Bioethanol Mixture for Diesel Engines

Sh. Imomov[1*], B. Khakimov[1], I. Nuritov[1], V. Tagaev[1]

[1]Bukhara Institute of Natural Resources Management of "Tashkent Institute of Irrigation and Agriculture Mechanization Engineers" the National Research University, Republic of Uzbekistan

***Email**: shavkatimomov26@gmail.com

***Received**: 10 October 2023; **Accepted:** 29 November 2023; **Published:** 7 December 2023*

Abstract: In the article, the increase of environmental and epidemiological problems in parallel with the decrease of hydrocarbon fuel reserves, as well as the constant increase in the price of traditional energy resources in recent years, the increasing demand for renewable energy sources in the world, the increase in the demand for fuel mixtures, and the problems of updating the methods of their preparation, and the main fuels the fact that the application of bioethanol addition technology has led to an increase in the amount of water, it is dedicated to the solutions to accelerate the corrosion of metal. In addition, the article is devoted to determining the amount of bioethanol added to diesel fuel, mixing time and temperature depending on the parameters of density and viscosity in the formation of a mixture of diesel and bioethanol fuel.

Keywords: motor vehicle; bioethanol; energy alternative resources; pump power;

Introduction

In the world, the development and use of devices that perform the process of mixing bioethanol with high efficiency and energy-saving traditional fuels takes a leading place. "Given that the share of bioethanol fuel in the production and use of alternative fuels on a global scale is 20-25 percent, and this indicator is expected to be 120 billion liters in 2020" (Boboev et al., 1995) high quality and productivity and energy-resource efficient diesel and the development of bioethanol fuel mixture devices is considered one of the important tasks. Comprehensive measures are being taken to reduce labor and energy consumption in agricultural production of our republic, to save natural resources, to increase the scope of alternative fuels used in agricultural machinery, to develop high-quality liquid alternative fuels and to use them as additional fuel in agricultural machinery. Great attention is being paid to the production and use of devices that mix diesel and bioethanol fuels in diesel engines without changing their quality indicators.

At present, the increase in the number and volume of motor transport and agricultural machine-tractor parks causes an increase in the amount of toxic gases released into the atmosphere. One of the main ways to reduce the amount of toxic gases released into the atmosphere, to increase the performance of engines and the amount of carbon fuels is to use biofuels as fuel in engines (Boboev et al., 1995; U. Karimov et al., 2009; GOST 18509-88 Standard Test Method; Kadyrov S.M. 2016 & Imomov et al., 2021).

Methodology

12% high-quality diesel fuel + bioethanol produced on the basis of the study of the methods of creating a mixture of diesel and bioethanol fuel and the characteristics of the mixture. studied on the test bench [Boboev et al., 1995; Kadirov et al., 2011; Khakimov et.al. 2018; Khakimov et al., 2021; Polvonov et.al., 2003 and Itinskaya & Kuznetsov, 1983).

ND-21 type high-pressure fuel pump operating parameters, using pure and 12 percent fuel mixtures, obtaining adjustment characteristics of the pump was carried out in accordance with the requirements of GOST 8670-82. During the laboratory tests, the following were used: KI 921M test stand, ND–21 fuel pump and injectors, instruments for measuring temperature, pressure, and speed, and the necessary pipes. (Boboev et al.,1995; Karimov et.al., 2009 and Kadirov et al., 2011)

All figures and tables should be labeled according to the sequence of 1, 2, 3. The caption for figures should be stated on the subsequent line right after the figures. The caption for the tables should be placed on the line right before the table. One level of subsection is allowed for methodology. Results or discussion should not be stated in this section.

Figure 1. KI 921 control test stand (1st base; 2-manometer; 3-tachometer; 4-measuring beakers; 5- screw adjusting the rotation speed of the drive shaft)

The shaft of the stand drive is checked by rotating it at a speed of 900 rpm for 60 seconds and the boundary conditions are determined. Each experiment is carried out for 1 minute, the mass of fuel delivered by the pump section is measured, and the experiment is carried out in 6 repetitions. In the tests carried out for each case, the uneven transfer of fuel was determined by this expression (Boboev et al.,1995 and GOST 18509-88):

$$\delta = \frac{2\left(G_{maa} - G_{\min}\right)}{G_{\max} + G_{\min}} \cdot 100\,\%, \tag{1}$$

where Gmax and Gmin are the maximum and minimum fuel volume of the sections during the test, mm^3.
Cyclic transmission

$$q_H = \frac{G_{yp} \cdot 10^3}{n_ц} \cdot \gamma_{ё},$$

(2)

where Gyp is the average value of the amount of fuel delivered by sections at the given time;
γё – specific gravity, for diesel fuel γё = 0.086 g/cm^3.

