The study of the toxicity of exhaust gases of a diesel engine when operating on methanol and methyl ester of rapeseed oil

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Abstract. While legal restrictions on the use of fossil fuels are applied to conserve natural resources, mixed alcohol fuels, vegetable oils and their esters are increasingly attracting attention as promising alternative sustainable energy sources for cars. The paper substantiates the need for the use of biofuels (BF) in diesel engines (DE) and studies such eco-friendly energy sources as methanol (M) and rapeseed oil methyl ether (ROME). M and ROME potentially lead to some solutions to environmental problems, because for their production, there are quite abundant resources and these energy sources are characterized by relatively low emissions of harmful substances during combustion. The paper presents the results of experimental studies of the toxicity of DE powered by M and ROME, and shows an improvement in its environmental performance.

The significant growth of the tractor fleet, as well as the expansion of its scope of activity in production, lead to a significant increase in emissions of toxic components and exhaust gas (EG) smoke. Scientists have found that high concentrations of harmful substances such as nitrogen oxides (NOx), unburned hydrocarbons (CHx), carbon monoxide (CO) and dioxide (CO2), soot (C) cause inflammation of the respiratory tract mucous membranes, chronic bronchitis, nervous disorders, irreversible changes in the cardiovascular system and numerous other diseases [1-6].

One of the ways to solve this problem is the use of alternative renewable fuels with better environmental performance. Fuels derived from plant seeds, as well as alcohols, can be used as such renewable energy sources. All this can be attributed to fuels of biological origin or the so-called liquid BF [7-12].

According to the forecasts of the Institute for Energy Research of the Russian Academy of Sciences and the Analytical Center under the Government of the Russian Federation, in the likely scenario by 2040, the use of liquid BF will increase by 2.3 times. The share of all renewable energy sources in the global energy mix will grow to 18% by 2040 [13-21]. The purpose of this work is to study the load conditions of the toxicity of DE EG when working on M and ROME. In the course of the research, BF of the following composition were used: M - 88% and ROME - 12%, supplied by a dual fuel supply system [22-30].

A number of bench tests of the DE were carried out to investigate the influence of operating modes, as well as the adjustment parameters of the fuel supply equipment on the content of toxic components in the EG.
Figure 1. Changes in the environmental performance of DE depending on $p_e$: a - DF; b - M and ROME; c - $NO_x$; d - $CO_2$.

During the bench tests, the optimal values of the angles of the start of the supply of each of the two fuels were determined, and the adjustment characteristics of the DE were obtained when operating on
these fuels. The optimal values of the setting angles of fuel injection advance based on the economic performance of the DE were set and amounted to: 34° of rotation of the crankshaft for M and 34° - for ROME [31-39].

When removing the characteristics of this research topic, the influence of load conditions on the content of toxic components in the EG of a DE running on both diesel fuel (DF) and M with ROME was studied [40-47].

Figure 1 shows the load characteristics of the toxic parameters of a DE running on M and ROME.

Analyzing the graphs of the toxicity of DE EG at the nominal speed mode when operating on M with, it is seen that there is a decrease in the NOx content in almost the entire range of the load study (except $p_e>0.66$ MPa). The use of methanol and leads to a decrease in CO at a load exceeding 0.47 MPa, and total of CHx at maximum loads at $p_e>0.56$ MPa, while a slight increase in CO2 was observed in the entire range of the pe study [48-56].

Figure 2 shows the load characteristics of the EG smoke of a DE running on M and ROME.

Analyzing the graphs of the smoke content of DE EG at the nominal speed mode when working on M with the ROME, it is seen that there is a decrease in the soot content over the entire range of the load study [57-62].

The results of studies of the environmental performance of DE are summarized in table 1.

Table 1. Results of research on the environmental performance of DE ($n=1800$ min$^{-1}$, $p_e=0.59$ MPa).

| Fuel          | $NO_x$, ppm | C, Bosch | $CO$, % |
|---------------|-------------|----------|---------|
| DF            | 760         | 5.0      | 0.29    |
| M and ROME    | 400 (decrease by 47.4%) | 0.48 (decrease by 90.4%) | 0.16 (decrease by 44.8%) |

A promising solution for improving the environmental performance of a DE running on BF of the following composition is given: M -88%, ROME -12% [63-68]. When the DE is running on M and ROME (at the nominal mode), the content of $NO_x$ in the EG decreases by 47.4%, $C$ by 90.4%, and $CO$ by 44.8%.

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