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INVESTIGATION OF THE RHEOLOGICAL PROPERTIES OF DIESEL OILS

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Abstract. This article presents information on increasing the power and service life of diesel engines operating under severe conditions. It also provides the results of scientific research carried out on the influence of sediments on the quality of oils used in diesel engines, as well as on the changes in their rheological and physicochemical properties.

Keywords: diesel oils, diesel engine, sediment, hydrocarbon composition, lubrication, viscosity index, viscosity–temperature properties, rheological properties, temperature, pressure.

Аннотация. В данной статье представлена информация по увеличению мощности и срока службы дизельных двигателей, работающих в тяжелых условиях. В нем также представлены результаты научных исследований, проведенных по изучению влияния отложений на качество масел, используемых в дизельных двигателях, а также на изменение их реологических и физико-химических свойств.

Ключевые слова: дизельные масла, дизельный двигатель, осадок, углеводородный состав, смазка, индекс вязкости, вязкостно–температурные свойства, реологические свойства, температура, давление.

Annotatsiya. Ushbu maqolada og'ir sharoitlarda ishlaydigan dizel dvigatellarining quvvati va xizmat muddatini oshirish haqida ma'lumotlar keltirilgan. Shuningdek, u cho'kindilarning dizel dvigatellarida ishlatiladigan moylarning sifatiga ta'siri, shuningdek ularning reologik va fizik-kimyoviy xususiyatlarining o'zgarishi bo'yicha olib borilgan ilmiy tadqiqotlar natijalarini beradi.

Kalit so'zlar: dizel moylari, dizel dvigatel, cho'kma, uglevodorod tarkibi, moylash, yopishqoqlik indeksi, yopishqoqlik–harorat xususiyatlari, reologik xususiyatlar, harorat, bosim.

Introduction.

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In our Republic, significant scientific and practical results have been achieved in the development and application of technologies for producing turbine oils with improved colloid–tribological properties based on local crude oil. In the "Strategy of Actions on Further Development of the Republic of Uzbekistan," the following tasks are defined: "…to further modernize and diversify industry through the rapid development of high-tech processing sectors, primarily the production of high value-added finished products based on deep processing of local raw materials, and to transition to a qualitatively new stage of development."

In this regard, developing the scientific and technological foundations for intensifying the production of turbine oils based on multifunctional local raw materials, as well as managing their tribological and environmental properties in a targeted manner, is of great importance [1].

The rheological properties of diesel oils in production and application depend on their composition and colloid–chemical characteristics. When selecting diesel oils for engines, attention must be paid to the following indicators: oil fluidity, the degree of cleaning engine parts, cooling of parts, and the energy consumption for friction during the formation of the protective lubrication layer [2, pp. 180–181].

Object and Methods of Research. The viscosity of oils, besides being influenced by external factors such as temperature and pressure, depends on volume, molecular structure, and the interaction of molecules with each other and with other components. In diesel oils, intermolecular interactions at temperatures below +40 °C are of particular importance. At higher temperatures (200 °C … 260 °C), viscosity becomes dependent not only on temperature but also on the mass fraction of high-molecular-weight hydrocarbons.

For example, n-alkanes become oriented, their molecules align parallel to each other (liquid crystals). They may form tertiary crystalline structures. A further decrease in temperature increases the concentration of the dispersed phase, leading to the formation of a dispersed structure.

Results and Discussion. During oil flow, the bonds between molecules break, resulting in a decrease in viscosity. Such liquids do not follow Newton's law (their viscosity is not dependent on the velocity gradient). If viscosity depends on the rate of flow, then the fluid is considered anomalous [3, pp. 186–188].

Figure 1. Effect of the molecular mass of hydrocarbons in the oil composition on its thermal–viscosity properties.

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1 – isoalkanes; 2 – alkyl monocyclic aromatic hydrocarbons and cycloalkanes.

