Study of diesel operation using diesel fuel and methyl fluid

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Abstract. The obtained processing of the results of research in the field of science shows that domestic and foreign researchers have developed the prerequisites, conducted a series of experimental works using high-precision measuring equipment to study the working process of a diesel engine. There are studies on the possibility of using methyl fluid in diesel engines as a motor fuel. At the same time, it should be noted that studies on the use of methyl fluid as a motor fuel were carried out without studying the complex effect on environmental, effective indicators and the performance of the working process in a diesel cylinder. There is little work on the use of methyl-fluid with separate feed in high-speed small-sized diesel engines with air cooling.

One of the options for increasing the efficiency of a diesel engine is the systematic improvement of the work processes that make up its duty cycle. Theoretical studies of engine duty cycles have shown that it is important to achieve an optimal process flow of combustion in each particular engine type.

The working process that takes place in the cylinders of the diesel engine determines the main indicators of the engine - power, specific fuel consumption, maximum loads in the parts and the temperature state of the details of the cylinder-piston group. The main tasks in the study of the workflow are to establish the dependencies of its main indicators on various design factors and to choose a combination of design parameters for which the best performance of the workflow is achieved. In the actual diesel cycle, heat losses during its supply and conversion into operation are inevitable due to a number of physicochemical and technical reasons. The supply of heat to the working fluid begins even before the top dead center, as a result of self-ignition and ignition of fuel injected, into the compressed air medium. The compression pressure for naturally aspirated diesel engines is (38 - 50) - 102 kPa, for supercharged diesel engines (45 - 100) - 102 kPa and a temperature of 800 - 900 K and 900 - 1000 K, respectively, which exceeds the fuel auto-ignition temperature by about 430 - 490 K. The degree of efficiency of a diesel engine is largely dependent on the quality of the process flow of combustion. In this regard, a number of requirements are imposed on the process flow of combustion, which should ensure the necessary efficiency of the cycle (relatively high temperatures and pressure of the cycle, minimum fuel and air consumption), reliable operation of the diesel engine (not exceeding the permissible temperature and pressure values and their slew rate per cycle). The simultaneous fulfillment of these requirements is impossible, since in some cases they contradict each other. The problem is solved compromise, depending on the requirements for this diesel engine, by selecting the main factors affecting the development of the process flow of combustion. These factors are the choice of fuel with the appropriate physicochemical properties and its preparation before feeding into the diesel cylinder, creating favorable conditions for atomization.
and mixing of fuel with air, ensuring the correct ratio between fuel and air (air excess coefficient $\alpha$), choosing the necessary fuel supply law by the angle of rotation of the crankshaft, the creation of an optimal thermal regime in the cylinder of the diesel engine, providing the minimum time for preparing fuel for ignition [1-4].

From the moment of fuel injection into the cylinder to the end of its burnout, complex physicochemical processes of evaporation, ignition and ignition occur, occurring with a finite rate of heat generation, changes in pressure and temperature and accompanied by heat loss.

Important resulting parameters characterizing the process of fuel ignition are the pressure and temperature of the gases in the cylinder. The analysis of the fuel process flow of combustion is carried out according to a detailed indicator diagram taken from a diesel cylinder.

The main experimental material used to assess the perfection of the working process occurring in the cylinder of a diesel engine is an indicator diagram of the process and hourly fuel consumption. With the appropriate diagram, most of the parameters characterizing the work process can be obtained with appropriate processing; average indicator pressure $p_c$, compression pressure $p_c$, maximum ignition pressure $p_i$, pressure rise rate $\frac{dp}{d\varphi}$, heat release characteristics in the diesel cylinder (fuel burnout law $x_i = f (\varphi)$, heat release rate $\frac{dx_i}{d\varphi} = f (\varphi)$, duration ignition $\varphi_g$), the temperature of the gas in the cylinder at any time and many other parameters.