Hourly fuel consumption (Boboev et al.,1995 and GOST 18509-88):

$$G_ё = 6 \cdot 10^{-3} \frac{\sum G \cdot \gamma_ё \cdot n}{n_ц},$$

(3)

бунда ∑G – the total amount of fuel in the measuring vessels, cm^3;
n – pump shaft rotation number, ayl/ min;
nц – number of cycles.
where ∑G is the total amount of fuel in measuring containers, cm^3;
n - the number of revolutions of the pump shaft, rev/min;
nц is the number of cycles.

Based on the test experience and calculations carried out on the test bench, a graph of the dependence of the adjustment characteristic of the fuel pump on the cyclic transmission was built.

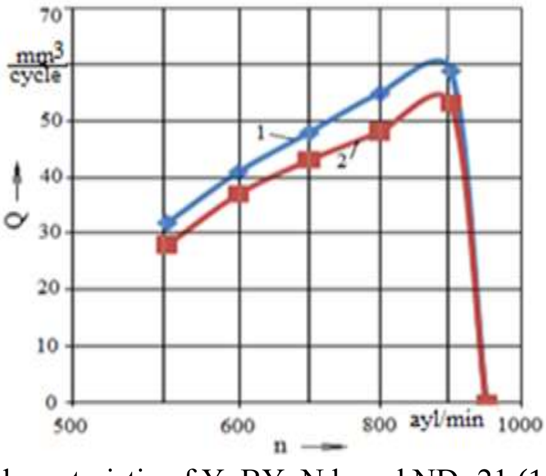

Figure 2. Adjustment characteristic of YuBYoN brand ND‒21 (1-on pure diesel fuel; In a mixture of 2-12 percent bioethanol)

A graphical analysis of the adjustment characteristic shows that the cyclic transmission of fuel has decreased from 30 cm3 to 24.5 cm3 (18.3%). The results obtained to study the performance of the diesel fuel bioethanol 12 percent mixture engine were conducted on the KI-5543M test stand equipped with the D-21A1 engine in the above-mentioned experimental laboratory (Boboev et al.,1995; Karimov et.al., 2009). Tests were carried out based on GOST18509-88 (Tractor and combine diesels. Methods of bench testing) of auto tractor engines. Power and economy are the main parameters that evaluate the operational performance of the engine. Engine efficiency is evaluated based on specific fuel consumption per unit of effective power.

To have more complete information in determining the main parameters of the engine, the following equipment was used to obtain the characteristics of diesel fuel + bioethanol based on the requirements of GOST 18509-88 (Boboev et al.,1995; Karimov et al., 2009 and Kadyrov et al., 2016):

- loading device – KI−5543M
- instrument for measuring rotation frequency – TE204
- fuel consumption measuring device – PSID
- air consumption measuring device RG-200
- pressure measuring device – DDG-160/600
- temperature measuring instrument - TU 25202100338
- white filter paper that determines the amount of smoke

The KI-5543M test stand serves to apply loads to the engine during tests and adjust its power, frequency of revolutions, as well as measure the torque produced by the engine (Kadyrov et al., 2016). Below is a diagram and overview of the KI-5543M test stand equipped with a D-21A1 engine (Fig. 3).

Figure 3. D−21A1 engine of test stand KI−5343M general appearance (1-KI−5543M test stand; 2-PSID - electronic scale; 3-D−21A1 engine)

To heat the mixed fuel to certain temperatures and use it in the engine during testing, to achieve the minimum fuel consumption and to determine the amount of exhaust gases released into the atmosphere, the following PSID brand electronic scale and white filter paper were used.

