Features of the use of methanol as a diesel fuel

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Abstract. The use of alcohols as motor fuel is very important both for saving fuel oil and for reducing the environmental burden. One of the most promising alcohol fuels for the internal combustion engine is methanol. Its production is possible from almost any raw material containing carbon, but the largest amount of methanol is produced in Russia from natural gas. There is an extensive raw material available for the production of methanol, and its cost is low compared to other alternative fuels. In addition, methanol can solve the problem of reducing the main, most toxic components of exhaust gases, nitrogen oxides and soot. Vyatka agricultural Academy continues to study the effect of alcohol consumption on diesel engines when they are fed with methanol using various methods. The article presents the features of using alcohol when it is used with the supply of an experimental portion of diesel fuel.

When working on methanol using diesel fuel as an ignition, it is necessary to take into account the distinctive properties of methanol when using it as a motor fuel [1-5].

Considering the chemical formula of alcohol, it can be noted that the methanol molecule in its composition contains less carbon and more oxygen. Since carbon is the main source of fuel, its lower content in the methanol molecule causes a lower calorific value per unit mass of fuel, and the presence of an oxygen atom requires a smaller stoichiometric amount of air required for complete combustion of the fuel. As a result, the differences in the calorific value of the stoichiometric mixture are small. Increased oxygen content in methanol prevents the occurrence of cracking conditions and contributes to a significant reduction in the content of soot and particulate matter in the diesel exhaust when working on methanol. Methanol does not contain sulfur, which is a highly undesirable component of fuel. Sulfur and sulfur compounds cause corrosion of parts, contribute to the formation of carbon—all this together leads to intense engine wear [6-13].

The implementation of a method for using methanol as a motor fuel by feeding it directly into the cylinder and igniting it from the igniting part provided for the installation of two fuel systems. The additional pump is attached with a gasket in place of the oil filler neck. The general view of the diesel engine installed on the stand is shown in figure 1. General view of the cylinder head with an additional nozzle is shown in figure 2.

Since the main distinctive feature of diesel engines is self-ignition of fuel during compression, the use of methanol in serial diesels is possible only in combination with other high-methane fuels, in particular diesel. This requires the use of special measures and is the reason for the complexity of the design, cost of manufacturing and operation of the diesel engine. The value of the cetane number determines the duration of the ELV, the "stiffness" of the combustion process and the maximum pressure...
of the cycle, i.e. the main parameters that characterize the working process of a diesel engine are determined.\cite{Gorenje}

The basis of the method for calculating the fuel ignition delay period is laid in the well-known works of D. N. Vyrubov, A. I. Tolstov, M. S. Khovakhi, G. M. Kamfer, A. N. Voynov, Y. B. Sviridov and others \cite{14-25}.

![Figure 1. Type of diesel engine installed on the stand.](image)

At low cetane numbers, there is an excessive delay in ignition, so the "rigidity" of the combustion process increases, resulting in a deterioration of the energy and economic indicators of the diesel, increased wear, noise and exhaust gas toxicity \cite{26-30}.

Turning to the thermophysical properties of methanol that affect the mixing conditions, we note that the surface tension and viscosity of methanol is lower than that of diesel fuel, and close to the values for gasoline. Reducing the viscosity leads to a change in the geometry of the sprayed fuel Flare. At low viscosity, the fuel penetrates through the gaps in the plunger pair of the fuel pump, which leads to a change in the dose, a decrease in the cyclic flow rate, and a decrease in the injection pressure. Such fuel can leak through the holes of the spray nozzles, which inevitably increases the formation of carbon. The fuel lubricates the precision vapors of the fuel pump, and when the viscosity decreases, the lubricating properties deteriorate, which can lead to an increase in the intensity of their wear. Reducing the cycle feed leads to a drop in power. Leaks and leaks increase the consumption of low-viscosity fuel. In this regard, in most published papers on the use of methanol in diesels, it is recommended to add 1...2% castor oil, which is highly soluble in alcohols, ensures the performance of fuel equipment parts. The heat capacity of methanol in the liquid phase is higher, and in the gas phase is lower than that of diesel fuel. The thermal conductivity in both the liquid and gas phases is higher than that of diesel fuel, and the diffusion coefficient is also higher. At equal temperatures, the saturated vapor pressure is much higher \cite{31-40}.

