The results of the influence of methanol on the effective performance of a diesel engine when working with DFS

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Abstract. The most effective way to use methanol in internal combustion engines today is to supply it directly to the diesel cylinders using a dual fuel supply system and igniting the ignition portion of diesel fuel. Thus, the study of the working processes of diesel engines refitted to work on alternative renewable fuels (methyl alcohol) is an urgent scientific task of important national economic importance, since it allows replacing petroleum motor fuel, and significantly improves effective, power, economic and environmental indicators. As a result of the adjustment tests of the 2H 10.5 / 12.0 base diesel engine when operating on diesel fuel and methanol with a dual fuel supply system, we can conclude that the installation angles of feed start are optimal from the point of view of efficiency and economy Θdf = 34 ° and Θm = 34 °.

Internal combustion engines (ICE) are the most common type of heat engine. They account for 80% of all mechanical energy generated in the world, while ICE consume a significant amount of natural materials and raw materials, including petroleum products, which are non-renewable resources. Given the trends in the rise in the price of oil products while reducing oil reserves, the problem of increasing fuel efficiency has become especially acute.

In addition, ICE is one of the main environmental pollutants. By the end of the 20th century, as a result of the intensive development of industry and automobile transport, the problem of protecting the environment from pollution by its toxic substances arose. The presence of toxic components (carbon oxides, nitrogen oxides, hydrocarbons and others) in the exhaust gases of ICE emitted into the atmosphere creates a danger to human health [1-4].

Taking into account the noted factors, the problems of reducing atmospheric pollution by toxic substances emitted by ICE and increasing their efficiency become especially acute and go beyond the framework of the particular task of engine building.

Significant improvements in the quality of mixture formation, combustion, and, in general, increase the efficiency of work and reduce harmful diesel emissions, can be achieved using alternative fuels, in particular methanol. In this regard, the problem of improving the effective and environmental performance of automotive diesel engines by supplying methanol with a dual fuel supply system (DFSS) is relevant.

In the Vyatka State Agricultural Academy, the Department of Heat Engines, Automobiles and Tractors conducted research on the use of methyl alcohol (methanol) on a serial diesel engine 2H 10.5 / 12.0. In accordance with the purpose, objectives and research methodology [5-7], bench tests were carried out. As the experiment showed, the best results are obtained with the simultaneous supply of a
pilot portion of diesel fuel (DF) and methanol. Figure 1a, shows the effect of the use of methanol on the specific effective fuel consumption of a diesel engine 2H 10.5 / 12.0 when working with DFSS at various installation angles of advancing fuel injection (AAFI) in the nominal operating mode at \( n = 1800 \) min\(^{-1}\).

Considering the efficiency of a diesel engine when working on methanol with DFSS for various installations of AAFI, the following can be noted. The minimum value of \( g_{\Sigma} \) is observed when methanol is fed at the installation of the AAFI \( \Theta_m = 34^\circ \) and injection of DF with the installation of the AAFI \( \Theta_{df} = 34^\circ \) and equals \( g_{\Sigma} = 502 \) g / (kW·h). With a change in the installation of AAFI for both DF \( \Theta_{df} \) and methanol \( \Theta_m \) in one direction or another, the efficiency indicators deteriorate. With an increase in the installation AAFI DF to \( \Theta_{df} = 38^\circ \) and \( \Theta_m = 34^\circ \), the value of \( g_{\Sigma} \) increases to \( g_{\Sigma} = 510 \) g / (kW·h). With a decrease in the installation AAFI DF to \( \Theta_{df} = 30^\circ \) and \( \Theta_m = 34^\circ \), the value of \( g_{\Sigma} \) also changes upwards and amounts to \( g_{\Sigma} = 506 \) g / (kW·h) [8-12].

With an increase in the installation AAFI of methanol to \( \Theta_m = 38^\circ \) and \( \Theta_{df} = 34^\circ \), the value of the specific effective consumption increases to \( g_{\Sigma} = 506 \) g / (kW·h). With a decrease in the installed AAFI of methanol to \( \Theta_m = 30^\circ \) and \( \Theta_{df} = 34^\circ \), the value of \( g_{\Sigma} \) changes to \( g_{\Sigma} = 508 \) g / (kW·h).

