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RESEARCH ON THE LUBRICITY PROPERTIES OF AUTOMOTIVE GASOLINE AND GASOLINE OXYGENATE FUEL BLENDS

Abstract: This article presents information on the octane number of alcohols in a mixture with gasoline, the effect of isopropanol content on the lubricity of gasoline, the formation of grooves formed as a result of friction in the device for determining the lubricity of gasoline samples No. 1, No. 2, No. 3 and domestic AI-80 and AI-91 gasolines using a DN-300M digital binocular microscope, and the studies conducted to determine the lubricity of gasolines, including the fact that the oxygenates selected by us do not deteriorate the lubricity of gasolines.

Key words: gasoline, isopropanol, lubricity, oxygenate, octane, automotive, methanol, ethanol.

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ИССЛЕДОВАНИЕ СМАЗЫВАЮЩИХ СВОЙСТВ АВТОМОБИЛЬНОГО БЕНЗИНА И СМЕСЕЙ БЕНЗИНА С КИСЛОРОДОМ

Аннотация: В статье приведены сведения об октановом числе спиртов в смеси с бензином, влиянии содержания изопропанола на смазывающую способность бензина, образовании канавок, образующихся в результате трения в приборе для определения смазывающей способности образцов бензинов № 1, № 2, № 3 и отечественных бензинов АИ-80 и АИ-91 с использованием цифрового бинокулярного микроскопа ДН-300М, а также проведенные исследования по определению смазывающей способности бензинов, в том числе установлено, что выбранные нами оксигенаты не ухудшают смазывающую способность бензинов.

Ключевые слова: бензин, изопропанол, смазывающая способность, оксигенат, октановое число, автомобильный, метанол, этанол.

Introduction

Today, the role of oxygenated additives in the production of automotive gasolines that meet modern environmental requirements is of great importance. By using oxygenated additives, the octane number of gasoline increases, and their resource also increases due to renewable raw materials. Gasolines containing oxygenates exhibit improved washability and flammability properties, while the formation of carbon monoxide and hydrocarbons as a result of the combustion of these gasolines is significantly reduced.

The main part

The recommended concentration of oxygenates in gasoline is 3-15%. In this case, the oxygen content in gasoline should not exceed 2.7%. It has been proven that oxygenates in this amount do not have a negative effect on engine power, although the heat release rate is significantly lower than that of petroleum-based gasolines [1; 270-b, 2; 154-b.].

Oxygenate performance index. Oxygenates exhibit the same octane number, saturated vapor pressure, and heat release properties as gasoline components in a mixture. However, oxygenates are hygroscopic, meaning they can absorb moisture from the air. This property can cause gasolines containing oxygenates to become cloudy at low temperatures [3 ; 20-43 p.].

The octane number of alcohols in a mixed state decreases with the elongation of the hydrocarbon radical (Figure 1).

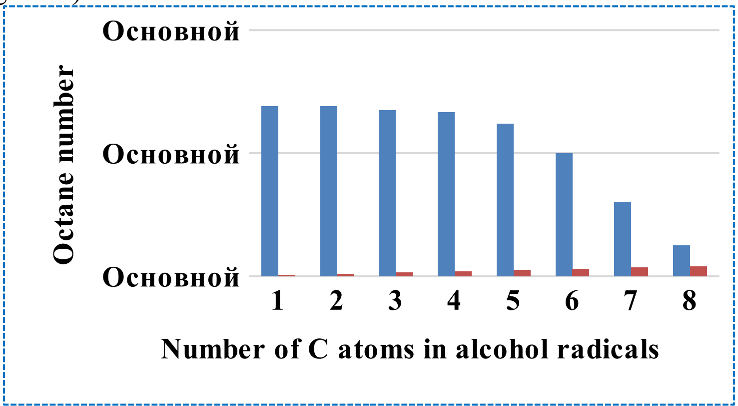

Figure 1. Octane number of alcohols in mixtures with gasoline: *1 – methanol, 2 – ethanol, 3 – isopropyl alcohol, 4 – sec-butyl alcohol, 5 – amyl alcohol, 6 – hexyl alcohol, 7 – heptyl alcohol, 8 – nonyl alcohol*

methanol is a high-octane alcohol, it is not widely used as an oxygenate for gasolines. The main reason for this is the toxicity of methanol, poor solubility in hydrocarbons, and high hygroscopicity. Like all alcohols, methanol has a negative effect on the densification of materials and is actively corrosive to non-ferrous metals. This leads to a decrease in engine life and deterioration of fuel quality. It is advisable to add up to 5% methanol to gasoline, and in these proportions the gasoline-methanol mixture (BMA) will maintain a homogeneous state. When using BMA, it is necessary to solve the problem of its high sensitivity to moisture. BMA can dissolve no more than 0.1% water, at a higher water concentration, the mixture separates into two layers. When the temperature decreases, BMA first becomes cloudy and then separates into two layers. Therefore, in practical applications, there is a temperature range for the use of BMA [4 ; 26-29 p. 5 ; p. 568.].

gasoline -methanol mixtures from separating into two layers, higher alcohols are added as stabilizers. For example, tertiary butyl alcohol (a mixture of tertiary butyl alcohol and methanol is called oxynol) or isopropyl alcohol can be added to increase the stability of BMA .

