The study of the properties of ethanol-fuel emulsions with the use of supplements targeted actions

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Abstract. Internal combustion engines play a significant role in environmental pollution. In large cities, they are one of the main sources of toxic substances released into the atmosphere. One of the main tasks, along with improving the economic performance of diesels, is to reduce the toxicity of their exhaust gases. For these purposes, it is necessary to study the operation of diesels using alternative fuels. However, their use usually requires significant changes in the design of engines compared to diesels running on petroleum fuel. To study the main performance properties of ethanol-fuel emulsions as a substitute for petroleum fuels in the conditions of expanding the raw material base of automobile fuels and simultaneously reducing their negative impact on the environment, the Vyatka agricultural Academy continues to study the impact of alcohol use in diesels when they are fed using emulsions. The article presents the results of the research.

At a lower temperature in the cylinder, more time is required for heating, evaporation of droplets and formation of active radicals. Consequently, the ignition delay period increases. Increases the time spent in the cylinder until the critical temperature at which self-ignition occurs is reached. As the injection continues, a large amount of fuel accumulates in the cylinder, which cannot ignite for a long time. A large number of active radicals are formed, which initiate the formation of self-ignition foci, so that with the beginning of fuel ignition, the gas pressure and the rate of pressure increase in the cylinder will increase. Gorenje will occur to the upper dead point (TDC) with a decrease in volume. Gorenje process is shifted relative to the TDC in such a way that the greatest pressure is reached near the TDC. This is accompanied by a sharp increase in compression, a decrease in expansion, and, as a result, a decrease in indicator indicators. In addition, increased Gorenje pressure negatively affects the reliability of parts of the crank mechanism [1-11].

Setting the late setting angle when running on diesel fuel (DT) causes the fuel to be injected into a charge that has a higher pressure and temperature. The rate of pre-flame reactions increases. However, the point on the indicator chart corresponding to the beginning of Gorenje is still shifted to the right. The rate of pressure increase and the maximum gorenje pressure decrease. The entire Gorenje process is also shifted to the right. Most of the fuel is burned when the piston moves down. In the case of Gorenje, most of the heat generated by fuel combustion is used to heat the cylinder walls, and is also lost along with the exhaust gases (for example). Thus, the subsequent injection also worsens the indicator indicators [12-18].
Figure 1. Combined fuel characteristics of a diesel engine when working on a DT with an injection angle installation depending on the angle of p.k.v. at \( n = 2200 \, \text{min}^{-1}, \, p_e = 0.64 \, \text{MPa}; \)

\( - - - \, \Theta_{vpr \, DT} = 20^\circ, \quad - - - \, \Theta_{vpr \, DT} = 23^\circ, \quad - - - \, \Theta_{vpr \, DT} = 26^\circ, \quad - - - \, \Theta_{vpr \, DT} = 29^\circ. \)

Figure 2. Combined fuel characteristics of a diesel engine when working on a DT with an injection angle installation depending on the angle of p.k.v. at \( n = 1700 \, \text{min}^{-1}, \, p_e = 0.69 \, \text{MPa}; \)

\( - - - \, \Theta_{vpr \, DT} = 20^\circ, \quad - - - \, \Theta_{vpr \, DT} = 23^\circ, \quad - - - \, \Theta_{vpr \, DT} = 26^\circ, \quad - - - \, \Theta_{vpr \, DT} = 29^\circ. \)

When working on ethanol-fuel emulsion (ETE), the fuel ignites by a slightly different mechanism. Ete droplets in the diesel cylinder are exposed to increasing temperature and pressure, which leads to the start of the ete droplet evaporation process. Due to the significant difference in the boiling point of ethanol and fuel oil, the alcohol particles contained in fuel oil drops initially evaporate, which contributes to the rupture of fuel oil drops. These microfractures contribute to the intensification of the
evaporation process of fuel oil drops. The intensity of these processes depends on the pressure and temperature in the diesel cylinder when the air-fuel mixture is formed. At earlier installation angles, fuel combustion is more active, with higher speeds and ends faster, which leads to an increase in the maximum combustion pressure and an increase in the rate of pressure build-up.

