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STUDY AND DEVELOPMENT OF TECHNOLOGY OF TRIBOLOGICAL PROPERTIES OF DIESEL COMBUSTION

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Abstract. In this article, the results of studying C9-C17 carbon fatty acid amides as lubricating-dispersing additives for diesel fuel are presented. Additionally, the determination of lubricating-dispersing properties was carried out by sedimentation of the prepared stabilizing agent system based on colloidal graphite of the C-1 grade at a concentration of 1.0% by mass, resulting in a change in optical density. The determination of antioxidant efficiency was based on the photometric method, where, under experimental conditions, a change in optical density in the oxidation process was detected.

Keywords: diesel fuel, carbon fatty acid amides, lubricating-dispersing additives, optical density, sedimentation, antioxidant efficiency, oxidation.

Аннотация. В работе представлены результаты исследования амидов карбоновых кислот C9-C17 в качестве моющие-диспергирующих присадок для дизельных топлив. А также изучены моющие-диспергирующих свойств топлива на основе определения изменения оптической плотности при седиментации модульных загрязнителей на базе коллоидного графита марки С-1, взятого в концетрации 1,0 % масс. Определены антиокислительной эффективности присадок к топливам и маслам, в основе которого лежит измерение оптической плотности образца в ходе его окисления в заданных условиях опыта.

Ключовые слова: дизельные топлива, амидов карбоновых кислот, моющие-диспергирующие присадки, оптической плотност, седиментация, антиокислительной эффективность, окисления.

Аннотация. Ушбу мақолада дизель ёқилғиси учун ювувчи – диспергирловчи присадка сифатида C9-C17 карбон кислоталар амидларини ўрганиш натижалари келтирилган. Шунингдек, ювиш-диспергирлаш хоссасини аниқлаш 1,0% масс концентрациядаги С-1 маркали коллоид графит асосида тайёрланган ифлослантирувчи модул тизимни седиментацияланишида оптик зичликни ўзгариши натижасида аниқланди. Антиоксидланиш самарадорлигини аниқлаш асосий усули сифатида фотометрик усул танланди, у тажриба шароитида оксидланиш жараёнида намуна оптик зичлигини ўзгаришига асосланган ҳолда топилди

Калит сўзлар: дизель ёқилғиси, карбон кислоталар амидлари, ювувчи-диспергирловчи присадкалар, оптик зичлик, седиментациялаш, антиоксидлаш самарадорлиги, оксидланиш.

In our republic, diesel fuel is considered an important traditional fuel used in freight vehicles, automobiles, and passenger buses, which are operated with diesel engines. According to current forecasts, in the coming years (730.1 thousand tons in 2018, 701.2 thousand tons in 2019), the volume of diesel fuel consumption is expected to increase. Consequently, improving the quality and accelerating the combustion of diesel fuel and enhancing its characteristics become significant issues.

The use of special additives is considered one of the directions for improving the quality of diesel fuel [1, 86-97 p., 2; 64 p., 4; 228 p., 4; 250 p.]. Lubricating-dispersing additives are widely used for extending the service life of diesel engines, ensuring the cleanliness of engine parts, and fulfilling their function, which involves removing soot particles from the "combustion" chamber.

In recent years, the use of composite additives containing cyclic amines and their derivatives has been widely suggested as lubricating-dispersing additives for diesel fuel. Cyclic amines and their derivatives have one important characteristic, thermal stability, which allows them to be used in the composition of lubricating-dispersing additives for diesel fuel.

The following requirements are set for lubricating-dispersing additives: they should have weak or low acidity, good solubility in diesel fuel, possess properties of surface-active substances, and not decompose at temperatures of 220-250 °C. A "synergistic" lubricating-dispersing additive is known to improve certain characteristics of engine and fuel system lubricants at concentrations of 0.01-0.05% by mass. However, excessively high concentrations may adversely affect fuel prices.

To produce multifunctional lubricating-dispersing additives that improve the operational performance of diesel fuel, a variety of additives synthesized at low concentrations are developed according to the purpose.