In practice, when obtaining laboratory test results, two methods of measuring fuel consumption are used - measured in units of weight and volume.

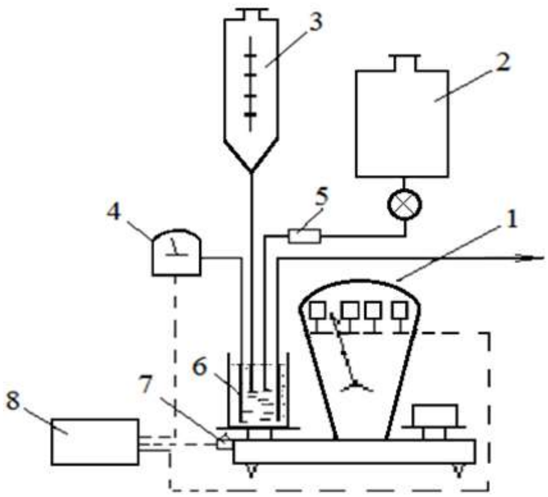

Figure 4. Electronic scale PSID (1-electronic scale; 2-diesel fuel tank; 3-container for bioethanol; 4- eletron temperature gauge; 5-electromagnetic clutch; 6-heater; 7-switch; 8-electric steering wheel)

If the fuel consumption is not measured while the engine is running, the fuel consumption in the tank placed on the same circuit of the scale is kept the same. For this, the electromagnetic tap is activated periodically using a circuit breaker. Before measuring, the fuel supply from the fuel tank is stopped, and the fuel supply from the tank in the weighing circuit is transferred. When the indicator of the scale reaches the division where the calculation should be started, the electronic stopwatch starts and measures the measurement time, and thus the exact dimensions of the fuel consumption are obtained. Using the results of the experiment, the hourly fuel consumption is determined by the following expression (Boboev et al., 1995; U. Karimov et al., 2009; GOST 18509-88 Standard Test Method; Kadyrov S.M. 2016 & Imomov et al., 2021).

$$G_{ё} = 3{,}6 \frac{G_{тaж}}{\tau_{ё}}, \tag{4}$$

When the effective power of the engine Ne is known, it will be possible to determine its specific fuel consumption (GOST 18509-88 Standard Test Method; Kadyrov S.M. 2016).

$$g_e = \frac{G_{ё} \cdot 10^3}{N_e}, \tag{5}$$

Based on experimental results and practical calculations during the D-21A1 engine test, the engine's hourly fuel consumption was determined while operating the engine on a 12% fuel mixture. The D-21A1 engine had an effective power of 17.8 kW on pure diesel fuel, and a specific fuel consumption of 224 g/kWh. On a 12 percent fuel mixture, the effective power was 18.4 kW, and the specific fuel consumption was 217 g/kWh. Therefore, fuel consumption was reduced by 7% (Kadyrov et al., 2016; Kadirov et al., 2011; Itinskaya et al., 1983; Ganiboyeva et al., 1983 and Karimov, 1989).

Viscometer VPJ-4 was used in the tests to determine the viscosity of "diesel fuel+bioethanol" fuel mixtures of 4, 6, 8, 10, 12 and 15 percent. Viscosity is the main indicator of diesel fuel, and changes in its temperature significantly affect the performance of the fuel pump. It is known that the viscosity of fuel decreases with increasing temperature and is directly proportional to temperature. When the temperature increases in the range of +50 - +100 °C, the viscosity changes little, on the contrary, it increases when the temperature is low [Boboev et al., 1995; U. Karimov et al., 2009; Khakimov et al., 2022 and Itinskaya et al., 1983).

