Study of indicators of the working process of tractor diesel when working on ethanol and rapeseed oil

V A Likhanov, O P Lopatin¹, A S Yurlov and N S Anfilatova

Department of thermal engines, automobiles and tractors, Vyatka State Agrotechnological University, October prospect, 133, Kirov, 610017, Russian Federation

¹E-mail: nirs_vsaa@mail.ru

Abstract. The use of alternative fuels derived from natural gas, coal, and renewable energy sources in tractor diesel engines (TDE) will solve the problem of replacing petroleum fuels, significantly expand the raw material base for obtaining motor fuels, and reduce the negative impact of motor vehicles on the environment. The use of alternative oxygenate fuels, such as ethanol (E), in diesel engines is particularly promising. As a result of the analysis of the conducted studies, it was found that it is possible to organize the working process in the cylinder of a TDE when it operates on E and rapeseed oil (RO), with their separate supply directly to the cylinders and ignition from the ignition fuel (pilot) with a high cetane number. As a starting fuel, it is possible to use RO, which is capable of self-ignition due to its physical and chemical properties. At the same time, it is expected to improve the performance of the working process, environmental and efficient performance of the TDE with the complete replacement of diesel fuel (DF).

Currently, TDE are widely used on cars and tractors in all industries, agriculture, transport due to their high efficiency, reliability and economy. Nevertheless, the increasing fleet of TDE is one of the main causes of environmental pollution and the increase in the consumption of petroleum motor fuel. The transport sector accounts for a third of the world's energy consumption, which is mainly generated from fossil fuels, whose global and national reserves are continuously declining. Increasing year-on-year depletion of fossil fuel reserves and high levels of environmental pollution are forcing State governments to implement strict emission standards for TDE exhaust gases and to encourage activities and research aimed at the use of alternative fuels, including motor vehicles. All this suggests that research on the impact of alternative fuels on the organization of the working process in the cylinder, environmental and efficient performance of TDE, is an important scientific task, which determines the possibility of widespread use of non-traditional fuels and is essential for the development of the country.

[1-7].

The analysis of the results of scientific research shows that domestic and foreign scientists have partially investigated the possibility of using ethanol in TDE as a motor fuel and the use of RO. At the same time, it should be noted that studies on the use of E and RO as motor fuel were conducted without studying the complex impact on the environmental, effective performance and performance of the working process in the cylinder of a TDE [8-17].
As a result of studies of the effect of the use of E and RO when changing the setting angle of fuel injection advance (SAFIA) on the performance of the TDE, the optimal value of pilot RO was determined, which is at the nominal operating mode ($n=1800 \text{ min}^{-1}$, $p_e=0.588 \text{ MPa}$) $q_i=13 \text{ mg/cycle}$, at which the maximum value of $\eta_e$ is reached (figure 1).

![Figure 1. The influence of the use of E and RO on the change in the SAFIA of the TDE on the performance indicators.](image)

In terms of efficiency, the optimal SAFIA were $\Theta_E=34^\circ$ and $\Theta_{RO}=34^\circ$ (figure 2).

![Figure 2. The effect of the use of E and RO on the change in the SAFIA of the TDE on the total specific effective fuel consumption.](image)

Figure 3 shows the indicator diagrams obtained at the SAFIA of E $\Theta_E=34^\circ$ and various $\Theta_{RO}$. As can be seen from the diagrams, the late supply of pilot RO, which initiates ignition, leads to a shift of the ignition start point to the right of the upper dead center, as a result of which the entire combustion process is shifted to the expansion line, which leads to a decrease in the maximum gas pressure in the cylinder of the TDE [18-25].
Figure 3. Indicator diagrams at $\theta_E = 34^\circ$ and various setting angles of RO injection advance at $q_c = 13$ mg/cycle.

Figure 4 shows the effect of the use of E and RO on the indicator diagrams of a TDE, in comparison with the operation on DF at the rated mode. The graphs show a slight decrease in the maximum gas pressure in the cylinder, and the entire combustion process is slightly shifted from the line of the upper dead center. This leads to a decrease in the rate of pressure build-up of the combustion process in comparison with DF [26-34].

Figure 4. Indicator diagrams of the TDE on E and RO in comparison with the operation on DF: $\quad$ - DF; $\quad$ - E and RO.

The analysis of the heat release characteristics shown in figure 5 shows that when the TDE is running on E and RO, the maximum heat release rate is shifted to the right from the upper dead center.
At the same time, there is a decrease in \((d\chi/d\phi)_{\text{max}}\) from 0.063 when working on standard fuel to 0.61 when switching to E and RO. In addition, as can be seen from the graph, when running a TDE on E and RO, the curve \(\chi\) is similar to the curve when running on base fuel, which indicates the same complete combustion of fuel in the cylinder of a TDE [35-43].

The effect of the use of E and RO on the parameters of the combustion process of a TDE is shown in figure 6.
Figure 7 shows the effect of the use of E and RO on the heat dissipation characteristics at different loads of the TDE at the rated speed.

At the same time, at medium and low load, the maximum heat release rate when running a TDE on E and RO is significantly lower than when running on DF. With increasing load, the rate of heat release when working on E and RO increases significantly and exceeds the rate of heat release on DF. A similar pattern is observed for the values of active heat release $\chi_i$ at $p_z$ and $T_{max}$. The use of E and RO increases the increase in the intensity of fuel burn-up with an increase in the load of the TDE [44-57].

For the use of E and RO as fuel in a TDE, the following conclusions were made and the following recommendations were proposed.

The optimal SAFIA during the operation of a TDE on E and RO are determined: for E $\Theta_E=34^\circ$, for RO $\Theta_{RO}=34^\circ$.

It is established that when working on E and RO, the power indicators of the TDE do not decrease with the complete exclusion of the use of petroleum DF. The influence of E and RO on the parameters of the combustion process and the characteristics of heat generation, power and economic performance of the TDE was determined. At the same time, it was found that with the use of E and RO, the maximum effective efficiency is shifted towards high load modes of operation.

To ensure the stable operation of the TDE and maintain the best effective performance the value of the ignition fuel should be 13 mg/cycle at the rated operating mode.

To prevent premature wear of the parts of the fuel supply equipment of the TDE, it is necessary to add 1-2% castor oil to the E.

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