Based on this information, we can expect an improvement in the quality of fuel atomization, acceleration of heating and evaporation of methanol drops in the cylinder when working with the supply of a pilot portion of diesel fuel. However, it is necessary to keep in mind the differences in the heat of evaporation and total enthalpy. So, in the case of methanol, the heat of evaporation at normal pressure
is almost 4.5 times, and the total enthalpy is almost 4 times higher than that of diesel fuel. When applied to the same energy content, the evaporation heat of methanol is 10 times higher than that of diesel fuel.

Figure 2. General view of the cylinder head with an additional nozzle.

The decrease in the temperature of the stoichiometric mixture in methanol, according to various estimates, is 122 ... 200°C, and for spent motor fuels-17 ... 30°C. It is known that in the conditions of a diesel process with insufficiently intensive heat and mass transfer, the temperature decrease in certain areas of the charge volume occupied by the torch, even in the case of DT, reaches 150...200°C. The high heat of evaporation of methanol in conditions of limited heat supply from the charge and its surrounding parts can, therefore, make it difficult to vaporize and ignite. Apparently, it is a significant local decrease in the charge temperature due to the large heat consumption for evaporation that explains the significantly greater increase in the ignition delay period when alcohol is fed to the cylinder in a mixture with diesel fuel compared to its supply through the diesel intake system [41-50].

When injecting methanol through a nozzle into a diesel cylinder, important characteristics, in addition to density, viscosity and surface tension, are compressibility and calorific value of a unit of fuel volume. To inject the same amount of heat into the cylinder as in the case of diesel fuel, in the case of methanol, 2.26 times the volume of fuel must be supplied to the cylinder (figure 3). This requires, first of all, a revision of such parameters of the fuel supply system as the diameter of the plunger and the equivalent cross-section of the nozzle holes. Otherwise, the fuel injection duration will increase and sub-splashes may occur. In addition, the capacity reserve of the fuel pump intended for diesel fuel injection may not be sufficient to supply the required amount of methanol [51-60].

Certain changes in the design and materials used must be accepted due to the increased vapor elasticity and the corrosive activity of alcohols. Increased steam elasticity is the cause of large cavitation wear and the appearance of steam cavities in the low-pressure system of fuel equipment, which reduce the uniformity and stability of the injected portions of fuel. Therefore, it is recommended to use a fuel bypass in the pump, increasing the pumping pressure to 0.4...0.5 MPa, use additional electric pumps located near the fuel tank, and also revise the size of the fuel supply system to reduce cavitation.

The corrosive activity of alcohols, as well as their activity in relation to a number of plastics, requires
a revision of the materials of the fuel system parts. There is a special danger of electrolytic corrosion of metal pairs, such as: aluminum-steel, aluminum-brass, zinc-brass in the presence of alcohol.

Figure 3. Graphic representation of the intersection of the ignition torches of a portion of diesel fuel and methanol in a diesel cylinder.

It is recommended to avoid materials containing magnesium, antimony, cadmium, lead, and zinc. For the main parts of the fuel system, it is considered appropriate to use steel, aluminum and its alloys (avoiding the combination of steel and aluminum in one unit). For small parts, you can also use copper and its alloys. Limiting the use of copper is mainly due to the catalytic effect it has on fuel oxidation. The use of chromium-Nickel and stainless steels gives particularly good results. It is claimed that with the right choice of materials, coatings are usually not needed. At the same time, good results are obtained by anodizing aluminum, chrome and nickel plating of steel products. You can also use alcohol-resistant lacquers. [61-65].

To the features of methanol, it is necessary to add its poor Miscibility with diesel fuel and good water solubility in alcohol, which makes it easier to separate mixtures of diesel fuel and methanol; at the same time, it is very difficult to avoid the water content in alcohol. The presence of water increases the corrosion activity of methanol.

Thus, when using methanol with the supply of a pilot portion of diesel fuel, it is possible to ensure that the power indicators are maintained at the level of the base diesel when a small amount of fuel is supplied for ignition. This is achieved by saving diesel fuel by supplying methanol and possibly improving environmental performance.

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