With a simultaneous increase in the installed AAFI DF \( \Theta_{df} = 38^\circ \) and methanol \( \Theta_m = 38^\circ \), \( g_{\Sigma} \) grows to \( g_{\Sigma} = 505 \) g / (kW·h). With a simultaneous decrease in the installation of AAFI DF \( \Theta_{df} = 30^\circ \) and methanol \( \Theta_m = 30^\circ \), the value of the specific effective consumption increases to \( g_{\Sigma} = 513 \) g / (kW·h).

Figure 1b, shows the effect of the use of methanol when working with AAFI on the specific effective fuel consumption of a diesel engine 2H 10.5 / 12.0 at various installation of high-voltage alternatives at maximum torque at \( n = 1400 \) min\(^{-1}\).

With a change in the \( g_{\Sigma} \) values, it can be seen that with an increase in the installed AAFI of methanol from \( \Theta_m = 22^\circ \) to \( \Theta_m = 34^\circ \), the value of \( g_{\Sigma} \) decreases over the entire range of the change in the installed AAFI DF. With the installation of AAFI of methanol \( \Theta_m = 38^\circ \), the value of the specific effective consumption of \( g_{\Sigma} \) increases with all the installation of AAFI DF. As can be seen from the graph, the minimum value of the specific effective fuel consumption \( g_{\Sigma} \) is achieved with a combination of installation AAFI DF \( \Theta_{df} = 34^\circ \) and methanol \( \Theta_m = 34^\circ \) and equal to \( g_{\Sigma} = 490 \) g / (kW·h). When you change the installation AAFI DF \( \Theta_{df} \) and methanol \( \Theta_m \) in one direction or another, the efficiency indicators deteriorate [13-18].

With an increase in the installation AAFI DF to \( \Theta_{df} = 38^\circ \) and \( \Theta_m = 34^\circ \), the value of \( g_{\Sigma} \) increases to \( g_{\Sigma} = 506 \) g / (kW·h). With a decrease in the installation AAFI DF to \( \Theta_{df} = 30^\circ \) and \( \Theta_m = 34^\circ \), the value of \( g_{\Sigma} \) decreases to \( g_{\Sigma} = 493 \) g / (kW·h).

With an increase in the installation AAFI to \( \Theta_m = 38^\circ \) and \( \Theta_{df} = 34^\circ \), the value of the specific effective consumption increases to \( g_{\Sigma} = 512 \) g / (kW·h). With a decrease in the methanol AAFI installation to \( \Theta_m = 30^\circ \) and \( \Theta_{df} = 34^\circ \), the value of \( g_{\Sigma} \) increases to \( g_{\Sigma} = 502 \) g / (kW·h).

With a simultaneous increase in the installed methanol AAFI to \( \Theta_m = 38^\circ \) and DF \( \Theta_{df} = 38^\circ \), the specific effective consumption increases to \( g_{\Sigma} = 511 \) g / (kW·h). With a decrease in the installed AAFI DF \( \Theta_{df} = 30^\circ \) and methanol to \( \Theta_m = 30^\circ \), \( g_{\Sigma} \) changes to \( g_{\Sigma} = 494 \) g / (kW·h).

With installation of AAFI DF \( \Theta_{df} = 30^\circ \) and methanol \( \Theta_m = 34^\circ \), in the nominal operation mode at a speed of \( n = 1800 \) min\(^{-1}\), the value of \( g_{\Sigma} \) increases to \( g_{\Sigma} = 506 \) g / (kW·h). At maximum torque mode at a speed of \( n = 1400 \) min\(^{-1}\), the value of the specific effective flow rate changes to \( g_{\Sigma} = 494 \) g / (kW·h). With installation of AAFI DF \( \Theta_{df} = 30^\circ \) and methanol \( \Theta_m = 30^\circ \) in the nominal operating mode at \( n = 1800 \) min\(^{-1}\), the value of \( g_{\Sigma} \) is already \( g_{\Sigma} = 513 \) g / (kW·h), and at maximum torque at \( n = 1400 \) min\(^{-1}\) the value of \( g_{\Sigma} \) changes to \( g_{\Sigma} = 494 \) g / (kW·h).