Ethanol is added to gasoline in larger quantities as an oxygenate compared to methanol. This is because ethanol is soluble in hydrocarbons and has a lower hygroscopicity than methanol. Today, gasohol gasoline (gasoline containing 10-20% ethanol) is widely used in North and South America. This can be explained by the large amount of ethyl alcohol produced from sugarcane in these countries. In European countries, commercial automobile gasoline of the E-85 brand (gasoline containing up to 85% ethanol) is used [6; 552-b, 7; 19-34 p.].

Results: The aim of our research is to investigate the effect of isopropanol content on the lubricity of gasoline. Therefore, we took gasoline samples based on BK, IP and MTBE and tested them on the effect of gasoline on lubricity in the ASTM D6079 standard apparatus. The process conditions are given in Table 1.

Table 1

Test conditions

Indicator	Conditions
Fuel sample volume, cm ^{3}	2±0.20
Friction range of movement, mm	1.00±0.02
Frequency, Hz	50±1
Sample temperature, ^{o}C	25±2
Relative humidity, %	>30
Combined load, g	200±1
Test time, minutes	75.0±0.1
Bath surface, cm ^{3}	6±1

As commercial gasoline, samples of domestic automotive gasolines AI-80 and AI-91 and gasoline obtained with BK, IP and ETBE of AI-80 automotive gasoline were taken. Oxygenates and gasoline samples BK-5 (№1), IP-5 (№2), ETBE-5 (№3) (where the abbreviation of the oxygenate in the gasoline and its amount are indicated by 5%) were prepared. Lubricity tests were carried out on a piston- frequency device (HFFR). The main reason for choosing the ASTM D6079 standard is that the lubricity is determined in this device at a temperature of 25 ^{o}C. Because at temperatures above this, automotive gasolines can evaporate or degrade.

As commercial gasoline, samples of domestic automotive gasolines AI-80 and AI-91 and gasoline obtained with BK, IP and ETBE of AI-80 automotive gasoline were taken and these samples were tested in a laboratory device for determining the lubricity for 5, 10 and 15 minutes. The images obtained using a DN-300M digital binocular microscope are presented in Figures 1 and 2, which show that the lubricity of domestic AI-80 gasoline and AI-91 gasoline without oxygenates is significantly lower. In samples with the addition of BK, IP and ETBE to AI-80 gasoline, we can see that the lubricity of AI-80 gasoline is relatively increased.