Thus, in order to assess the quality of the diesel working process, it is necessary to measure the following basic parameters: effective power $N_e$ and hourly fuel consumption $G_f$. After this, it is necessary to analyze the indicator chart. Another group of parameters determines factors that affect the quality of the working process to varying degrees. The main parameters in this group of parameters are the characteristics of the fuel supply system - the duration and law of the fuel supply, the quality of atomization, as well as the air flow and its temperature, the quality of cleaning the cylinder of residual gases, the temperature of the walls of the ignition chamber, etc. The maximum pressure is found directly from the indicator diagram gases $p_{max}$. If the diagram shows the change in gas pressure $p$ depending on the angle of rotation of the crankshaft $\varphi$, then the average $\left( \frac{dp}{d\varphi} \right)_a$ and maximum $\left( \frac{dp}{d\varphi} \right)_{max}$ gas pressure rise rates are easily determined [5-8].

The rapid depletion of oil reserves and the environmental degradation caused by global warming due to emissions of pollutants from the transport sector, as well as strict emission standards, necessitated the search for alternative fuels for internal ignition engines. In the previous few decades, vegetable oils and biodiesel have been predominantly investigated as alternative fuels for compression-ignition engines [9-12]. An alternative fuel that contains more oxygen improves the properties of the fuel as well as the ignition process. However, alcohols such as ethanol and methyl fluid have also received wide attention from researchers due to the presence of large amounts of oxygen. Alcohols derived from bioresources are widely used in compression-ignition engines as an additional fuel for petroleum diesel fuel. However, methyl fluid has an advantage due to its low price and higher oxygen content [13-16].

Methyl fluid can be added to diesel fuel either in mixed mode or in separate injection mode. In mixed mode, in most cases, methyl fluid and diesel fuel are mixed with the additive. While in separate injection mode, diesel fuel is injected through a nozzle, and additional nozzles are installed in the cylinder head of the engine to supply methyl fluid.

Indication of a diesel engine consists in sequentially removing indicator charts from all cylinders using an indicator. The cylinder diagrams and pressure are determined from the indicator diagrams, and together with the remaining parameters, they analyze the working process and operation of the fuel equipment, verify the correct distribution phases and make decisions about adjusting the diesel engine.

The ignition delay period in a diesel engine is of great importance for the subsequent ignition of fuel, especially with volumetric mixture formation. It is usually considered the beginning of the process flow of combustion in a diesel engine when the pressure line is torn off from the compression-expansion line in the indicator diagram [17-20].
The implementation of the method of using methyl fluid by feeding it directly into the ignition chamber and igniting from the ignition portion of diesel fuel with a separate supply involves the installation of two fuel systems, including two HPFP and two nozzles per cylinder. A general view of a 2H 10.5 / 12.0 diesel engine mounted on a stand with two HPFPs is shown in figure 1. In this case, the serial fuel system is used to supply methyl fluid, and an additional fuel system is installed to supply the ignition diesel. HPFP brand 2UTNM is mounted with a spacer on the seat of the oil filler neck of the diesel engine and is rotated from a spline bushing specially designed for the base pump with elongated slots by means of a coupling with an internal gear rim. On the flange of the spacer for mounting bolts, the grooves are sawn through, so that the pump casing can be rotated relative to the spacer, changing the value of the installation advance angle of injection of diesel fuel, since the camshaft of the pump for feeding methyl fluid remains stationary. The installation advance angle of methyl fluid injection at the serial pump varies as usual by shifting the splined flange relative to the gear wheel of the fuel pump drive. The FD-22 series multi-jet injectors are used to inject methyl fluid into the cylinder. A view of the nozzles for supplying methyl fluid (installed above) and diesel fuel (installed below) of the 2H 10.5 / 12.0 diesel is shown in figure 2. For injection into the ignition diesel fuel cylinder, multi-jet nozzles FD-22 are used, for installation and fastening of which additional holes are drilled in the cylinder heads [21-25].

![Figure 1](image1.png) **Figure 1.** Tractor diesel engine mounted on the stand.  