As the viscosity of diesel fuel decreases, the fuel delivery of the plunger in one stroke (cycle) decreases. This decrease is caused by the leakage of fuel from the gaps between the plunger - bushing and the nozzle and the body of the injector and the change in the duration of the injection time. The relative change of fuel supply to the cylinder through the injector in relation to the change of fuel viscosity was 3-6 percent [Khakimov et al., 2022; Polvonov et al., 2003; Itinskaya et al., 1983; Ganiboyeva et al., 1983 and Karimov, 1989). Air consumption was measured using RG-200 (Fig. 6)

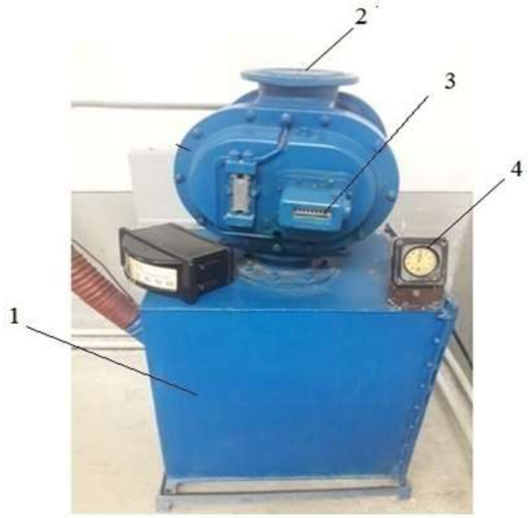

Figure 6. Air consumption meter RG-200 (1 receiver; 2nd air cleaner; 3-air consumption meter; 4th stopwatch)

Air consumption per hour is calculated from the following expression (Boboev et al., 1995; and Karimov et al., 2009).

$$G_x = \frac{3600 \cdot V}{\tau}, \tag{6}$$

where V is the volume of air consumed according to the meter readings, m^3;
τ - air consumption time s.

The density of atmospheric air is determined based on the Mendeleev-Clapeyron equation.

$$\rho = \frac{\rho_0}{RT_0}, \tag{7}$$

where ρ_0 is atmospheric pressure, Pa
R - constant gas pressure in air, R = 238 Dj/kg, K;
T_0 - atmospheric air temperature.

The results of the experimental test calculation showed that air consumption for pure diesel fuel is 14.91 kg, and for a 12% mixture it is 13.87 kg per hour. Theoretically, the amount of air needed for the combustion of 1 kg of fuel is determined.

Result and Discussion

Experimental research tests by heating bioethanol as a diesel fuel additive to specified quantities and temperatures 4; 6; 8; 10; The study of the effect of the mixture of 12 and 15 percent on the engine operation was carried out on the K-5343M stand in the above-mentioned ways. The characteristics of the D–21A1 engine operating on pure diesel fuel and fuel mixture were obtained, and the processes of adaptation to fuel mixtures were studied. In the tests, it was found that the formation of the fuel mixture in the diesel engine and its combustion intensity depend on the pressure and temperature of the compressed air, the smoothness of the exhaust, and the amount and volatility of the fuel in the air. But the chemical composition of the fuel is mainly important for fuel combustion, it determines not the mixing temperature of the fuel, but also the time that passes from the time the fuel is given to the moment when it starts to spontaneously ignite. In diesel engines, the period before the self-ignition process is determined by t, during which physical (combustion, mixing with air, heating, evaporation) and complex chemical processes (various stages of oxidation of fuel molecules) take place in the combustion chamber. As a result, 10-15% of fuel energy is released, and heat is accumulated. Currently, the piston inside the cylinder is Yu.Ch.N. moving towards, during the compression stroke the temperature rises and the fuel ignites.

In order to determine the maximum power, fuel economy, compressed air pressure, temperature and other relationships when the engine is running on a 12 percent mixture of diesel fuel with bioethanol, the D-21A1 diesel engine test stand was improved and tests were conducted according to a special methodology (Kadyrov et al., 2016 and Kadirov et al., 2011).

The theory of the ignition advance angle based on the results obtained during the tests of the D-21A1 diesel engine on diesel fuel and diesel fuel with a 12 percent mixture of bioethanol, the maximum pressure generated in the cylinders, the maximum power that can be achieved by the rotation angle of the crankshaft, fuel consumption and other parameters a spread indicator chart is constructed.

Graphical analysis in Figure 7 shows that the combustion process starts from point 2 for pure diesel fuel and points 2' (conventionally referring to points 3, 3' and 4, 4') for mixed fuel, the fuel burns and the pressure rises rapidly.

The rapid combustion period (for a 12% fuel mixture) lasts from 2' to 3', during which up to 70% of the heat energy is released. Due to the quality of the combustion process, the maximum pressure value was Pmax =6.15 MPa in the 12 percent fuel mixture, and Pmax =5.98 MPa in the pure diesel fuel. At this time, the combustion process does not end due to the continued supply of fuel.

