Modernization of a tractor motor for diesel combustible and methanol

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Abstract. When carrying out research to improve the environmental performance of motors, attention should be paid to reducing the nitrogen oxide content of the effluent gases, since they are the most toxic components among the entire range of polluting chemical compounds contained in exhaust gases, since they are formed in the burning process as a result of chemical reactions atmospheric oxygen and nitrogen. The most effective way of using methanol in internal burning engines is now to feed it directly to the diesel cylinder using a dual combustible supply system, which allows replacing up to 80% of the diesel combustible. The ignition of methanol in this case is due to the supply of a seed portion of diesel combustible. This method, with some changes and additions to the design of the motor, can be implemented on engines already in operation. In this paper, the effect of methanol application on the volumetric content and mass concentration of nitrogen oxides in exhaust gases calculated on the basis of the results of experimental studies of a motor of 2H 10.5 / 12.0 air cooling with a hemispherical burning chamber in a piston using a dual combustible delivery system and injection of diesel combustible (ignition) through a multi-jet nozzle, depending on the change in load.

The negative impact of transport on humans and the environment, which in the Russian Federation and abroad is commonly estimated by the criterion of “environmental safety” through specific emissions of harmful substances with exhaust gases (exhaust) of internal burning engines, is not fully objective. The results of air pollution in large cities, largely formed by transport. Transport engines play a significant role in environmental pollution. In large cities, they are one of the main sources of toxic substances. By their nature, exhaust gases in internal burning engines are a complex multicomponent mixture of gases, vapors, droplets of liquids and dispersed solid particles. Particular hazards to the atmosphere and the environment are toxic components such as nitrogen oxides and soot from the exhaust gas [1-4].

The qualitative course of the working process is associated with the level of organization of the process of mixture formation and can be ensured by adjusting the angle of the start of combustible injection, which determines the amount of evaporated combustible for the period of ignition delay. The lead angle of the beginning of combustible injection Θ, as a rule, is regulated for diesels based on the highest combustible efficiency at a speed corresponding to maximum power. It should be noted that the analysis of various characteristics of motors shows the existence of the highest levels of
nitrogen oxide emissions in the entire range of combinations of rotational speeds and loads, corresponding to the best specific combustible consumption.

In the Vyatka State Agricultural Academy at the Department of thermal engines, Vehicles and tractors, studies were conducted on the use of methyl alcohol (methanol) on a D-120 serial motor (2H 10.5 / 12.0). The diesel is used on tractors VTZ-2032, VTZ-30SSh, T-30, T-25A, T-25F, self-propelled chassis T-16MG.

The T-25A tractor is designed to operate on methanol with a dual combustible supply system (DST) presented in Figure 1. The methanol power system with DST allows replacing up to 80% of diesel combustible (DT). The diesel is started on diesel combustible, and then the methanol supply is turned on and the tractor is operated by adjusting the methanol supply according to the all-mode characteristic. The ignition dose of diesel remains constant [5-8].

![T-25A tractor](image1)

**Figure 1.** General view of the T-25A tractor with a power system modernized for methanol with a dual combustible supply system.

The implementation of the method of using methanol by supplying it directly to the burning chamber and ignition from the ignition portion of the diesel combustible with the help of DST provides for the installation of two combustible systems, including two high pressure combustible pumps and two nozzles for each cylinder. A general view of a 2H 10.5 / 12.0 motor mounted on a stand with two high-pressure combustible pumps is shown in Figure 2. The serial combustible system is used to supply methanol, and an additional combustible system is installed to supply the ignition diesel. The 2UTNM injection pump is mounted with a spacer on the seat of the diesel oil filler neck and is driven from a specially designed for the base pump splined sleeve with elongated splines by means of a coupling with an internal gear ring. The grooves are cut on the spacer flange for the fixing bolts, so that the pump casing can be rotated relative to the spacer, while changing the value of the installation angle of advance of injection of diesel combustible, since the cam shaft of the pump for supplying methanol remains stationary. The installation angle of advancing methanol injection on a serial pump is changed as usual by shifting the spline flange relative to the gear wheel of the combustible pump drive [9-13].