Multifunctional lubricating-dispersing additives synthesized based on higher fatty acids (caprylic, lauric, myristic, palmitic, stearic), benzoic, m-toluic, nicotinic acids, hydrazalondione-2,4, and morpholine, diethylamine, acrylamide were produced (3.1.). These additives were tested on diesel fuel BNKI-2 (TDZ-1, TDZ-2, TDU) at a concentration of 0.0001% by mass.

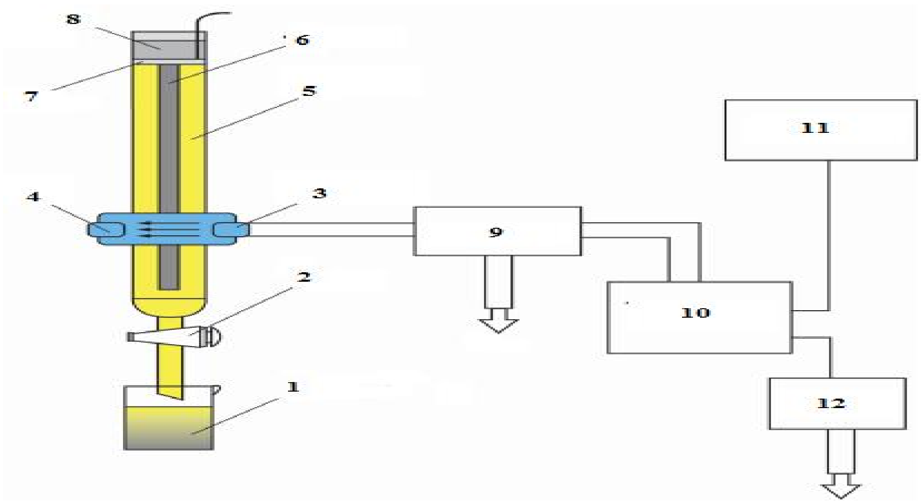
The synthesized lubricating-dispersing additives include morpholine stearic acid (MSA), morpholine benzoic acid (MBA), morpholine m-toluic acid (MTA), morpholine nicotinic acid (MNA), diethylamine stearic acid (DEASA), and hydrazalondione-acrylamide (HAA).

The main physicochemical characteristics of HAA additive are as follows:

Appearance: yellow-brownish viscous liquid. Density, kg/m3 – not less than 920, 3. Amine number, mg HC1 - not less than 33, 4. Solubility in diesel fuel - 50.0% mass fraction - clear homogeneous liquid.

As for the standard additive composition: synergistic and LAG-01 lubricating-dispersing additives, Agidol antioxidant additive were used. The additives were added to the diesel fuel up to 0.001-0.5% mass concentration for DYO testing and up to 0.5% mass for I-20 industrial engine testing.

Fractures, 2. Valve, 3. Gravity Source, 4. Light Receiver, 5. Main Channel, 6. Funnel, 7. Sediment, 8. Start Channel, 9. Photometer, 10. Thermometer AZ8852, 11. Computer, 12. Adapter.



The rapid laboratory method was used to evaluate the sedimentation of diesel fuel for assessing its dispersing and antioxidant properties [1; 86-97 p.].

The rapid method for evaluating the sedimentation of the diesel fuel dispersing properties is based on determining the change in optical density during sedimentation of the stabilizing agent system prepared with 1.0% mass concentration of colloidal graphite of grade C-1.

The photosedimentometer consists of two layers, including a special burette. The upper layer contains an standard suspension, while the lower layer contains the diesel fuel under evaluation, in which the sedimentation of the fuel particles occurs. These layers produce various sized particles, resulting in changes in optical density. These changes are detected by a photodetector and converted into corresponding signals on the computer.

The region where the colloidal graphite particles of the diesel fuel dispersing properties are stored is the sedimentation zone.The quantity and size of the particles were determined using electron microscopy. The obtained results were further processed using computer software. As seen in the second diagram, the hydrazalondione-acrylamide additive (HAA) increases the settling time of the particles in suspension in the diesel fuel, prevents their coagulation, and increases the optical density. The HAA additive (0.001-0.1)% mass concentration significantly improved the dispersing properties of diesel fuel, especially at 0.1% mass concentration where the optical density was equal to 375 mV. Below is the diagram showing the effect of the concentration of the HAA additive on the dispersing properties of diesel fuel:

