Influence of methanol use in diesel fuel on energy and economic indicators

A N Chuvashev and A I Chuprakov

Federal State Budgetary Educational Institution of Higher Education «Vyatka state agricultural academy», Department of thermal engines, automobiles and tractors, October prospect, 133, Kirov, 610017, Russian Federation

E-mail: aleks_dvs@mail.ru

Abstract. The problem of finding and using alternative energy carriers in transport has arisen since the invention of the internal combustion engine. It is possible to expand the raw material base of automobile fuels and at the same time reduce their negative impact on the environment by using non-traditional or alternative fuels. Among them, compressed natural gas and alcohols are most widely used in road transport. In the Vyatka agricultural Academy, work is underway to study the features of the use of alcohols in diesels when they are fed using a dual fuel supply system.

Extensive tests of the 2H 10.5/12.0 diesel were conducted to study the operating cycle when operating on conventional alternative fuel-methanol. A distinctive feature of our research is the use of a multi-jet nozzle for supplying the incendiary part of diesel fuel using specially manufactured sprayers. At the same time, the methanol supply was carried out through the standard fuel supply and spraying system [1-3].

Based on the provisions of GOST 18509-88, the main of several test modes was the mode of nominal engine operation, with the crankshaft speed of 1800 min⁻¹.

The development of a methanol-fueled propulsion system using DST provided primarily for maintaining the energy and economic indicators inherent in a standard engine. (figure 1).

Figure 2 it is shown that the consumption of diesel fuel increases from 1.85 kg/h at \( p_e = 0.127 \) MPa to 7.15 kg/h at \( p_e = 0.65 \) MPa when the power unit is running on a DT. The increase is 5.3 kg/h, or 74.1%. The graph shows that when the diesel engine is running on methanol using DST, the total fuel consumption increases with increasing load from 3.95 kg at \( p_e = 0.127 \) MPa to 10.6 kg at \( p_e = 0.65 \) MPa. The increase is 6.65 kg/h, or 62.7%.

When analyzing the results obtained, it should be noted that the fuel consumption when operating a power unit on alcohol fuel with DST is significantly higher than when operating a power unit on oil fuel. For example, when \( p_e = 0.127 \) MPa, the consumption of alcohol fuel when the power unit is running on DT is 1.85 kg/h, and when the power unit is running on alcohol fuel with DST - 3.95 kg/h. The increase is 53.2%. At \( p_e = 0.65 \) MPa, the consumption of alcohol fuel is also higher than when the power unit is running on oil fuel. If the consumption of oil fuel is 7.15 kg/h at the same load, but when the power unit is running on alcohol fuel with DST, then the consumption is 10.6 kg/h. The increase is 32.5%. The overall increase in alcohol fuel consumption is due to the fact that methanol has a lower calorific value, and to maintain energy indicators at the level of the experimental power unit, methanol
must be supplied in large quantities [4-6].
Figure 3 it is shown that when the power unit is running on oil fuel, the minimum specific consumption of oil fuel occurs at \( p_e = 0.50 \) MPa and is \( g_e = 265 \) g/(kW\cdot h). At rated load (\( p_e = 0.585 \) MPa) \( g_e = 273 \) g/(kW\cdot h). The graph shows that when the power unit is running on alcohol with the pilot fuel supply, the minimum value of the total specific effective fuel consumption is achieved at \( P_E = 0.54 \) MPa and is \( g_{e\Sigma} = 490 \) g/(kW\cdot h). At rated load (\( p_e = 0.585 \) MPa) the \( g_e \) value is 502 g/(kW\cdot h).

![Figure 3](image)

When analyzing the results obtained, it should be noted that the specific fuel consumption when the power unit is running on alcohol with a pilot portion of DT, respectively, is also higher than when the power unit is running on DT. In the nominal mode, the value of \( g_e = 273 \) g/(kW\cdot h) when the power unit is running on DT, when the power unit is running on alcohol with the supply of a pilot portion of DT and the same load is \( g_{e\Sigma} = 502 \) g/(kW\cdot h). The increase was 45.6% [7-9].

![Figure 4](image)

Figure 4 it is shown that when a diesel engine is running on a DT, the value of the effective efficiency increases. When the load increases, it increases from \( \eta_e = 0.185 \) at \( p_e = 0.127 \) MPa to \( \eta_e = 0.266 \) at \( p_e = 0.65 \) MPa, while the maximum value is reached at \( p_e = 0.50 \) MPa and is \( \eta_e = 0.315 \). The graph shows that when a diesel engine is running on methanol using DST, the effective efficiency value increases. When the load increases, it increases from \( \eta_e = 0.16 \) at \( p_e = 0.127 \) MPa to \( \eta_e = 0.320 \) at \( p_e = 0.65 \) MPa, while the maximum value is reached at \( p_e = 0.54 \) MPa and is \( \eta_e = 0.34 \).