For rice. 1 shows the combined graphs of changes in the heat release indicators in the diesel cylinder at when the rotation speed is equal to 2200 min\(^{-1}\) and \(p_c = 0.64\) MPa when working on the fuel oil at different installation angles, depending on the angle of rotation of the crankshaft.

The maximum average temperature of the \(T_{\text{max}}\) cycle at the setting angle \(\Theta_{\text{vpr DT}} = 29^\circ\) is 2240 K and is observed at the angle \(\varphi_{\text{Tmax}} = 4.0^\circ\) C. When the setting angle decreases to \(\Theta_{\text{vpr DT}} = 26^\circ\), the \(T_{\text{max}}\) value decreases to 2199 K and is observed at the angle \(\varphi_{\text{Tmax}} = 5.0^\circ\) p.k.v. after TDC. When the setting angle is further reduced \(\Theta_{\text{vpr DT}} = 23^\circ\), the \(T_{\text{max}}\) value decreases to 2115 K and is observed at an angle \(\varphi_{\text{Tmax}} = 7.0^\circ\) p.k.v. after TDC. At \(\Theta_{\text{vpr DT}} = 23^\circ\) \(T_{\text{max}} = 2076\) K.

Analyzing the heat release graphs, it should be noted that when switching to earlier values of the installation angles, the heat release rate \(d\varphi/d\varphi\) decreases, and the maximum speed is shifted to the left along the axis. At \(\Theta_{\text{vpr DT}} = 29^\circ\), the maximum heat release rate \((d\varphi/d\varphi)_{\text{max}} = 0.082\) is observed at an angle of \(\varphi = -1.5^\circ\) C up to TDC. A decrease in the value of the installation angle to \(\Theta_{\text{vpr DT}} = 26^\circ\) the value \((d\varphi/d\varphi)_{\text{max}}\) increases to 0.093 is observed at the angle \(\varphi = -0.5^\circ\) p.k.v. after TDC. If the setting angle value \(\Theta_{\text{vpr DT}} = 23^\circ\), the value \((d\varphi/d\varphi)_{\text{max}}\) increases to 0.097, observed at the angle \(\varphi = 0.0^\circ\) p.k.v. after TDC. When the angle value is further reduced to \(\Theta_{\text{vpr DT}} = 20^\circ\), the value \((d\varphi/d\varphi)_{\text{max}}\) increases to 0.106 and is observed at an angle \(\varphi = 2.0^\circ\) p.k.v. after TDC. The curves of relative heat release \(\chi\) and active heat release II reach their maximum faster when working on later injection angle installations than on earlier ones, which is associated with an earlier start of combustion and an increase in the rate of heat release [19-26].

For rice. 2 shows the combined graphs of changes in indicators that characterize the heat release in the diesel cylinder at when the rotation speed is equal to 1700 min\(^{-1}\) and \(p_c = 0.69\) MPa when working on the fuel oil at different installation angles, depending on the angle of p.k.v.

The dependences of changes in the curves of heat release indicators are preserved, for example, at when the rotation speed is equal to 2200 min\(^{-1}\) and \(p_c = 0.64\) MPa. The maximum average temperature of the \(T_{\text{max}}\) cycle at the installation injection angle \(\Theta_{\text{vpr DT}} = 29^\circ\) is 2285 K and is observed at the angle \(\varphi_{\text{Tmax}} = 1.5^\circ\) p.k.v. after TDC. When the injection angle setpoint is reduced to \(\Theta_{\text{vpr DT}} = 26^\circ\), the \(T_{\text{max}}\) value decreases to 2230 K and is observed at an angle \(\varphi_{\text{Tmax}} = 2.5^\circ\) p.k.v. after TDC. At the setting value injection angle \(\Theta_{\text{vpr DT}} = 23^\circ\), the \(T_{\text{max}}\) value increases to 2145 K and is observed at the angle \(\varphi_{\text{Tmax}} = 3.0^\circ\) p.k.v. after TDC [27-35].