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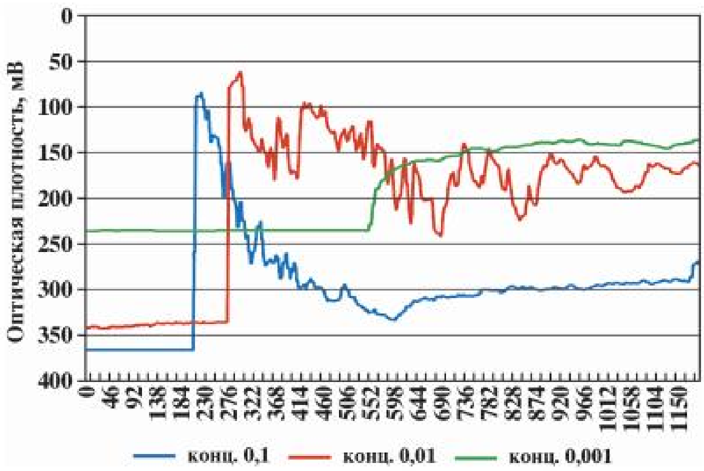


As shown in the diagram, the concentration of the HAA additive (% mass) has a significant impact on the dispersing properties of diesel fuel. At concentrations of 0.001% and 0.01%, the effect is considered nominal. However, at a concentration of 0.1% mass, the optical density reaches 375 mV, indicating a substantial improvement in the dispersing properties. Here's the requested diagram illustrating the evaluation of the antioxidant properties based on the chosen method: The chosen method for evaluating the antioxidant properties is the photometric method. It relies on changes in optical density during the oxidation process, which serves as the basis for assessing the sample's antioxidant activity.

Image 3. Device for determining the thermal stability of diesel fuel samples (left - a steam or water bath for heating samples, right - "Unifot" photometer for determining the optical density of combustion).

To evaluate the thermal stability of the fuel, a specially designed cylindrical vessel with a capacity of 3-5 ml was used, and the fuel was heated for 3-5 hours at temperatures up to 180°C. Oxidation was carried out simultaneously in 4 test tubes with 2 ml of sample each in a thermostat-controlled water bath (see Image 3). The optical densities of the tested samples were measured at wavelengths of 470 nm (blue filter) and 525 nm (green filter). The optical density values at OD470 and OD525 were plotted against the oxidation time to create a graph showing their dependence on the oxidation time [5,6].

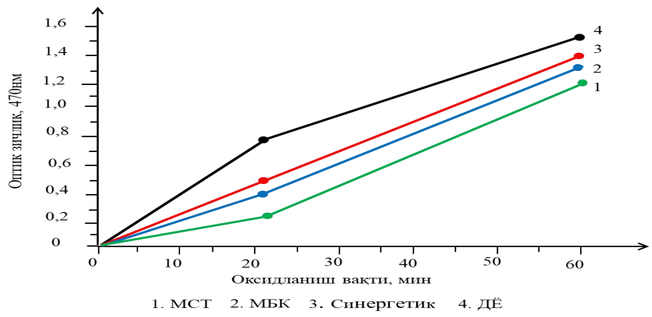
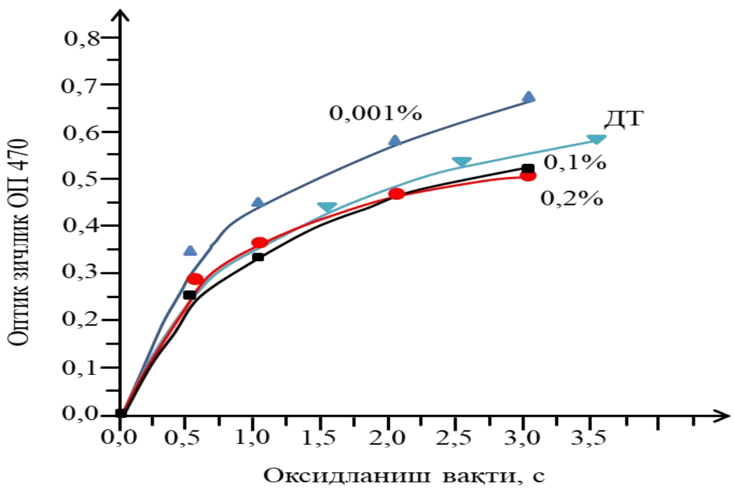


Image 1. Dependence of the optical density at OD470 at 180°C on the oxidation time for base diesel and diesel with 0.5% mass additives. 1 - Base diesel (BD); 2 - Biodiesel (BD); 3 - Synergistic; 4 - Diesel with additives.

