Influence of alcohol-fuel emulsions on effective indicators of the diesel depending on change of a corner of injection of fuel

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Abstract. Today in our country and around the world much attention is paid to the environmental situation. Road transport plays a significant role in environmental pollution, especially air pollution. One of the most effective ways to reduce exhaust emissions is the use of alternative fuels, including those produced from renewable raw materials. Such fuels are methyl and ethyl alcohols, as well as emulsions based on them. The use of these fuels in spark-ignition engines has been used for a long time and has shown its effectiveness. At the same time, the question of the use of the above fuels in automobile and tractor diesels has not been studied. In addition to reducing the toxicity of exhaust gases at work of engines on alternative fuels, noted by most researchers, there is a need to further explore effective and economical indicators of the combustion process. The article presents a comparative analysis of the use of diesel fuel emulsions with methanol and ethanol and concludes on the effectiveness of the use of alcohols as an additive to diesel fuel.

The article presents the results of studies conducted on the basis of the research laboratory of the Vyatka state agricultural Academy to study the effect of alcohol-fuel emulsions on the diesel engine and the content of toxic components in the exhaust gases. In accordance with the methodology, purpose and objectives of the study, a set of works was performed to study the effect of the use of alcohol-based emulsions as motor fuel on the main effective indicators of diesel D-240 [1, 2].

Bench tests consisted in removal of adjusting, loading and speed characteristics both at work of the diesel engine on diesel fuel(DT), and at work of the diesel engine on two types of emulsions: methanol and diesel fuel and ethanol and diesel fuel. Both emulsions had the same content of components: dispersing additive - < 1 %, distilled water ≤ 7 %, methyl or ethyl alcohol - ≤ 25 %, Dt - ≤ 68 %. The studied emulsions were fed into the combustion chamber of the engine through the standard fuel supply system.

For each fuel type, the value of the optimal fuel injection advance setting (UOVT) was determined based on the minimum values of the effective fuel consumption while maintaining the engine power at the serial level.

Removal of adjusting and loading characteristics was made on two parts of rotation of a crankshaft: 2200 min\(^{-1}\) - a nominal high-speed mode and 1700 min\(^{-1}\) - the frequency corresponding to the maximum torque. Control characteristics were recorded at four different UOVT angles: 20º, 23º, 26º and 29º. All characteristics were removed at equal values of average effective pressures [3].

When the diesel engine D-240 on diesel fuel, at engine speed n=2200 min\(^{-1}\) and a constant value of
the diesel fuel consumption of 13.5 kg/h (figure1), it can be stated that with a minimum value of the diesel fuel injection angle of 20°, the maximum value of the effective specific consumption of diesel fuel of 254 g/(kW⋅h) is achieved. The value of the effective power (Ne) is minimal and is equal to 53.5 kW. By increasing the injection angle of diesel fuel to 23°, the specific consumption of diesel fuel is reduced to 246 g/(kW⋅h), and the effective power is increased to 54.9 kW. By increasing the angle of injection of diesel fuel to 26° the value of the specific consumption of diesel fuel is reduced to a minimum-241 g/(kW⋅h), and the effective power of the diesel engine reaches a maximum - 55.8 kW, which corresponds to the factory values at the optimal installation of UOVT. By increasing the angle of injection of diesel fuel to 29° specific consumption increases again, up to 253 g/(kW⋅h), and the effective power reaches a value of 53.9 kW [4].

The analysis of schedules of work of the diesel engine D-240 on emulsion of methanol and diesel fuel, at speed of rotation of a crankshaft n = 2200 min\(^{-1}\) and constant value of the hourly expense of emulsion of 17.5 kg/h presented in figure 1, allows to state the following. Lower heat of combustion of emulsions, in comparison with diesel fuel, leads to an increase in hourly and specific fuel consumption. Thus, the hourly consumption of diesel fuel in the emulsion is 11.8 kg/h. With a minimum emulsion injection angle of 20°, the effective specific consumption of diesel fuel in the emulsion is 215 g/(kW⋅h). The value of the effective power Ne at an emulsion injection angle of 20° is 54.7 kW. By increasing the angle of installation of UOVT to 23°, the value of the effective specific flow rate of DT in the emulsion is reduced to a minimum - 213 g/(kW⋅h), while the effective power reaches a maximum - 55.8 kW. By increasing the installation angle UOVT to 26°, the effective specific flow rate DT in the emulsion increases to a value of 221 g/(kW⋅h).

![Figure 1](image)

**Figure 1.** The main indicators of diesel D-240 when working on DT, methanol and ethanol emulsions, depending on the change in the angle of UOVT at the crankshaft speed n = 2200 min\(^{-1}\);
- - DT; -- emulsion of methanol and DT; □- - □ emulsion of ethanol and DT.

In this case, the effective power is reduced to a value of 50.6 kW. By increasing the setting angle UOVT to a value of 29°, the value of the effective specific flow rate of DT in the emulsion increases to 232 g/(kW⋅h), while the effective power reaches a minimum of 47.6 kW [5].
Figure 2. The main indicators of diesel D-240 when working on DT, methanol and ethanol emulsions, depending on the change in the angle of UOVT at the crankshaft speed \( n = 1700 \text{ min}^{-1} \);
- - DT; -- emulsion of methanol and DT; \( \square - \square \) emulsion of ethanol and DT.

