Indicators of the diesel engine combustion process when working on methanol with DST depending on the load changes in different operating modes

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Abstract. In the Vyatka state agricultural Academy, on the basis of the Department of heat engines, cars and tractors, the development of a 2CH 10.5/12.0 diesel engine for working on methanol using a dual fuel supply system was carried out. The paper presents an analysis of the parameters of the 2CH 10.5/12.0 diesel combustion process depending on the load change at the nominal speed and at the crankshaft rotation speed at maximum torque when working on diesel fuel and methanol with a dual fuel supply system.

Figure 1 shows the effect of using methanol with DST on the performance of the combustion process in the 2CH 10.5/12 diesel cylinder, depending on the load changes when working on DT and when working on methanol with DST at the nominal speed of the crankshaft [1-3]. The graphs show that when the diesel engine is running on a DT, the maximum combustion pressure $p_{z_{\text{max}}}$ increases from 5.8 MPa at $p_e=0.127$ MPa to 7.2 MPa at $p_e=0.65$ MPa. The increase in $p_{z_{\text{max}}}$ is 1.4 MPa, or 19.4 %. At the same time, when the load increases, the degree of pressure increase $\lambda$ increases accordingly. For example, for an experienced diesel engine, the value of $\lambda = 1.55$ at $p_e=0.127$ MPa, and when the load increases to the maximum at $p_e=0.65$ MPa, the value of $\lambda$ increases to 1.92. The increase is 19.3 %.

The maximum average temperature of $T_{\text{max}}$ gases in the diesel cylinder increases from 1540 K at $p_e=0.127$ MPa to 2020 K at $p_e=0.65$ MPa. The increase in the temperature value is 480 K, or 23.8 %. The value of the angle corresponding to the ELV when the diesel engine is running on the DT is slightly reduced. For example, at $p_e=0.127$ MPa, $\phi_{i} = 25^\circ \text{p.k.v.}$, and at a load of $p_e=0.65$ MPa $\phi_{i} = 22.7^\circ \text{p.k.v.}$ the reduction is 9.2 %. The maximum «stiffness» of the combustion process $(dp/d\phi)_{\text{max}}$ increases from 0.361 MPa/degree at $p_e=0.127$ MPa to 0.525 MPa/degree at $p_e=0.65$ MPa, or by 31.2 %. From the curves shown in the figure, it can be seen that when a 2CH 10.5/12.0 diesel engine is running on methanol with DST, the combustion process indicators change over the entire load range. Thus, when the load increases, the maximum combustion pressure $p_{z_{\text{max}}}$ increases from 5.2 MPa at $p_e=0.127$ MPa to 7.3 MPa at $p_e=0.65$ MPa. The increase is 2.1 MPa, or 28.8 % [4-10].

The degree of increase in pressure $\lambda$ changes from 1.39 at $p_e=0.127$ MPa to 1.95 at $p_e=0.65$ MPa, an increase of 28.7 %. The maximum average cycle temperature for a diesel engine running on methanol increases from 1360 K at $p_e=0.127$ MPa to 2040 K at $p_e=0.65$ MPa. The temperature increases when the load changes is 680 K, or 33.3 %. The angle corresponding to the ELV when working on
methanol with DST is \( \phi_i = 31^\circ \) p.k.v. at \( p_e = 0.127 \) MPa, and at \( p_e = 0.65 \) MPa, the value of \( \phi_i = 27.5^\circ \) p.k.v. The maximum «stiffness» of the combustion process at \( p_e = 0.127 \) MPa is \((dp/d\phi)_{max} = 0.225\), with increasing load increases and at the maximum value of \( p_e = 0.65 \) MPa reaches the value \((dp/d\phi)_{max} = 0.305 \) MPa/degree, or increases by 26.2 \% [11-15].

Analyzing the changes in the values of the combustion process in the 2CH 10.5/12.0 diesel cylinder, depending on the load change at \( n = 1800 \) min\(^{-1}\) and the optimal UWT, we can note the following [16-17].