With installation of AAFI DF \( \Theta_{df} = 34^\circ \) and methanol \( \Theta_m = 38^\circ \), in the nominal operating mode at a speed of \( n = 1800 \) min\(^{-1}\), the value of \( g_{\Sigma} \) increases to \( g_{\Sigma} = 506 \) g / (kW·h). At the maximum torque mode at a speed of \( n = 1400 \) min\(^{-1}\), the value of the specific effective flow rate changes to \( g_{\Sigma} = 512 \) g / (kW·h). With installation of AAFI DF \( \Theta_{df} = 38^\circ \) and methanol \( \Theta_m = 38^\circ \) in the nominal operating mode at \( n = 1800 \) min\(^{-1}\), the value of \( g_{\Sigma} \) is \( g_{\Sigma} = 505 \) g / (kW·h), at the maximum torque mode at \( n = 1400 \) min\(^{-1}\), the value of \( g_{\Sigma} \) changes to \( g_{\Sigma} = 511 \) g / (kW·h) [19-24].
Figure 1. The effect of the use of methanol on the total specific effective fuel consumption of a diesel engine 2H 10.5 / 12.0 when working with DFSS at various installations AAFI: a - at $n = 1800 \text{ min}^{-1}$ and $p_e = 0.585 \text{ MPa}$, $q_{cdf} = 6.6 \text{ mg / cycle}$; b - at $n = 1400 \text{ min}^{-1}$ and $p_e = 0.594 \text{ MPa}$, $q_{cdf} = 6.0 \text{ mg / cycle}$.

Thus, on the basis of the data obtained, the minimum value of the specific effective fuel consumption is observed with the installation of AAFI $\Theta_{df} = 34^\circ$ and methanol $\Theta_m = 34^\circ$, as in the nominal mode of operation at $n = 1800 \text{ min}^{-1}$ $g_{es} = 502 \text{ g / (kW \cdot h)}$, and in the maximum torque mode at $n = 1400 \text{ min}^{-1}$ $g_{es} = 490 \text{ g / (kW \cdot h)}$.

Figure 2a, shows the effect of the use of methanol on the maximum gas pressure in the cylinder of a diesel engine 2H 10.5 / 12.0 when working with DFSS with various installation of high voltage firing in the nominal operating mode at $n = 1800 \text{ min}^{-1}$. From the graphs it can be seen that with an increase in the injection angles of injection of diesel fuel and methanol, the maximum value of the gas pressure increases over the entire range of injection angles.

With the installation of the AAFI DF $\Theta_{df} = 26^\circ$, the maximum pressure increases from $p_{zmax} = 4.98 \text{ MPa at } \Theta_m = 22^\circ$ to $p_{zmax} = 5.81 \text{ MPa at } \Theta_m = 34^\circ$. The growth is 17.7%. With an increase in the installation AAFI to $\Theta_{df} = 30^\circ$, the maximum gas pressure changes from $p_{zmax} = 5.09 \text{ MPa at } \Theta_m = 22^\circ$ to $p_{zmax} = 6.55 \text{ MPa at } \Theta_m = 34^\circ$. The increase is 28.4%. When changing the installation AAFI of DF to $\Theta_{df} = 34^\circ$, the maximum gas pressure changes from 5.04 MPa to 7.31 MPa when changing the setting AAFI of methanol from $\Theta_m = 22^\circ$ to $\Theta_m = 38^\circ$, respectively. The increase is 44.5% [25-27].

With an increase in the installation AAFI to $\Theta_{df} = 38^\circ$, the maximum value of the gas pressure changes from $p_{zmax} = 5.02 \text{ MPa at } \Theta_m = 22^\circ$ to $p_{zmax} = 7.51 \text{ MPa at } \Theta_m = 38^\circ$. The change is 49.1%. With the installation of the AAFI DF $\Theta_{df} = 42^\circ$, the maximum pressure increases from $p_{zmax} = 5.26 \text{ MPa at } \Theta_m = 22^\circ$ to $p_{zmax} = 7.59 \text{ MPa at } \Theta_m = 34^\circ$. The growth is 43.4%.

With the installation of methanol AAFI $\Theta_m = 22^\circ$, the maximum pressure increases from $p_{zmax} = 4.98 \text{ MPa at } \Theta_{df} = 26^\circ$ to $p_{zmax} = 5.26 \text{ MPa at } \Theta_{df} = 42^\circ$. The growth is 5.6%.