The optical density at OD470 for the base diesel with additives is higher than that for the base diesel alone, indicating that the thermal oxidation rate of the base diesel is highest, resulting in more droplet formation during oxidation. The curve of the base diesel with the MST additive lies below, suggesting that its oxidation tendency is lower, meaning that the efficiency of the MST additive relative to synergistic and MBT additives is higher, i.e., its inhibitory effect on oxidation is relatively stronger.

At the Bukhara Research Institute of Standardization, base diesel fuel with a concentration of 0.2% mass additives LAG-03, synergistic, agidol, and HAA, was investigated for thermal stability in the fifth figure at 180°C.



Emage 2. (From Image 8) Effect of synergistic concentration on the oxidation of Bukhara NQIZ diesel fuel at 160°C.

Image 9 depicts that at 160°C, the concentration of synergistic additive at both 0.1% and 0.2% mass significantly reduces the oxidation rate of Bukhara NQIZ diesel fuel, while at a concentration of 0.001% mass, it accelerates oxidation. The synergistic additive

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demonstrates effective action at 180°C, where the oxidation of the base diesel fuel accelerates sharply.

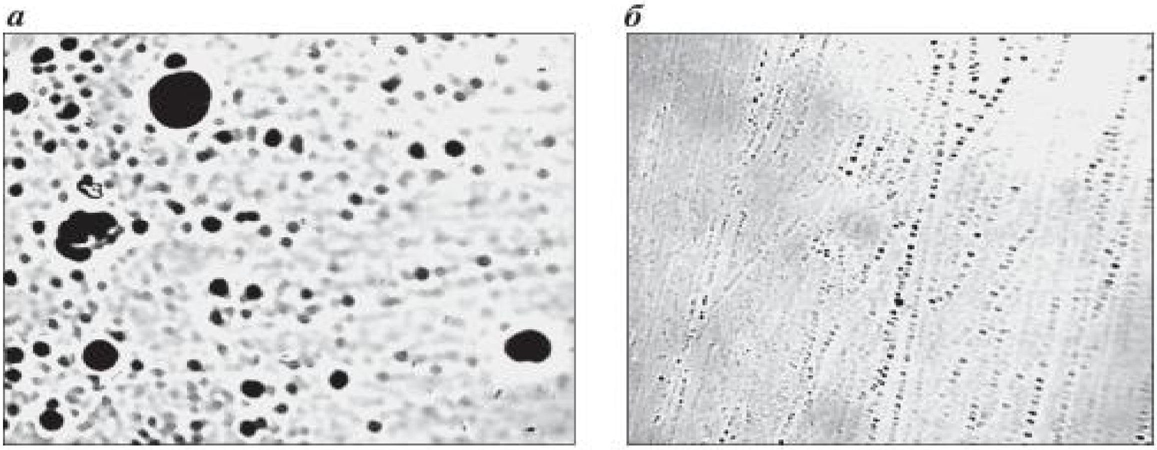

Image 3 shows the change in particle size after four hours of oxidation at 180°C for diesel fuel. (a) represents fuel without additives (particle size 1.0-25.0 μm); (b) represents fuel with a high-acidic additive (particle size 1.0-2.5 μm).

Microscopic examination results were obtained after diesel fuel samples in Figure 10 were oxidized for four hours at 180°C. When diesel fuel without additives (Figure 12, a) was oxidized, solid residue with particle sizes up to 25 μm was formed. When a high-acidic additive (Figure 12, b) was added to the diesel fuel at a mass concentration of 0.001%, the resulting particles had an average size of 2.5 μm.

Thus, when lubricating-dispersing additives based on carbon acids and amines (0.001-0.1% by mass) were added to diesel fuel, the tribological properties of the fuel (lubrication, dispersion, antioxidation) significantly improved.

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