# EFFECT OF PHYSICAL PROPERTIES OF FUEL MIXTURES ON ICE PERFORMANCE

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**Abstract:** *The scientific research presented in this study focused on determining the density (ρ) and kinematic viscosity (μ) of biodiesel–diesel blends, key properties for fuel characterization and engine performance. The objective was to assess the influence of biodiesel concentration on these parameters using methods compliant with GOST 3900 and GOST 33-82. At 15 °C, the density of pure biodiesel (B100) was measured at 0.886 g/cm³, which is 6.24% higher than conventional diesel, while B20 and B50 blends showed increases of 1.44% and 3.36%. At 20 °C, the kinematic viscosity of B100 was 1.97 times higher than diesel, whereas B20 and B50 exhibited moderate increases of 1.09 and 1.19 times. The results indicate deviations from the additivity principle, suggesting a synergistic effect in which diesel exerts a dominant influence on the blend properties, an aspect essential for optimizing combustion and lubrication characteristics.*

**Keywords:** *biodiesel, diesel fuel, density, kinematic viscosity, fuel blends, physical properties.*

## 1. Introduction

Currently, diesel is the main fuel used to operate transportation systems and various technical equipment. Compression ignition engines, which commonly use diesel, represent some of the most important sources of mechanical energy worldwide, being widely applied in road, rail, naval transport, as well as in industrial and agricultural machinery. However, the combustion of diesel generates significant polluting emissions and contributes to environmental degradation, while also having harmful effects on human health. In addition, fossil energy resources are limited and are in an accelerated process of depletion, which determines the need to identify and exploit alternative sources [3,6,12,14].

Research carried out in various countries has demonstrated that an effective solution consists in replacing fossil fuels with unconventional fuels obtained from renewable resources. In this context, renewable energy sources are becoming essential for ensuring the sustainability of the energy sector, offering the possibility of reducing dependence on conventional fuels and reducing the impact on the environment [16,17,19,21,22].

Biodiesel falls into this category, being a fuel obtained by transesterification of vegetable oils or animal fats. The raw materials used include rapeseed oil, sunflower oil, soybean oil, palm oil, as well as residual oils from the food industry.

Biodiesel is usually light yellow to brown in color, with a transparent or slightly cloudy appearance, depending on the raw material used and the degree of purification. From a physicochemical point of view, it has a slightly higher density than conventional diesel, a higher viscosity and an increased oxygen content, which favors more complete combustion [2,10].

At the same time, biodiesel is distinguished by a higher flash point, which gives it a higher degree of safety during handling and storage. These properties influence the combustion process and engine performance, giving biodiesel a significant role in reducing greenhouse gas emissions and in the transition to a cleaner and more sustainable energy system.

Therefore, research has been conducted on the use of biodiesel obtained from rapeseed oil and biodiesel-diesel blends in compression ignition engines, as an alternative to diesel, in order to evaluate the energy performance and environmental impact [4,5,7,9-11,18].

The purpose of this study is to investigate the influence of biodiesel concentration on the density and kinematic viscosity of biodiesel-diesel blends, by applying standardized methods.

## 2. Materials and method

The physical and chemical properties of fuels decisively influence the nature of the combustion process of the working mixture and the performance of engines. In the framework of theoretical research on biofuels, these properties were evaluated for SUPER DIESEL EURO 5 diesel, B100 biodiesel and biodiesel-diesel blends (B20 and B50). Experimental determinations focused on density, kinematic viscosity, ignition temperature and cloud/freezing temperature.

Density and kinematic viscosity are essential indicators of fuel quality, as they influence the processes of evaporation and formation of the working mixture in the combustion chamber of compression ignition engines. The dynamics of these processes determine the size of the sprayed droplets, the shape and structure of the flame, as well as the penetration length of the fuel jet into the combustion chamber. Reduced values of density and kinematic viscosity favor finer atomization and more uniform combustion.

Rapeseed oil methyl ester (B100) was obtained using the M8-KPB-01 plant, designed and built by the Joint Stock Company “Alimentarmaş” from Chisinau [2,15]. The fuel mixtures were prepared using a single batch of diesel and biodiesel, in the following proportions (% by mass): B20 – 20% biodiesel + 80% diesel, B50 – 50% biodiesel + 50% diesel and B100 – pure biodiesel.

The physical properties of fuels, such as density and kinematic viscosity, directly influence the process of formation and combustion of the fuel mixture. These characteristics determine both the quality of atomization and homogenization of the fuel with air, as well as the energy efficiency and engine emissions. The values of density and viscosity vary depending on the chemical composition and ambient temperature, which requires rigorous control of these parameters in the practical use of fuels.