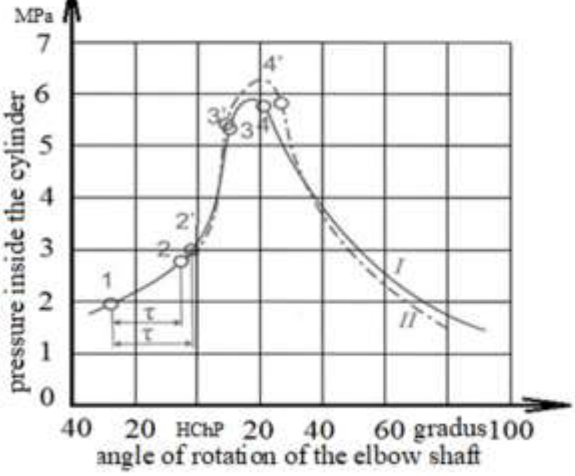

Figure 7. A theoretical spread indicator diagram of a diesel engine (When running on I-pure diesel fuel; In a mixture of II-12 percent bioethanol)

After that, the third period of slow combustion goes from point 3' to point 4', during which about 20% of the heat energy is released and fueling ends at the beginning of this period (Ganiboyeva et al., 1983 and Karimov, 1989).

Due to the high oxygen content of mildly oxidizable hydrocarbons and ethanol in the fuel mixture, the ignition delay is reduced, and the engine starts easily and runs smoothly and stably. In Fig. 8, a graph of the engine adjustment characteristic for the fuel injection advance angle is constructed.

To determine the dependence of fuel injection advance adjustment characteristic, specific fuel consumption ge, useful power Ne on the fuel injection angle θ, to establish the optimum fuel injection advance angle for the engine under test. Based on the data obtained during the test on pure diesel fuel and 12 percent mixed fuel, the current values of Ne Ge and ge are determined, and with their help, a diesel tuning characteristic is built according to the advance angle of fuel injection.

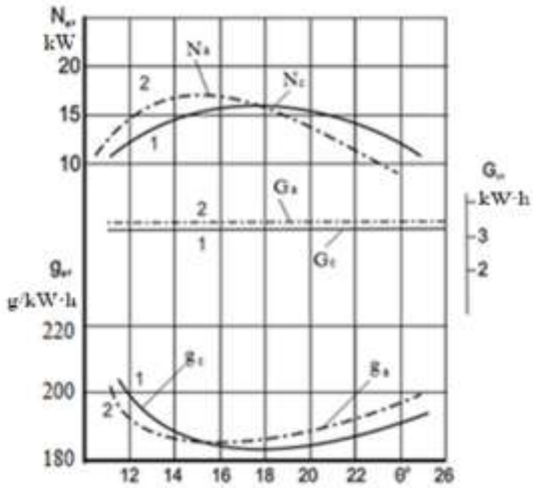

Figure 8. A graph of the characteristics of the adjustment of the engine by the angle of advance of the fuel injection (1 - on pure diesel fuel; In a mixture of 2-12% ethanol)

Graphical analysis shows that the engine running on pure diesel fuel has the highest power Nemax =17.8 kW and the lowest specific fuel consumption gemin =224 g/kW·h. The fuel injection advance angle is Y.Ch.N. until it reached 18°. When the engine is running on a 12 percent fuel mixture, the maximum power is Nemax =18.4 kW and the lowest specific fuel consumption is gemin =217 g/kW·h. reached by 16°. Since the experiments were carried out at moderate and constant conditions of rotation speed and fuel supply, the hourly fuel consumption remains practically unchanged, so the specific fuel consumption varies inversely with the power. Inadequate advance angle of the start of fuel injection causes increased bending intensity of piston group details. Therefore, the spray advance angle should be adjusted to its moderate value. In Fig. 9, the maximum engine performance was determined when the maximum idle speed in the corrector branch was in the range of 1800-1710 rpm, and the maximum speed in the corrector branch II was in the range of 1710-1200 rpm.