For injection of methanol into the cylinder, serial FD-22 multi-jet nozzles are used. A view of the nozzles for supplying methanol (installed at the top) and diesel combustible (installed at the bottom) of the 2H 10.5 / 12.0 motor is shown in Figure 3. For injection into the cylinder of the ignition diesel
combustible, multi-jet nozzles FD-22 are used, for installation and mounting of which additional holes are drilled in the cylinder heads.

For the correct orientation of the ignition DT jets in the volume of the diesel cylinder, in order to better ignite methanol, special nozzles for nozzles with a different arrangement of holes were made. Sprayers were made according to the drawings of the Vyatka State Agricultural Academy at the Noginsk Combustible Equipment Plant.

Figure 2. General view of a 2H 10.5 / 12.0 motor mounted on a stand.

Figure 3. View of the nozzles for supplying methanol (installed at the top) and diesel combustible (installed at the bottom) of a motor 2H 10.5 / 12.0.

The determination of the optimal values of the installation angles of the timing of the injection of the ignition combustible and methanol was carried out from the corresponding adjustment characteristics. The peculiarity consisted in the fact that at different fixed angles of advance of
injection of the ignition combustible, the angle of advance of injection of methanol changed and load characteristics were taken at each of the set values of the angles. Based on the results of these characteristics, a graph of \( g_e \) was plotted as a function of \( \Theta_m \) for different \( \Theta_0 \) and the minimum values of \( g_e \) were used to determine the optimal values of the angles \( \Theta_0 \) and \( \Theta_m \), taking into account the results of the indexing and the calculations performed to determine the heat release characteristics in the diesel cylinder [14-17].

Starting and warming up of the motor was carried out on diesel combustible. Then, the supply of methanol was turned on, and the supply of diesel combustible was reduced until misfires appeared, after which it was slightly increased until stable operation of the motor was achieved. Subsequently, the cyclic supply of pilot combustible remained constant, and the regulation of the regime was carried out only by changing the supply of methanol.

When conducting bench tests of diesel operation on diesel combustible and methanol, a necessary condition was the constancy of the position of the rail of the combustible pump in each of the investigated modes. Given the specifics of the 2H 10.5 / 12.0 motor, the main research modes were: nominal speed mode at a crankshaft speed of 1800 min\(^{-1}\) and maximum torque mode at a crankshaft speed of 1400 min\(^{-1}\).

Before testing, the motor was run-in for duration of 60 hours in modes according to the technical documentation of the manufacturer. Before starting bench tests, the motor was warmed up to a temperature of 85 ... 95 ° C. The temperature of the air and combustible during the experiments did not exceed the values specified in the technical documentation of the manufacturer [18-22].

Diesel maintenance was carried out in accordance with the manufacturer's instructions. Motor power, torque, average effective pressure and combustible consumption at various speed conditions were brought to standard atmospheric conditions, temperature and combustible density according to standards. After warming up, the motor was brought to the rated operating mode and effective indicators were determined. This mode was a control. Deviations of effective diesel performance by more than 2% indicated a violation in the operation of any motor system, which was immediately eliminated. After testing, the motor was returned to the control mode, and the indicators were checked.

To equalize temperatures, the motor ran for at least 5 minutes before each measurement. The motor rotational speed did not differ from the set by more than 5 min\(^{-1}\). The volume of the burning chamber when installing the indicator sensor for indexing the diesel increased due to the connecting channel under the sensor by no more than 1%, and the ratio of the diameter of the connecting channel to its length was more than 1, which corresponds to the requirements of the operating instructions for the MAI-5A device, intended for workflow indication [23-27].

To reduce the measurement error, the measurements during the tests in each experiment were repeated at least 3 times, and the result was averaged. In the same way, gas analysis and exhaust gas sampling were carried out to determine smoke.

Based on laboratory and bench tests and theoretical studies of the effect of the use of alternative combustibles - methanol with DST - on the processes of formation and decomposition of nitrogen oxides, toxic, power and economic indicators of a 2H 10.5 / 12.0 motor with a hemispherical burning chamber in the piston during injection of diesel combustible (ignition) through a multi-nozzle nozzle, the possibility of improving its environmental performance, in particular, reducing the content of nitrogen oxides in spent gases, saving diesel combustible, increasing effective performance, was established televisions.

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