![Figure 1. The effect of using methanol with DST on the performance of the diesel combustion process 2CH 10.5/12.0 depending on the load change at \( n = 1800 \) min\(^{-1}\): — diesel process; - - - - methanol with ignited DT.](image)

The maximum cycle pressure when running a diesel engine on methanol with DST at low loads is less than when running a diesel engine on DT. For example, at \( p_e = 0.127 \) MPa, the maximum cycle pressure is reduced from \( p_{z_{max}} = 5.8 \) MPa when the diesel is running on DT to \( p_{z_{max}} = 5.2 \) MPa when the diesel is running on methanol with DST. The decrease is 10.3 \%. With increasing load there is an increase in the maximum combustion pressure. For example, when \( p_e = 0.65 \) MPa, \( p_{z_{max}} = 7.2 \) MPa when running a diesel engine on DT, and when running a diesel engine on methanol with DST, \( p_{z_{max}} = 7.3 \) MPa. The increase is 1.37 \%. At the same time, the degree of pressure increase at \( p_e = 0.127 \) MPa when the diesel engine is running on diesel fuel is 1.55, and when the diesel engine is running on methanol with DST and the same load \( \lambda = 1.39 \), the decrease is 10.3 \%. When the load increases to \( p_e = 0.65 \) MPa, the degree of pressure increase when the diesel engine is running on DT \( \lambda = 1.92 \), and when the diesel engine is running on methanol with DST - 1.95. The increase is 3 \% [18-21].

The maximum average cycle temperature for a diesel engine running on methanol with DST at low loads (\( p_e = 0.127 \) MPa) is reduced to 1360 K compared to the maximum temperature for a diesel engine running on DT, which is 1540 K the decrease is 180 K, or 11.7 \%. When the load is increased to \( p_e = 0.65 \) MPa, the maximum average cycle temperature increases when the diesel engine is running on methanol using DST and is 2040 K compared when working on DT, which is equal to 2020 K. the increase is 20 K.

The ELV during operation of a diesel engine on methanol using DST increases over the entire load range. For example, when \( p_e = 0.127 \) MPa, the value of \( \phi_i = 31^\circ \) p.k.v., and when the diesel engine is running on DT \( \phi_i = 26^\circ \) p.k.v., the Increase is 5 \° p.k.v., or 16.1 \%. The maximum «stiffness» of the combustion process at \( p_e = 0.127 \) MPa when the diesel engine is running on DT is \((dp/d\phi)_{max} = 0.361\)
MPa/deg, and when the diesel engine is running on methanol with DST - 0.225 MPa/deg. The decrease is 37.7 %. When the load increases to p_e = 0.65 MPa, the maximum «stiffness» of the combustion process when running a diesel engine on DT is (dp/dφ)max = 0.525 MPa/deg, and when running a diesel engine on methanol with DST (dp/dφ)max = 0.305 MPa/deg, the decrease is 41.9 %.

Figure 2 shows the effect of using methanol with DST on the performance of the combustion process in a 2CH 10.5/12.0 diesel cylinder, depending on the change in the load at the speed of rotation at the maximum torque (n = 1400 min\(^{-1}\)) [22-25].

The graphs show that when the diesel engine is running on a DT, the maximum combustion pressure PZ max increases from 5.46 MPa at p_e = 0.127 MPa to 7.10 MPa at p_e = 0.635 MPa. The increase of 1.64 MPa, or 23.1 per cent. At the same time, the degree of pressure increase \(\lambda\) increases accordingly when the load increases. So, for an experienced diesel engine, the value of \(\lambda = 1.57\) at p_e = 0.127 MPa, and with an increase in the load to the maximum at p_e = 0.635 MPa, it increases to 2.04. The increase is 23 %. The maximum average gas temperature in the cylinder increases from 1400 K at p_e = 0.127 MPa to 1920 K at p_e = 0.635 MPa. The temperature increase is 520 K, or 27.1 %. The angle corresponding to the ELV when the diesel engine is running on the DT is slightly reduced. For example, when p_e = 0.127 MPa, the value of \(\phi_i = 25^\circ\) p.k.v., and at a load of p_e = 0.635 MPa \(\phi_i = 22.5^\circ\) p.k.v. The maximum «stiffness» of the combustion process increases from 0.405 MPa/deg at p_e = 0.127 MPa to 0.590 MPa/deg at p_e = 0.635 MPa. The increase is 31.3 %.

From the curves shown in the figure, it can be seen that when operating a 2CH 10.5/12.0 diesel engine on methanol with DST, the combustion process indicators change over the entire load range.