The absolute density of fuels was determined using the AH model hydrometer, according to the GOST 18481-81 standard for petroleum products. To measure the kinematic viscosity, the VPJ-2 type viscometer (GOST 10028-81) was used, with a capillary diameter of 0.56 mm. The choice of this device was based on the requirement that the sample evacuation time from the test piece be at least 200 s. Kinematic viscosity determinations were carried out at a temperature of +20 °C.

## 3. Results and discussions

Density (ρ) is one of the main physical characteristics of fuels. Both density and viscosity influence the process of combustion mixture formation, having a direct impact on engine operation. Density depends on the chemical composition of the fuel and can vary under the influence of environmental temperature, a change determined in particular by the solidification of the paraffins contained [1,8,13,20].

The density determination was carried out using the AH model hydrometer (GOST 18481-81), intended for petroleum products, according to the method regulated by GOST 3900. The measurements were carried out at a temperature of 15 °C.

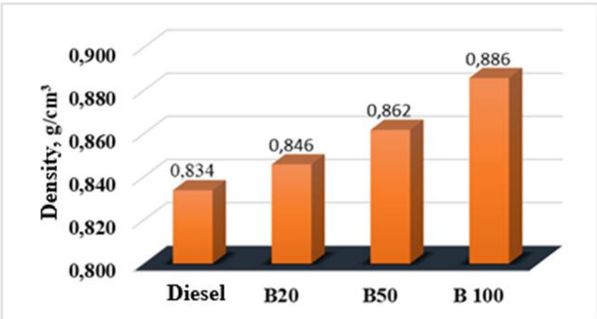


**Figure 1:** *Density values of the tested fuels [2].*

The density of biofuels (ρ) increases with increasing biodiesel concentration in diesel fuel (Fig. 1). For pure biodiesel B100, the value of 0.886 g/cm³ was obtained, within the range provided by the SM STB 1657:2009 (EN 14214:2003) standard, being 6.24% higher than the density of petroleum diesel. Also, the density of biodiesel-diesel blends increased compared to classic diesel, by 1.44% for B20 and by 3.36% for B50.

Kinematic viscosity (μ) is one of the most important properties of fuels, influencing the quality of their atomization in the combustion chamber of a compression ignition engine. It expresses the resistance to flow of a fluid: the higher the viscosity, the slower the flow. Temperature has a significant impact on this parameter - at high temperatures the viscosity decreases, and at low temperatures it increases.

A low viscosity favors the injection process by modifying the jet parameters (dispersion angle and penetration), but values that are too low can compromise the lubrication conditions of the tribological couplings (plunger-cylinder, piston-cylinder, etc.), which can lead to malfunctions.

The determination of the kinematic viscosity of the fuel samples was carried out at a temperature of 20 °C, using a VPJ-2 glass capillary viscometer (diameter 0.56 mm), according to the GOST 33-82 standard.

The measurement results (Fig. 2) show that the kinematic viscosity at 20 °C of B100 biodiesel is 1.97 times higher than that of petroleum diesel. For biodiesel-diesel blends, the viscosity increase is lower: 1.09 times for B20 and 1.19 times for B50, compared to diesel.

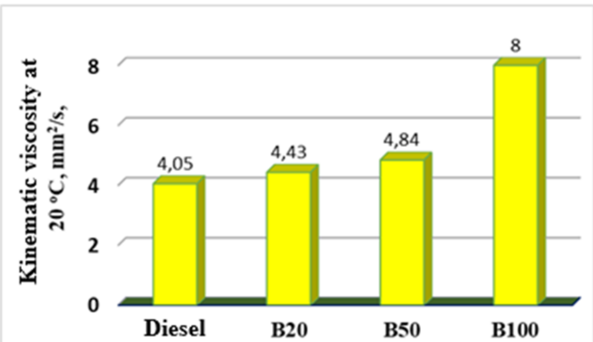


**Figure 2:** *Kinematic viscosity μ values of the tested fuels [2].*

Analysis of the data (Fig. 1, 2) indicates that the additivity principle is not respected: the density values and, in particular, the viscosity values of the B20 and B50 blends do not depend directly proportionally on the mass fractions of diesel and B100 biodiesel.

Probably, the density and viscosity of B20 and B50 blends are influenced to a greater extent by the properties of diesel fuel, thus generating a favorable synergistic effect.

## 4. Conclusion

Experimental research on the exploitation of the energy potential of biodiesel and biodiesel-diesel blends allowed the formulation of the following conclusions:

Laboratory studies have shown that the density (at 15 °C) and kinematic viscosity (at 40 °C) values for pure B100 biodiesel fall within the limits set by the SM STB 1657:2009 (EN 14214:2003) standard, which regulates the physicochemical and operational properties of fuels for compression ignition engines.

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