With an increase in the installation AAFI $\Theta_m = 26^\circ$ to the maximum value of the gas pressure changes from $p_{zmax} = 5.28 \text{ MPa at } \Theta_{df} = 26^\circ$ to $p_{zmax} = 6.10 \text{ MPa at } \Theta_{df} = 42^\circ$. The increase is 14.6%. With a change in the installation AAFI of methanol to $\Theta_m = 30^\circ$, the maximum value of the gas pressure changes from 5.68 MPa to 6.48 MPa with a change in the installation of AAFI of methanol from $\Theta_{df} = 26^\circ$ to $\Theta_{df} = 42^\circ$, respectively. The increase is 12.0%.

With an increase in the installed methanol AAFI to $\Theta_m = 34^\circ$, the maximum gas pressure changes from $p_{zmax} = 5.81 \text{ MPa at } \Theta_{df} = 26^\circ$ to $p_{zmax} = 6.98 \text{ MPa at } \Theta_{df} = 42^\circ$. The change is 18.6%. With the installation of AAFI of methanol $\Theta_m = 38^\circ$, the maximum pressure increases from $p_{zmax} = 7.31 \text{ MPa at } \Theta_{df} = 34^\circ$ to $p_{zmax} = 7.59 \text{ MPa at } \Theta_{df} = 42^\circ$. The growth is 4.0%.
Figure 2. The effect of the use of methanol on the maximum combustion pressure of a diesel engine 2H 10.5 / 12.0 when working with DFSS at various installations AAFI: a - at n = 1800 min⁻¹ and pₑ = 0.585 MPa, qcdf = 6.6 mg / cycle; b - at n = 1400 min⁻¹ and pₑ = 0.594 MPa, qcdf = 6.0 mg / cycle.

Figure 2b shows the effect of the use of methanol on the maximum value of gas pressure in a diesel cylinder 2H 10.5 / 12.0 when working with DFSS at various installations of AAFI and maximum torque mode at n = 1400 min⁻¹. From the graphs it can be seen that with an increase in the installation angles of injection of diesel fuel and methanol, the maximum gas pressure increases over the entire range of variation of the AAFI [28].

With the installation of AAFI of DF Θdf = 26°, the maximum value of the gas pressure increases from pₑ max = 5.19 MPa at Θm = 22° to pₑ max = 6.82 MPa at Θm = 34°. The growth is 31.1%. With an increase in the installation AAFI to Θdf = 30°, the maximum value of the gas pressure changes from pₑ max = 5.19 MPa at Θm = 22° to pₑ max = 7.22 MPa at Θm = 34°. The increase is 39.2%. When changing the installation AAFI of DF to Θdf = 34°, the maximum value of the gas pressure changes from 5.39 MPa to 7.60 MPa when changing the installation angle of methanol injection from Θm = 22° to Θm = 38°, respectively. The increase is 40.1%.

With an increase in the installation AAFI to Θdf = 38°, the maximum value of the gas pressure changes from pₑ max = 5.39 MPa at Θm = 22° to pₑ max = 7.74 MPa at Θm = 38°. The change is 43.6%. With the installation of AAFI of DF Θdf = 42°, the maximum pressure increases from pₑ max = 5.55 MPa at Θm = 22° to pₑ max = 8.17 MPa at Θm = 34°. The growth is 47.0%.

With the installation of methanol AAFI Θm = 22°, the maximum pressure increases from pₑ max = 5.19 MPa at Θdf = 26° to pₑ max = 5.55 MPa at Θdf = 42°. The growth is 7.0%. With an increase in the installation AAFI to Θm = 26°, the maximum value of the gas pressure changes from pₑ max = 6.01 MPa at Θdf = 26° to pₑ max = 6.4 MPa at Θdf = 42°. The increase is 6.4%. When the methanol installation AAFI is changed to Θm = 30°, the maximum value of the gas pressure changes from 6.52 MPa to 6.9 MPa when the installation angle of injection of DF changes from Θdf = 26° to Θdf = 42°, respectively. The increase is 5.7% [29-31].

With an increase in the methanol AAFI installation to Θm = 34°, the maximum gas pressure value changes from pₑ max = 6.82 MPa at Θdf = 26° to pₑ max = 7.37 MPa at Θdf = 42°. The change is 8.4%. With the installation of AAFI of methanol Θm = 38°, the maximum pressure increases from pₑ max = 7.6 MPa at Θdf = 34° to pₑ max = 8.17 MPa at Θdf = 42°. The growth is 7.5%.

Thus, we can conclude that the supply of methanol has a stronger effect on the change in the maximum value of gas combustion in the cylinder of a diesel engine 2H 10.5 / 12.0.

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