ethanol fuels, only specialized vehicles with universal fuel consumption (FFV – flexiblefuelvehicle) are used. Such cars can run on both regular gasoline and alcohol, as well as any mixture of alcohol and gasoline. The main design features of such cars are as follows [10]:

1. The on-board computer regulates the fuel-air ratio in a wider range depending on the bioethanol content in the fuel. This is most important for FFV vehicles, since complete combustion for gasoline is achieved with an air-fuel ratio of 14.7:1 (stoichiometric mixture), and for alcohol this ratio is 9:1.
2. The on-board computer adjusts the ignition timing over a wider range, depending on the actual octane number of the alcohol composition. The effective pressure in the engine cylinders directly depends on this, which means the output power and fuel consumption.
3. Metallic and non-metallic materials in contact with fuel are highly resistant to bioethanol.
4. Increased fuel tank to maintain range.
5. The fuel pump and injection system have increased capacity to provide more bioethanol fuel, which has a lower heating value than gasoline.
6. The electrical connections of the fuel system are electrically isolated because bioethanol fuel has a higher electrical conductivity than gasoline.

Thus, the technical problems associated with the peculiarities of the use of bioethanol fuel in the design of FFV vehicles are completely solved. Of course, this is associated with additional costs, however, obviously, they are so small that for most car brands the manufacturer sets the price at the level of base models [10].

To date, a number of technological problems associated with the use of bioethanol fuels remain unresolved. And the main problem lies in the "starting fraction" of alcohol fuel. Traditionally, commercial gasoline was used for these purposes, then they tried to use narrow hydrocarbon fractions, including pentane, isopentane, butane, isobutane and propane [11], to reduce the cost of the composition it was proposed to use low-quality gasolines and gasoline fractions, including by-products of oil refining and even waste. For example, the low-octane fraction of direct distillation of oil or gas condensate [12], the gasoline fraction of the hydrocracking process [13], coking gasoline [14] and the like.

These and other hydrocarbon fractions have one common drawback - low phase stability, that is, under operating and storage conditions, there is a possibility of separation of the hydrocarbon part and alcohol. The presence of water in the fuel and a drop in temperature dramatically increase the likelihood of delamination. To avoid it, there are increased requirements for the strength of alcohol, as a rule, the moisture content in alcohol should not exceed 2%, that is, the ethanol content must be at least 98%. This degree of dehydration of alcohol requires additional costs in its production. Certain difficulties arise when refueling cars, since moisture is often present in refueling containers.

According to the authors, it is possible to increase the phase stability of alcohol fuel if, instead of hydrocarbons, some low-boiling ethers are used as a "starting fraction".

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