Analyzing the results obtained, it should be noted that the value of effective efficiency is very high. When \( p_e = 0.127 \) MPa and diesel operation on DT is 0.185, and when diesel operation on methanol with DST - 0.16. The decrease was 13.5%. When increasing the load to \( p_e = 0.65 \) MPa, the value for
experimental diesel is 0.266, and when working on methanol with DST – 0.320. The increase was 16.8 % [10-13].

Figure 5 shows that when a diesel engine is running on a DT, the exhaust gas temperature also increases as the load increases. So, for an experienced diesel engine when working on DT at \( p_e = 0.127 \text{ MPa} \) \( t_g = 235^\circ \text{C} \) and when increasing the load to the maximum at \( p_e = 0.65 \text{ MPa} \) \( t_g = 645^\circ \text{C} \). This increase is 410 \(^\circ\)C, or 63.6 %. The graph shows that when a diesel engine is running on methanol using DST, the exhaust gas temperature also increases as the load increases. So, when the diesel engine is running on methanol with DST at \( p_e = 0.127 \text{ MPa} \), the value of \( t_g = 220^\circ \text{C} \), and when the load increases to the maximum at \( p_e = 0.65 \text{ MPa} \), it increases to \( t_g = 535^\circ \text{C} \). This increase was 315 \(^\circ\)C, or 58.9 %.

![Figure 5](image5.jpg)

Figure 5. Analysis of the use of alcohol with the supply of a pilot portion of DT for changes in the temperature of exhaust gases; - - diesel process, - - - - methanol with ignited DT.

When analyzing the results obtained, it should be noted that the temperature of the exhaust gases during the operation of the power unit on alcohol with the supply of the pilot part of the DT in the entire range of load changes is less than that of the serial power plant. So, when \( p_e = 0.127 \text{ MPa} \), \( t_g = 235^\circ \text{C} \) when the power plant is running on oil fuel, and when working on alcohol with the supply of an experimental portion of DT, \( t_g = 220^\circ \text{C} \). The decrease was 6.4 %. When changing the load on \( p_e = 0.65 \text{ MPa} \), the value of \( t_g = 645^\circ \text{C} \) when the power unit is running on DT and \( t_g = 535^\circ \text{C} \) when the power unit is running on alcohol with the supply of a pilot portion of DT. The reduction is 110 \(^\circ\)C, or 17% [14-16].

![Figure 6](image6.jpg)

Figure 6. Analysis of the use of alcohol with the supply of a pilot portion of DT to change the air flow; - - diesel process, - - - - methanol with ignited DT.

Figure 6 it is shown that when a diesel engine is running on a DT, the air consumption at \( p_e = 0.127 \text{ MPa} \) is 116.6 \( \text{kg/h} \) and decreases to 112 \( \text{kg/h} \) at \( p_e = 0.65 \text{ MPa} \). The decrease was 3.9 %. The graph shows that when working on methanol diesel using DST, the air consumption at \( p_e = 0.127 \text{ MPa} \) is 116 \( \text{kg/h} \) and decreases to 115 \( \text{kg/h} \) at \( p_e = 0.65 \text{ MPa} \).

Analyzing the results obtained, it should be noted that the air consumption at low loads when running a diesel engine on different types of fuel has the same value. When the load increases (\( p_e = 0.65 \text{ MPa} \)), the air consumption for the experimental diesel engine is 112 \( \text{kg/h} \), and when the diesel engine is running on methanol with DST – 115 \( \text{kg/h} \), the increase is 2.6 % [17-20].
Figure 7 it is shown that when the diesel engine is running on DT, the coefficient of excess air when working on DT decreases with increasing load from $\alpha = 4.45$ at $p_e = 0.127$ MPa to $\alpha = 1.15$ at $p_e = 0.65$ MPa. The decrease was 74.2%. The graph shows that when the diesel engine is running on methanol using DST, the excess air coefficient when the diesel engine is running on methanol with DST decreases with increasing load from $\alpha = 3.6$ at $p_e = 0.127$ MPa to $\alpha = 1.5$ at $p_e = 0.65$ MPa. This reduction is 58.3%.