Thus, when the load increases, the maximum combustion pressure pz max increases from 4.7 MPa at p_e = 0.127 MPa to 7.5 MPa at p_e = 0.635 MPa. The increase is 2.8 MPa, or 37.3 %. The value of the degree of pressure increase changes from 1.35 at p_e = 0.127 MPa to 2.16 at p_e = 0.635 MPa. The increase is 37.5 %. The maximum average cycle temperature when operating a diesel engine on methanol with DST increases from 1280 K at re = 0.127 MPa to 1960 K p_e = 0.635 MPa. The growth temperature is 680 K, or 34.7 per cent. The angle corresponding to the ELV when the diesel engine is running on methanol with DST is \(\phi_i = 31.5^\circ\) p.k.v., at p_e = 0.127 MPa, and at p_e = 0.635 MPa \(\phi_i = 26^\circ\) p.k.v. The maximum «stiffness» of the combustion process at p_e = 0.127 MPa (dp/dφ)max = 0.290
MPa/deg, with increasing load, the maximum «stiffness» increases. For example, with a maximum value of $p_e = 0.635$ MPa $(dp/d\phi)_{\text{max}} = 0.386$ MPa/deg. The increase in the maximum «stiffness» value is 24.9 %.

Analyzing the changes in the values of the combustion process in the 2CH 10.5/12.0 diesel cylinder, depending on the load change at the speed of $n = 1400$ min⁻¹ and the optimal setting of the UOVT, we can note the following. The maximum cycle pressure when running a diesel engine on methanol with DST at low loads is less than when running a diesel engine on DT. For example, at $p_e = 0.127$ MPa, the maximum cycle pressure is reduced from $p_{e,\text{max}} = 5.46$ MPa when the diesel is running on DT to $p_{e,\text{max}} = 4.7$ MPa when the diesel is running on methanol with DST. The decrease is 13.9 %. With increasing load there is an increase in the maximum combustion pressure. For example, when $p_e = 0.635$ MPa, the value of $p_{e,\text{max}} = 7.10$ MPa when running a diesel engine on DT, and when running a diesel engine on methanol with DST, $p_{e,\text{max}} = 7.50$ MPa. The increase is 5.3 %. In this case, the value of the degree of pressure increase at $p_e = 0.127$ MPa when the diesel engine is running on DT is 1.57, and when the diesel engine is running on methanol with DST and the same load is $\lambda = 1.35$. The decrease is 14.0 %.

When the load increases to $p_e = 0.635$ MPa, the degree of pressure increase when the diesel engine is running on DT is 2.04, and when the diesel engine is running on methanol with DST 2.16, the increase is 5.5 %. The maximum average cycle temperature when working on methanol diesel with DST, at low loads ($p_e = 0.127$ MPa) is 1280 K, and when working on DT $T_{\text{max}} = 1400$ K the increase is 120 K, or 8.6%. When the load increases to $p_e = 0.635$ MPa, the maximum average cycle temperature increases when the diesel engine is running on methanol with DST and is 1960 K compared when the diesel engine is running on DT, which is equal to 1920 K the increase is 40 K, or 2 %.

The ELV during operation of a diesel engine on methanol with DST increases over the entire load range, with $p_e = 0.127$ MPa, the angle $\phi_i = 31.5°$ p.k.v., and when operating a diesel engine on DT $\phi_i = 25.0°$ p.k.v., the increase is 6.5° p.k.v., or 20.6 %. With further increase in load to $p_e = 0.635$ MPa value $\phi_i$ of the diesel on methanol with DST is about 26.0° p.k.v., and when the diesel engine works on DT $\phi_i = 22.5\,\text{about}\,\text{p.k.v.}$, the maximum «stiffness» of the combustion process at $p_e = 0.127$ MPa when the engine is DT $(dp/d\phi)_{\text{max}} = 0.405$ MPa/deg, and when the diesel engine on methanol with DST - 0.290 MPa/deg. The decrease is 28.4 %. When the load increases to $p_e = 0.635$ MPa, the «stiffness» of the combustion process when running a diesel engine on DT is $(dp/d\phi)_{\text{max}} = 0.590$, and when running a diesel engine on methanol with DST $(dp/d\phi)_{\text{max}} = 0.386$ MPa/deg. The decrease is 34.6 %.

Thus, making a general conclusion about the use of methanol as a motor fuel when using a dual fuel supply system, it should be noted that the obtained indicators of the combustion process do not worsen the indicators of the combustion process obtained when working on diesel fuel, and in some cases even improve the combustion process, making the question of using alternative fuels more relevant.

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