Analyzing the graphics of the diesel D-240 when working on an emulsion of ethanol and diesel fuel at a nominal speed of the crankshaft \( n=2200 \text{ min}^{-1} \) and at a constant value of the hourly emulsion flow rate of 16,3 kg/h, the following conclusions can be drawn. The hourly flow rate of DT in the emulsion is 11,0 kg/h. With a minimum setting angle UOVT of 20º, the value of the specific effective flow rate of DT in the emulsion reaches 199,3 g/(kW·h), and the effective power is 55,2 kW. When the setting angle UOVT is increased to 23º, the value of the specific effective flow rate of DT in the emulsion is reduced to a minimum value of 197,2 g/(kW·h), and the effective power reaches a maximum of 55,8 kW. When the setting angle UOVT is increased to 26º, the value of the specific effective flow rate of DT in the emulsion increases to 202,2 g/(kW·h). In this case, the effective power is reduced to a value of 54,4 kW. With a further increase in the value of the setting angle UOVT to 29º, the trend of increasing the effective flow rate of DT in the emulsion and the drop in the effective power remains, and is 211,5 g/(kW·h) and 52,0 kW, respectively [6,7].

Analyzing the schedules of the diesel D-240 on diesel fuel at a crankshaft speed corresponding to the maximum torque mode and a constant value of the hourly diesel fuel consumption of 10,6 kg/h, we can state the following (figure 2). With a minimum installation angle of 20º, the maximum value of the effective specific consumption of diesel fuel is 241 g/(kW·h). At the same time, the value of the effective power is minimal – 44,1 kW. By increasing the installation angle UOVT to 23º, the specific flow rate DT decreases to a value of 233 g/(kW·h), and the effective power increases to a value of 45,5 kW. With an increase in the angle of installation of UOVT to 26º, the specific flow rate is reduced to a minimum of 230 g/(kW·h), and the effective power reaches a maximum of 46,6 kW. By increasing the angle of installation of UOVT to 29º, the value of the specific flow rate of DT is reduced to 239 g/(kW·h), and the effective power reaches a value of 44,3 kW.

Analysis charts of operation of the diesel engine D-240 emulsion of methanol and diesel fuel at frequency of rotation of the crankshaft corresponding to the maximum torque and the time constant of the emulsion flow rate of 14,3 kg/h allows you to state the following. The hourly flow rate OF dt in the emulsion is 9,65 kg/h. With a minimum installation angle of 20º, the effective specific flow rate of DT in the emulsion is 211 g/(kW·h). The value of the effective power at an angle of 20º is 45,3 kW. By increasing the angle of installation UOVT to 23º the value of the effective specific flow of DT in the
emulsion is reduced to a minimum - 202 g/(kW∙h), while the effective power reaches a maximum – 46,6 kW. With an increase in the angle of installation of UOVT to 26°, the value of the effective specific flow rate of DT in the emulsion remains at 211 g/(kW∙h), while the effective power is reduced to a value of 44,6 kW. With an increase in the angle of installation of UOVT to 29°, the value of the effective specific flow rate of DT in the MTE also increases to a value of 225 g/(kW∙h), while the effective power reaches a minimum of 42,3 kW.

Analyzing the schedules of the diesel D-240 when working on an ethanol emulsion with diesel fuel at a crankshaft speed corresponding to the maximum torque and at a constant hourly flow rate of 13,1 kg/h, we can draw the following conclusions. The hourly flow rate of DT in the emulsion is 8,8 kg/h. With a minimum installation angle of 20°, the specific effective flow rate of DT in the emulsion reaches 184,2 g/(kW∙h), and the effective power is 46,7 kW. When the uovt setpoint is increased to 23°, the specific effective flow rate OF dt in the emulsion is reduced to a minimum of 182,2 g/(kW∙h) and the effective power reaches a maximum of 47,2 kW. By increasing the value of the angle of installation of UOVT to 26°, the value of the specific effective flow rate of DT in the emulsion increases to 186,1 g/(kW∙h). In this case, the effective power is reduced to 46,2 kW. With a further increase in the value of the angle of installation of UOVT to 29°, the tendency to increase the effective flow rate of DT in the emulsion and a drop in the effective power remains.

Based on the experimental bench tests of working process of diesel engine D-240 the values of the optimum installation angles of fuel injection: diesel fuel - 26 degrees of crankshaft rotation before top dead center, the emulsion of methanol with diesel and ethanol with diesel fuel - 23 degrees of crankshaft rotation before top dead center. At the same time, it was found that it is possible to maintain effective performance at the level of serial diesel at a concentration of methanol and ethanol in the emulsion - 25%. This results in a 32,5% replacement of diesel fuel by replacing it with other components. The specific effective fuel consumption when working on an emulsion with ethanol is lower than the specific effective fuel consumption when working on an emulsion with methanol in all the studied modes and setting the optimal angle of UOVT. This is due to the difference in the physico-chemical properties of ethanol and methanol (calorific value, boiling point and evaporation, self-ignition temperature, surface tension, etc.) that affect the interaction with the components of the emulsion on the processes preceding combustion, and the combustion mechanism of the emulsion in the combustion chamber of a diesel engine.

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