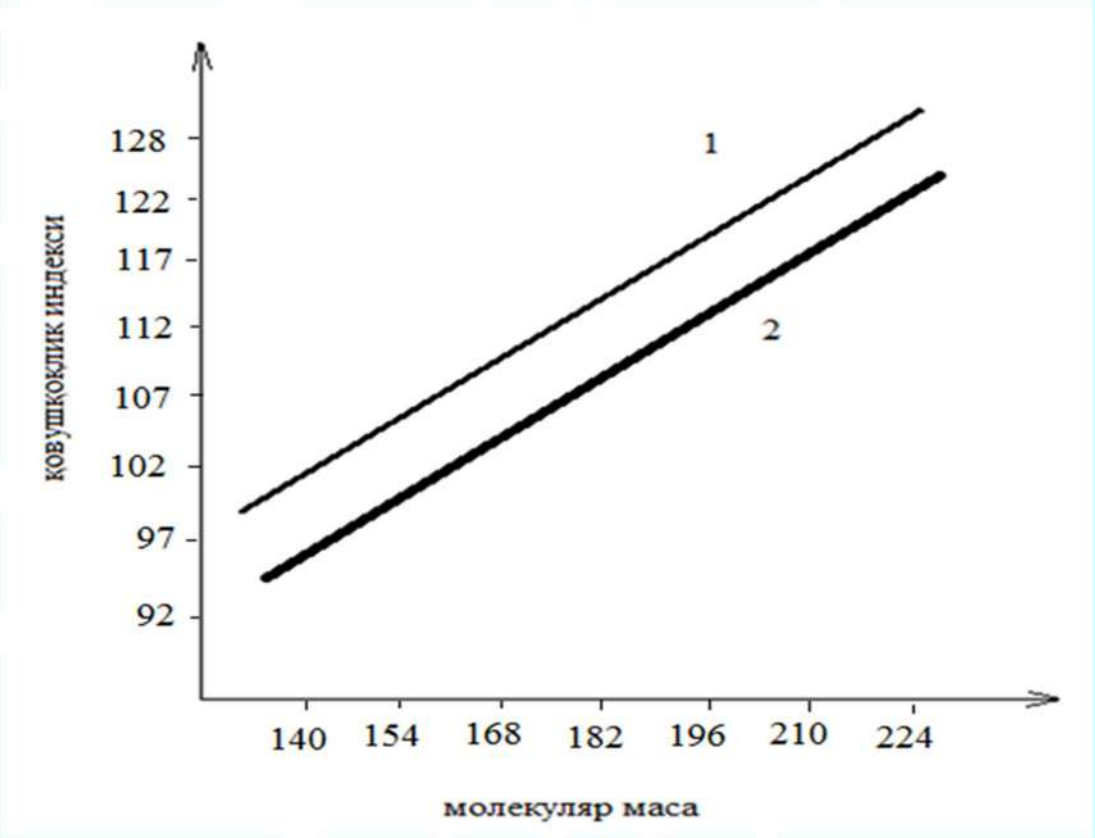


Figure 1. Influence of the molecular mass of hydrocarbons in the oil composition on its thermal–viscosity properties. 1 – isoalkanes; 2 – alkyl monocyclic aromatic hydrocarbons and cycloalkanes.

From this figure, it follows that the viscosity of oils depends on the molecular structure of hydrocarbons. In other words, n-alkanes and isoalkanes have low viscosity, while under the same conditions, the viscosity of cycloalkanes is higher than that of monocyclic aromatic hydrocarbons (an increase in the number of aromatic rings leads to an increase in viscosity).

In selectively refined oil fractions, the content of n-alkanes and resin–asphaltene substances is low, and therefore they do not significantly affect the viscosity of the oil. Heteroatomic compounds (sulfur-, nitrogen-, and oxygen-containing substances, as well as oxidation products) lead to the formation of micelles that deteriorate the viscosity properties of the oil [4, pp. 176–182].

The colloid–chemical properties of diesel oils can be improved by removing solid hydrocarbons and short or branched-chain polycyclic aromatic hydrocarbons from the oil fractions.

The thermal–viscosity properties of diesel oils depend not only on viscosity but also on the specific operating temperatures of the oil. The higher the thermal–viscosity curve, the better the viscosity index and the improved properties of the oil (Figures 1 and 2).