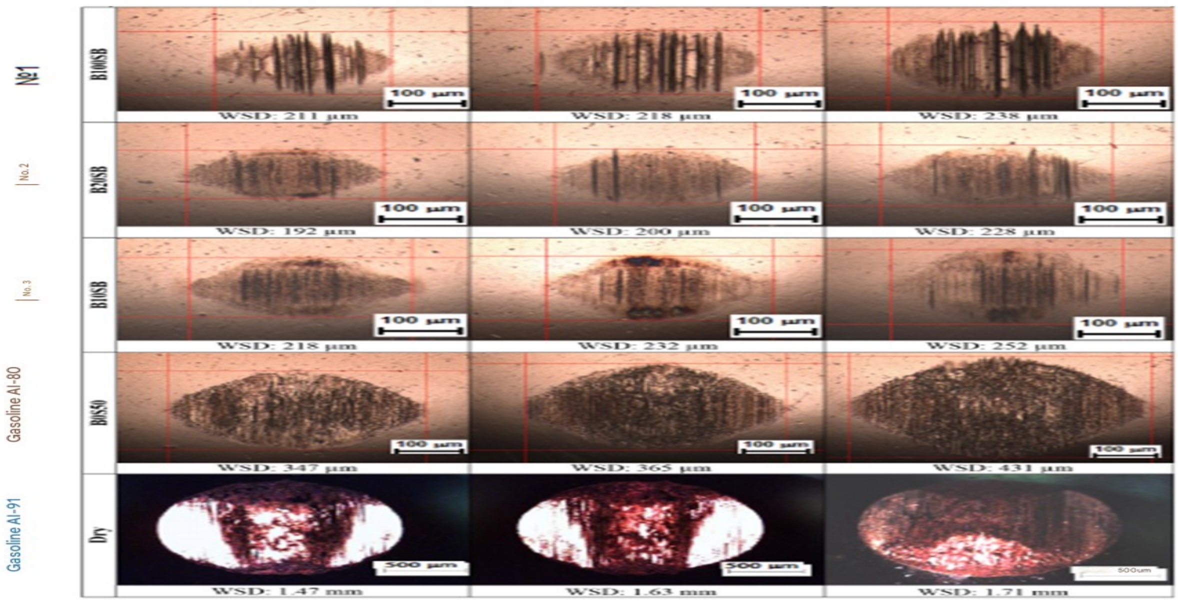

Figure 2. Photograph of grooves formed as a result of friction in a device for determining the lubricity of gasoline samples No. 1, No. 2, No. 3 and domestic AI-80 and AI-91 gasolines using a DN-300M digital binocular microscope.

In particular, this positive effect is more pronounced in the gasoline sample with BK, which can be assumed to be a positive effect of ethanol and oxygen in butylcarbitol on lubrication. The gasoline sample with IP shows a better performance than the sample with BK. We can even see that the lubricating ability of gasoline has changed positively in the gasoline sample with ETBE. The main reason why we used the gasoline samples we obtained at an average concentration of 5% is the maximum concentration of these additives.

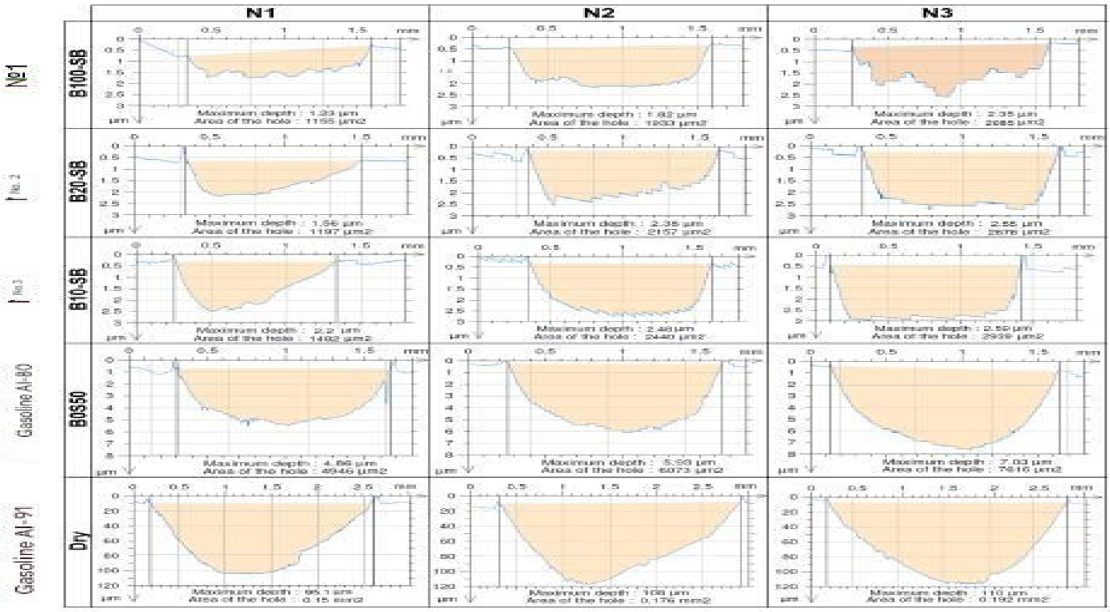

Fig. 2. The depth of the grooves formed as a result of friction in the device for determining the lubricity of gasoline samples No. 1, No. 2, No. 3 and domestic AI-80 and AI-91 gasolines using a DN-300M digital binocular microscope

automotive gasolines and gasoline samples taken for testing are presented in Table 2.

The main goal of the research conducted by us is to determine the negative effects of these additives in obtaining a composition of additives with a synergistic effect for automotive gasolines. If they change some of the properties of automotive gasolines in a negative way, a new problem may arise, such as preventing these unpleasant situations.

Table 2

The results of the ditches formed as a result of the erosion

Fuel and fuel-oxygen mixture	Edirilish ditch, mkm
AI-80 gasoline	580
AI-91 gasoline	590
Gasoline+oxygen sample #1	412
Gasoline+oxygen sample #2	428
Gasoline+oxygen sample #3	501

Studies conducted to determine the lubricating ability of automotive gasolines showed that the oxygenates selected by us did not worsen the lubricating ability of gasolines, but rather served to improve their ability.

Conclusion: The lubricity properties of gasoline and gasoline + oxygenate fuel mixtures were studied. When determining the lubricity of gasoline AI-80 and AI-91, the wear rate of AI-80 gasoline was 580 µm, and that of AI-91 gasoline was 590 µm. In a gasoline sample with the addition of AI-80 and oxygenate composition, this indicator was found to decrease to 412 µm.

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