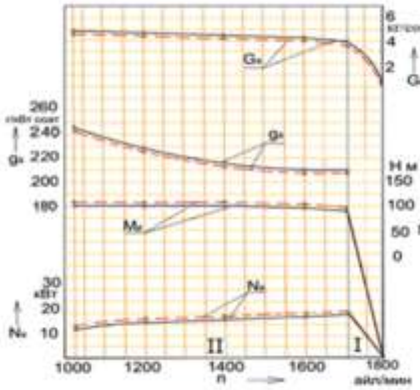

Figure 9. Speed characteristics of a diesel with an adjuster shaft

Analysis of the data presented in the graph in Figure 9 shows that (Boboev et al., 1995; Karimov et al., 2009; Kadyrov S.M. 2016; Kadyrov & Nikitin, 1992; Khudoyberdiev, 2007 and Khakimov et al., 2021) the operating procedures of both branches depend on the peak value of the parameters of pure travel, power, economy, torque and number of revolutions. Hourly fuel consumption depends on the number of revolutions of the drive shaft and the cyclic transmission of the fuel apparatus. Reducing the number of revolutions of the drive shaft in the correction zone led to a decrease in fuel consumption per hour. This can be explained by the reduced number of strokes of the high-pressure pump plungers per unit of time (Khakimov et al., 2021; Ermatova et al., 2021; Bazarov et al., 2019 and Bazarov et al., 2020).

Hourly fuel consumption decreases when the number of revolutions in the zone in which the regulator works increases. This phenomenon occurred due to the shift of the adjuster to the side where the cyclic transmission of the high-pressure pump rack is reduced. The pump rod or the doser is moved by means of the adjuster and the amount of fuel delivered to the cylinder changes. When the torque reaches its maximum value, even if the engine load increases, the corrector does not increase the fuel delivery, and the rotational speed, power and torque decrease, the engine runs unstable and the fuel consumption increases. The level of unevenness of the adjuster according to the number of revolutions of the crankshaft at the idle speed and nominal power $\delta = 0.12\%$, the nominal coefficient of the torque reserve of the torque converter in the operation of the fuel transfer corrector. It is estimated at M = 0.15% (Imomov et al., 2009; Imomov et al., 2007; Marupov et al., 2020 and Imomov et al., 2020).

As can be seen from the tuning characteristic graphs above, underloading the engine will affect the economical operation and increase the specific fuel consumption. To increase the performance of machine-tractor units, it is necessary to ensure that the load of the tractor during operation is close to the maximum load.

Conclusions

By using fuel prepared by mixing 12% of bioethanol with diesel fuel in the device, it is possible to save 12 ml of diesel fuel per liter and reduce the amount of waste gases released into the atmosphere by 25-30%.

1. Specified injection angle of the fuel pump of the diesel engine
2. 2 degrees advanced and the pressure of the injector needle at 1.4-1.6 mPa makes it possible for the mixture to have a higher combustion intensity.
3. When the fuel produced from a quantitative mixture of bioethanol with diesel fuel is used in farm power tools, fuel consumption is reduced by 6-7%, engine power is increased by 6-8%, work quality and productivity are increased by 2.5%.

Acknowledgement

The researcher did not receive any funding for this study, and the results have not been published in any other sources.

References

Bazarov, B. I., Magdiev, K. I., Sidikov, F. Sh., & Odilov, O. Z. (2019). Sovremennye tendentsii v ispolzovanii alternativnyx motornyx topliv. Journal of Advanced Research in Technical Science, 14(2), 186–188.

Bazarov, B. I., Otabaev, N. I., Odilov, O. Z., Meliev, H. O., & Axynov, J. A. (2020). Features of using liquefied petroleum gas with addition of dimethyl ether as fuel of car with spark-ignition engine. International Journal of Advanced Research in Science, Engineering and Technology, 7(11), 15695–15698.

Boboev, H. M., Marupov, I. M., Jalolov, B. Q., & Omonov, M. O. (1995). Practical exercises on the theory of tractor and car engines. Tashkent: New Age Generation Publishing House.