Analyzing the heat release graphs, we can conclude that when working on an earlier installation, the injection angle is characterized by a decrease in the heat release rate \((d\varphi/d\varphi)\), the maximum speed point is shifted to the left. At \(\Theta_{\text{vpr DT}} = 29^\circ\), the maximum heat release rate \((d\varphi/d\varphi)_{\text{max}} = 0.085\) is observed at an angle of \(\varphi = -3.5^\circ\) p.k.v. after TDC. When the injection angle value decreases to \(\Theta_{\text{vpr DT}} = 26^\circ\), the value \((d\varphi/d\varphi)_{\text{max}}\) increases to 0.098 and is observed at an angle of \(\varphi = 3.0^\circ\) p.k.v. after TDC. When the setting value injection angle \(\Theta_{\text{vpr DT}} = 23^\circ\), the value \((d\varphi/d\varphi)_{\text{max}}\) increases to 0.106 and is observed at an angle of \(\varphi = -2.5^\circ\) p.k.v. after TDC. The curves of relative heat release \(\chi\) and active heat release \(\chi\) reach their maximum faster when working on later installations.

Fig. 3 shows a combined graph of indicators that characterize the dissipation in the diesel cylinder at when the rotation speed is equal to 2200 min\(^{-1}\) and \(p_c = 0.64\) MPa when working on ets at various Uout installations, depending on the angle of p.k.v. after TDC. The curves of changes in thermal characteristics when working on diesel fuel and ets are preserved [36-47].
With a later injection, the maximum average temperature of the $T_{\text{max}}$ cycle decreases. The maximum average temperature of the $T_{\text{max}}$ cycle at the installation injection angle $\Theta_{\text{vpr DT}} = 29^\circ$ is 2635 K and is observed at the angle $\varphi_{T_{\text{max}}} = 5.0^\circ$ p.k.v. after TDC. When the injection angle setpoint is reduced to $\Theta_{\text{vpr ETE}} = 26^\circ$, the $T_{\text{max}}$ value decreases to 2575 K and is observed at an angle $\varphi_{T_{\text{max}}} = 9.0^\circ$ p.k.v. after TDC. At the setting value injection angle to $\Theta_{\text{vpr ETE}} = 23^\circ$, the $T_{\text{max}}$ value decreases to 2511 K and is observed at the angle $\varphi_{T_{\text{max}}} = 11.5^\circ$ p.k.v. after TDC. When the uovt setting value is further reduced to $\Theta_{\text{vpr ETE}} = 20^\circ$, the $T_{\text{max}}$ value decreases to 2426 K and is observed at an angle $\varphi_{T_{\text{max}}} = 11.5^\circ$ p.k.v. after

**Figure 3.** Combined fuel characteristics of a diesel engine when working on a ETE with a injection angle installation depending on the angle of p.k.v. at $n = 2200$ min$^{-1}$, $p_e = 0.64$ MPa; $\Theta_{\text{vpr DT}} = 20^\circ$, $\Theta_{\text{vpr DT}} = 23^\circ$, $\Theta_{\text{vpr DT}} = 26^\circ$, $\Theta_{\text{vpr DT}} = 29^\circ$.

**Figure 4.** Combined fuel characteristics of a diesel engine when working on a ETE with a injection angle installation depending on the angle of p.k.v. at $n = 1700$ min$^{-1}$, $p_e = 0.69$ MPa; $\Theta_{\text{vpr DT}} = 20^\circ$, $\Theta_{\text{vpr DT}} = 23^\circ$, $\Theta_{\text{vpr DT}} = 26^\circ$, $\Theta_{\text{vpr DT}} = 29^\circ$. 

TDC [48-53].