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The magnitude of the viscosity index depends on the colloid–chemical characteristics of the oil, as well as on molecular mass, chemical structure, and the ratio and concentration of different hydrocarbons present in the oil [5, pp. 24–25].

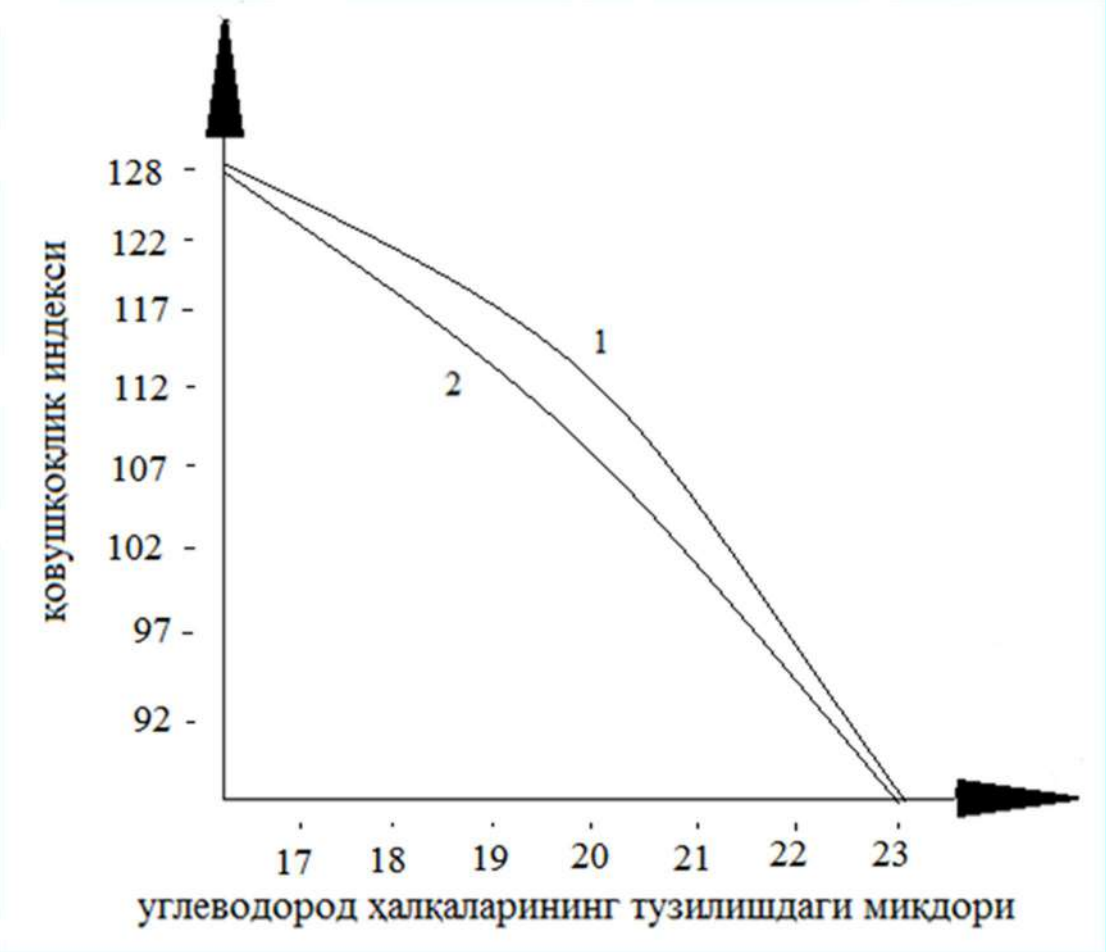


Figure 2. Effect of the number of carbon atoms in the hydrocarbon rings of oil on its thermal–viscosity properties.

1 – alkyl aromatic hydrocarbons; 2 – alkyl-based cyclohexanes.

The viscosity index of hydrocarbons contained in oils is high in n-alkanes (200), while this indicator is significantly lower in isoalkanes. As the hydrocarbon chain length increases, the viscosity index also increases [7; pp. 4–25]. In cycloalkanes and aromatic hydrocarbons, an increase in the number of carbon atoms in the alkyl chain (Figure 2), as well as an increase in the number of carbon atoms in the cyclic part of the molecules, also leads to an increase in the viscosity index [6; pp. 4–25].