Ermatova, D. I., Matmurodov, F. M., Imomov, Sh. J., & Aynakulov, Sh. A. (2021). Measure for extinguishing vertical vibrations on the seat of a wheel tractor when moving along a random profile of the path. IOP Conference Series: Earth and Environmental Science, 868(1), 012003. https://doi.org/10.1088/1755-1315/868/1/012003

Ganiboyeva, E. M., Khakimov, B. B., & Xaliqulov, M. A. (2021). Changes in the efficiency of modern tractor engine oils. International Journal of Advanced Research in Science, Engineering and Technology, 8(8).

GOST 18509-88. (1988). Tractor and combine diesels. Standard test methods.

Imomov, S. Z. (2007). Engineering design calculation of a biogas unit recuperator. Applied Solar Energy (English Translation of Geliotekhnika), 43(3), 196–197. https://doi.org/10.3103/S0003701X07030058

Imomov, S. Z. (2009). Heat transfer process during phase back-and-forth motion with biomass pulse loading. Applied Solar Energy (English Translation of Geliotekhnika), 45(2), 116–119. https://doi.org/10.3103/S0003701X09020052

Imomov, S., Kholikova, N., Alimova, Z., Nuritov, I., & Temirkulova, N. (2021). Oil purification devices used in internal combustion engines. AEGIS 2021. IOP Conference Series: Earth and Environmental Science, 868(1), 012XXX. https://doi.org/10.1088/1755-1315/868/1/012XXX

Imomov, S., Shodiev, E., Tagaev, V., & Qayumov, T. (2020). Economic and statistical methods of frequency maintenance of biogas plants. IOP Conference Series: Materials Science and Engineering, 883(1), 012124. https://doi.org/10.1088/1757-899X/883/1/012124

Itinskaya, N. I., & Kuznetsov, N. A. (1983). Materials used in tractors: Instructional manual.

Tashkent: Tashkent Publishing House.

Kadirov, S. M., Salimov, O. U., & Proskurin, A. I. (2011). Engines and automobile theory. Tashkent: Tashkent New Age Generation Publishing House.

Kadyrov, S. M. (2016). Internal combustion engines. Tashkent: New Age Generation Publishing House.

Kadyrov, S. M., & Nikitin, S. E. (1989). Car and tractor engines. Tashkent: Tashkent Publishing House.

Karimov, U. (1989). The theory of tractors and cars. Tashkent: Mehnat Publishing House.

Karimov, U., Khudoyberdiev, T., Mirzaev, I., & Marupov, I. (2009). Practical exercises on the theory of tractor and car engines. Tashkent: New Age Generation Publishing House.

Khakimov, B. B., & Salimov, O. U. (2018). Puti povysheniya dispersnosti raspylivaniya mnogokomponentnoy fuel mixture v kamerakh goraniya dvigetya. Agroilm: Tashkent New Age Generation publishing house.

Khakimov, B. B., Rajabov, N. K., Sharipov, Z. Sh., Kalandarova, S. T., G’aniboyeva, E. M., & Kulmamatov, O. A. (2021). Analysis of methods of forming diesel and bioethanol fuel mixture. AEGIS 2021. IOP Conference Series: Earth and Environmental Science, 868(1), 012XXX. https://doi.org/10.1088/1755-1315/868/1/012XXX

Khakimov, B. B., Rajabov, N. Q., Sharipov, Z. Sh., Kalandarova, S. T., G'aniboyeva, E. M., & Kulmamatov, O. A. (2022). Analysis of methods of forming diesel and bioethanol fuel mixture. AEGIS 2021. IOP Conference Series: Earth and Environmental Science, 868(1), 012XXX. https://doi.org/10.1088/1755-1315/868/1/012XXX

Khudoyberdiev, T. S. (2007). Theory and calculation of tractors and cars. Tashkent: Tashkent Publishing House.

Marupov, I., Imomov, S., Ermatova, D., Majitov, J., Kholikova, N., Tagaev, V., & Nuritov, I. (2020). Research of vertical forces for acting tractor unit. IOP Conference Series: Earth and Environmental Science, 614(1), 012153. https://doi.org/10.1088/1755-1315/614/1/012153

Polvonov, A. S., Bozorov, S. M., Sharipov, Q. A., et al. (2003). Materials used in vehicles: Instructional manual. Tashkent: UzFA Fan Publishing House.