Figure 8 it is shown that when the diesel engine is running on DT, the filling coefficient at low loads ($p_e = 0.127$ MPa) is 0.90, and at maximum load ($p_e = 0.65$ MPa) - 0.865. The decrease was 3.9%. The graph shows that when the diesel engine is running on methanol using DST, the filling coefficient at low loads ($p_e = 0.127$ MPa) is equal to 0.86, and at maximum load ($p_e = 0.65$ MPa) does not change and is also equal to 0.86.

Analyzing the results obtained, it should be noted that the excess air coefficient for $p_e = 0.127$ MPa and diesel operation on DT is 4.45, and for diesel operation on methanol with DST $\alpha = 3.6$. The decrease was 19.1%. At $p_e = 0.65$ MPa, the value for $\alpha$ diesel engine running on DT is 1.15, and for a diesel engine running on methanol with DST $\alpha = 1.5$. The increase was 23.3% [21-23].

Figure 7. Analysis of the use of alcohol with the supply of a pilot portion of DT to change the filling coefficient; - - diesel process, - - - - methanol with ignited DT.

Figure 8. Analysis of the use of alcohol with the supply of a pilot portion of DT to change the excess air coefficient; - - diesel process, - - - - methanol with ignited DT.

Analyzing the results obtained, it should be noted that while maintaining energy characteristics, it is possible to achieve savings in motor fuel by replacing it with alternative fuel.

References
[1] Kozlov A N, Anfilatov A A and Chuvashov A N 2019 *Journal of Physics: Conf. Series* **1399** 055051
[2] Chuvashov A N and Chuprakov A I 2019 *Journal of Physics: Conf. Series* **1399** 055085
[3] Skryabin M L 2020 *IOP Conf. Series: Earth and Environmental Science* 421 072012
[4] Chuvashov A N, Chuprakov A I and Anfilatov A A 2020 *IOP Conf. Series: Materials Science and Engineering* 734 012184
[5] Likhanov V A and Lopatin O P 2018 *IOP Conf. Series: Materials Science and Engineering* 457 012011
[6] Likhanov V A and Lopatin O P 2019 *Journal of Physics: Conf. Series* 1399 055016
[7] Likhanov V A and Lopatin O P 2019 *Journal of Physics: Conf. Series* 1399 055020
[8] Likhanov V A, Lopatin O P and Yurlov A S 2019 *Journal of Physics: Conf. Series* 1399 055026
[9] Likhanov V A and Lopatin O P 2020 *IOP Conf. Series: Earth and Environmental Science* 421 072018
[10] Lopatin O P 2020 *IOP Conf. Series: Earth and Environmental Science* 421 072019
[11] Likhanov V A and Lopatin O P 2017 *Thermal Engineering* 64(12) 935-44
[12] Likhanov V A and Lopatin O P 2019 *Ecology and Industry of Russia* 23(9) 60-5
[13] Likhanov V A and Lopatin O P 2018 *Ecology and Industry of Russia* 22(10) 54-9
[14] Marchuk A, Likhanov V A and Lopatin O P 2019 *Theoretical and Applied Ecology* 3 080-6
[15] Romanyuk V, Likhanov V A and Lopatin O P 2018 *Theoretical and Applied Ecology* 3 27-32
[16] Likhanov V A and Rossokhin A V 2018 *IOP Conf. Series: Materials Science and Engineering* 457 012007
[17] Likhanov V A and Skryabin M L 2019 *IOP Conf. Series: Earth and Environmental Science* 315 032045
[18] Likhanov V A and Rossokhin A V 2019 *Journal of Physics: Conf. Series* 1399 044038
[19] Likhanov V A and Lopatin O P 2020 *IOP Conf. Series: Materials Science and Engineering* 734 012202
[20] Likhanov V A, Lopatin O P and Yurlov A S 2020 *IOP Conf. Series: Materials Science and Engineering* 734 012208
[21] Likhanov V A and Rossokhin A V 2020 *IOP Conf. Series: Materials Science and Engineering* 734 012207
[22] Likhanov V A, Kozlov A N and Araslanov M I 2020 *IOP Conf. Series: Materials Science and Engineering* 734 012211
[23] Skryabin M L and Likhanov V A 2020 *IOP Conf. Series: Materials Science and Engineering* 734 012075
[24] Lopatin O P 2020 *IOP Conf. Series: Materials Science and Engineering* 734 012199
[25] Skryabin M L and Likhanov V A 2019 *Journal of Physics: Conference Series* 1399 044063