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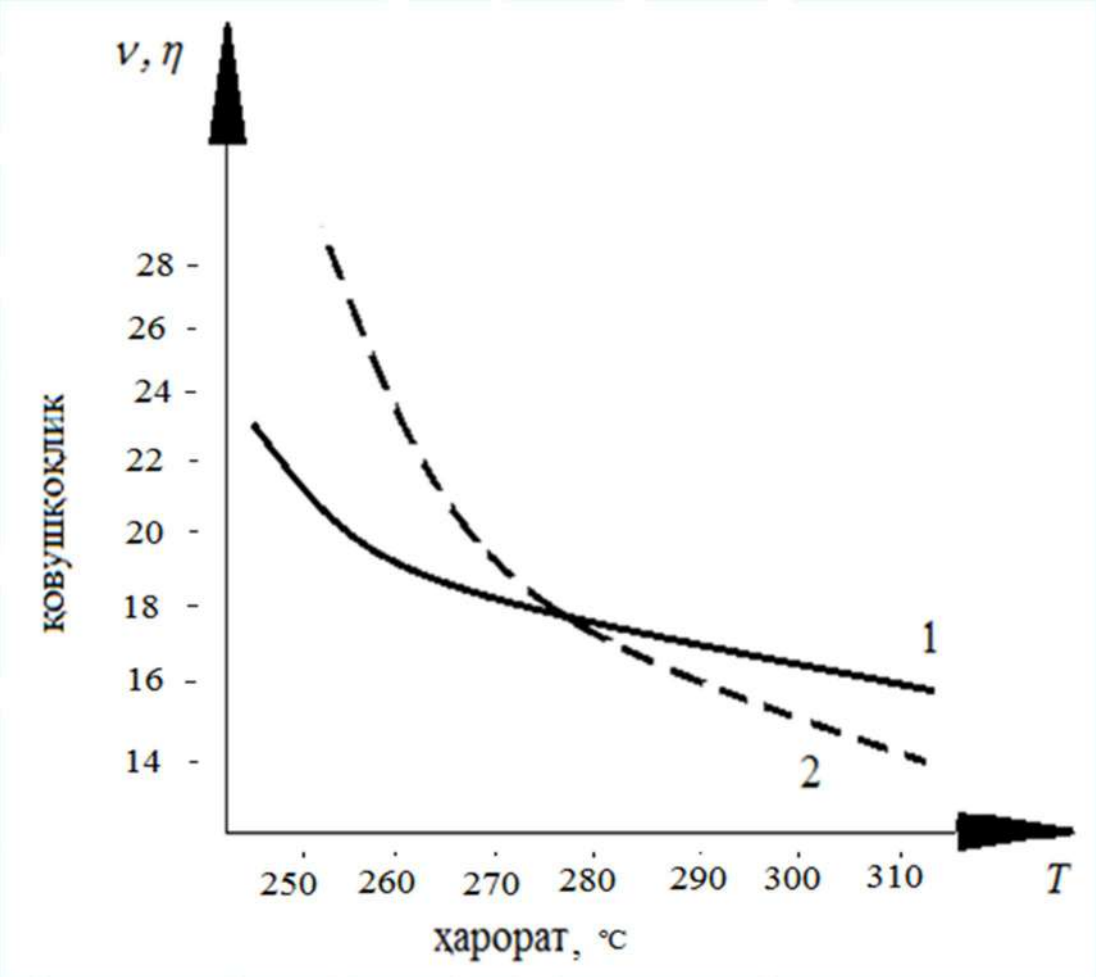


Figure 3. Effect of temperature on the viscosity of oil with and without viscosity improvers. 1 – oil with viscosity improvers; 2 – oil without viscosity improvers.

Conclusion. The viscosity of diesel oil also depends on the temperature of the environment in which it is used. As the temperature increases, its viscosity decreases accordingly. To prevent this, viscosity improvers are added to the oil, which make it possible to improve the oil's viscosity characteristics at higher temperatures.

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