Analyzing the graphs of heat release indicators, it can be concluded that when working on alcohol emulsion at an earlier installation of injection angle, as well as when working on fuel oil, a decrease in the heat release rate \( \frac{dy}{d\varphi} \) and a shift of the maximum speed to the left is characteristic. Thus, at the angle \( \Theta_{\text{vpr ETE}} = 29^\circ \), the maximum heat release rate \( \frac{dy}{d\varphi}_{\text{max}} = 0.138 \) and is observed at the angle \( \varphi = 0.5^\circ \) p.k.v. after TDC. When the injection angle value decreases to \( \Theta_{\text{vpr ETE}} = 26^\circ \), the value \( \frac{dy}{d\varphi}_{\text{max}} \) increases to 0.143 and is observed at an angle of \( \varphi = 4.0^\circ \) p.k.v. after TDC. At the setting value injection angle \( \Theta_{\text{vpr ETE}} = 23^\circ \), the value \( \frac{dy}{d\varphi}_{\text{max}} \) increases to 0.161 and is observed at the angle \( \varphi = 7.0^\circ \) p.k.v. after TDC. When the value of the injection angle parameter is further lowered to \( \Theta_{\text{vpr ETE}} = 20^\circ \), the value \( \frac{dy}{d\varphi}_{\text{max}} \) increases to 0.168 and is observed at an angle of \( \varphi = 11.0^\circ \) p.k.v. after TDC. Relative heat release curves \( \chi \) and active heat release \( \chi \) for earlier models the injection angle setting reaches its maximum later than in earlier stages, which is due to the earlier start of combustion.

Fig. 4 shows a combined graph of indicators that characterize the dissipation in the diesel cylinder at maximum torque at when the rotation speed is equal to 1700 min\(^{-1}\) and \( t_p = 0.69 \) MPa when working on one for various injection angle installations, depending on the angle of p.k.v. the nature of the curves of change is similar to the mode of operation on one at nominal mode when the rotation speed is equal to 2200 min\(^{-1}\) and \( t_p = 0.64 \) MPa [54-65].

At a later injection, the value of the maximum average temperature of the T\(_{\text{max}}\) cycle falls, and this maximum is shifted to the expansion line. Thus, the maximum average temperature of the T\(_{\text{max}}\) cycle when setting injection angle \( \Theta_{\text{vpr ETE}} = 29^\circ \) is 2658 K and is observed at an angle of \( \varphi_{\text{Tmax}} = 3.5^\circ \) p.k.v. after TDC. When setting injection angle decreases to \( \Theta_{\text{vpr ETE}} = 23^\circ \), the T\(_{\text{max}}\) value decreases to 2603 K and is observed at an angle of \( \varphi_{\text{Tmax}} = 6.5^\circ \) p.k.v. after TDC. When the setting value is injection angle \( \Theta_{\text{vpr ETE}} = 20^\circ \), the T\(_{\text{max}}\) value decreases to 2542 K and is observed at the angle \( \varphi_{\text{Tmax}} = 8.0^\circ \) p.k.v. after TDC.

Analyzing the graphs of heat release, we can conclude that when working on earlier injection angle installations, a decrease in the heat release rate \( \frac{dy}{d\varphi} \) and a shift of the maximum speed to the left along the axis \( \varphi \) are characteristic. At \( \Theta_{\text{vpr ETE}} = 29^\circ \), the maximum heat release rate \( \frac{dy}{d\varphi}_{\text{max}} = 0.143 \) and is observed at \( \varphi = 0^\circ \) p.k.v. after TDC. When the injection angle value decreases to \( \Theta_{\text{vpr ETE}} = 26^\circ \), the value \( \frac{dy}{d\varphi}_{\text{max}} \) increases to 0.151 and is observed at an angle of \( \varphi = 2.0^\circ \) p.k.v. after TDC. When the setting value is injection angle \( \Theta_{\text{vpr ETE}} = 23^\circ \), the value \( \frac{dy}{d\varphi}_{\text{max}} \) increases to 0.168 and is observed at the angle \( \varphi = 4.5^\circ \) p.k.v. after TDC. The curves of relative heat release \( \chi \) and active heat release \( \chi \) reach their maximum faster when working on later installations than on earlier ones.

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