![Figure 2](image2.png) **Figure 2.** Nozzles for supplying methyl fluid (installed at the top) and diesel fuel (installed at the bottom).

For the correct orientation of the process flow in combustion jets of diesel fuel in the volume of the diesel cylinder, in order to better ignite the methyl fluid, special nozzles for nozzles with a different arrangement of holes were made.

Determination of the optimal values of the installation advance angle of injection of the pilot fuel and methyl fluid was carried out from the respective adjustment characteristics. The peculiarity was that at different fixed advance angles of injection of the ignition diesel fuel, the advance angle of methyl fluid injection changed and load characteristics were taken at each of the set angles. The results of these characteristics were used to plot the $g_e$ as a function of $\Theta_m$ for different $\Theta_d$ and the minimum values of $g_e$ were used to determine the optimal angles $\Theta_d$ and $\Theta_m$, taking into account the results of the indexing and calculations performed to determine the characteristics of heat generation in the cylinder of a diesel engine [26].

When conducting bench tests of a diesel engine on diesel fuel and methyl fluid, a necessary condition was the constancy of the position of the fuel pump rail on each of the modes under study. Given the specificity of the diesel engine 2H 10.5 / 12.0, the main research modes were: nominal
speed at crankshaft speed \((n = 1800 \text{ min}^{-1})\) and maximum torque mode at crankshaft speed \((n = 1400 \text{ min}^{-1})\).

Indicator diagrams of a diesel engine 2H 10.5 / 12.0 when operating on diesel fuel and when operating on methyl fluid with separate feed at rotational speed \((n = 1800 \text{ min}^{-1})\) and \(p_e = 0.585 \text{ MPa}\) are presented in figure 3a. The results of indexing show a slight increase in the maximum ignition pressure \(p_{z \text{ max}}\). Thus, in a diesel engine, the value of \(p_{zd \text{ max}} = 6.97 \text{ MPa}\), and when operating on separate feed methyl fluid - 0.290 MPa / deg. It should be noted that the process flow of combustion when working on methyl fluid with separate feed is somewhat shifted to the expansion line. If for a diesel engine, the maximum cycle pressure \(p_{z \text{ max}}\) is reached at an angle of \(\varphi = 7.0^\circ\) after \(0^\circ\), then when working on methyl fluid with separate flow at \(\varphi = 10.1^\circ\) after \(0^\circ\). Similar conclusions can be drawn from the indicator chart processing, taken at the frequency of rotation \((n = 1800 \text{ min}^{-1})\) presented in figure 3b.

**Figure 3.** Indicator diagrams of diesel engine 2H 10.5/12.0 when working on diesel fuel and methyl fluid with separate feed: a - with \(n = 1800 \text{ min } - 1\); b - at \(n = 1400 \text{ min}^{-1}\); ----- - diesel fuel, -------- - methyl fluid with separate feed

For a serial diesel engine with \(p_e = 0.594 \text{ MPa}\) \(p_{zd \text{ max}} = 7.03 \text{ MPa}\), and when operating on methyl fluid with separate feed, the same values of the average effective pressure \(p_{zm \text{ max}} = 7.42 \text{ MPa}\). The values of the maximum "stiffness" \((dp / d\varphi)_\text{max}\) when working on methyl fluid with a separate flow are reduced at this speed mode. Thus, \((dp / d\varphi)_\text{max} = 0.581 \text{ MPa} / \text{ deg}\) in a syrian diesel engine, and when operating on separate feed methyl fluid \((dp / d\varphi)_\text{max} = 0.372 \text{ MPa} / \text{ deg}\). The process flow of combustion when working on methyl fluid with a separate feed is, also shifted to the expansion line. The maximum cycle pressure in a serial diesel engine is achieved at an angle of \(\varphi = 6.0^\circ\) after \(0^\circ\), and when the diesel is running on methyl fluid with a separate feed - at an angle of \(\varphi = 7.8^\circ\) after \(0^\circ\) [27-30].

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