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METHODS FOR IMPROVING AUTOMOTIVE FUEL QUALITY INDICATORS THROUGH THE USE OF ADDITIVES

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Abstract: This article examines the issues of improving the efficiency of internal combustion engines and reducing exhaust emissions by adding special additives to automotive fuels. Under laboratory conditions, the MN-9950 additive was added to AI-92 gasoline and tested on a Chevrolet Cobalt engine to evaluate its effect on engine operation, fuel consumption, and environmental performance. The results showed that fuel additives help stabilize the combustion process, reduce the risk of detonation, increase engine power, and clean fuel system components. In addition, the MN-9950 additive was found to be effective in reducing the amount of harmful exhaust gases, including CO, HC, and NOx. The obtained results can be practically applied to optimize engine performance, reduce fuel consumption, and improve the environmental safety of vehicles.

Key words: Automotive fuel, fuel quality, octane number, additives, detonation, combustion process, environmental indicators.

INTRODUCTION

Today, the rapid increase in the number of vehicles has made fuel quality one of the most pressing issues. The reliable, efficient, and long-term operation of internal combustion engines directly depends on the quality of fuel. Using low-quality fuel leads to reduced engine power, incomplete combustion, increased fuel consumption, and higher amounts of toxic and harmful exhaust emissions. Therefore, improving fuel quality indicators is of significant importance in modern automotive engineering and operation.

One of the main practical problems today is the insufficient octane number of fuel, unstable combustion, and contamination of fuel system components. These issues contribute to intensified engine knocking, faster wear of engine parts, and deterioration of environmental performance.

One of the most effective ways to address these problems is the addition of special chemical additives to fuel. Additives can increase the fuel's octane number, improve the combustion process, clean engine components, and reduce the amount of harmful and toxic emissions. Therefore, enhancing fuel quality through the use of additives is a topic of both practical and scientific relevance.

REVIEW OF LITERATURE ON THE SUBJECT

The issues of fuel quality and its impact on the performance of internal combustion engines have been extensively studied by numerous local and international researchers. Scientific literature provides detailed insights into the physicochemical properties of fuel, their influence on the combustion process, and methods to improve operational and environmental indicators.

Studies by P. Balochay and A. Pitivonchi demonstrated that the main quality parameters of automotive fuels, particularly octane number, cleanliness, and stability, directly affect engine performance. The authors emphasized that using low-quality fuel leads to reduced engine power and contamination of fuel system components [3]. A.A.Gureyev also substantiated in his works that fuel quality is a critical factor determining the economic and technical performance of engines [4].

A.I.Kolchin and V.P.Demidov scientifically established that the efficiency of the combustion process in internal combustion engines depends on fuel quality. Their studies provided a detailed analysis of how combustion stability affects engine power and service life [5]. Similar issues have been widely addressed in the fundamental research of J.B. Heywood and W.W.Pulkrabek, where it was noted that fuel resistance to knocking and optimal combustion timing are key conditions for engine efficiency [6,7].

Regarding fuel additives, A.M. Danilov conducted in-depth studies, emphasizing that additives can increase the octane number of fuel, improve combustion, and protect engine components [8]. R. Stone's research focused on enhancing engine service life and operational reliability by improving fuel quality in modern engines [9].

Regulatory documents also play an important role in evaluating fuel quality. The RD-50-170-85 standard specifies technical requirements for automotive gasoline, including octane number and volatility [10]. The international standard ISO 22854:2016 regulates methods for assessing fuel combustion quality and knock resistance [11].

Environmental issues have been extensively covered in the works of V.P. Spiridonov, highlighting that reducing toxic and harmful exhaust emissions is one of the critical tasks of modern transportation systems [12].

RESEARCH METHODOLOGY

The research methodology is based on laboratory experiments conducted on a Chevrolet Cobalt engine using AI-92 gasoline with the MN-9950 fuel additive. The study involved monitoring engine performance under controlled conditions, focusing on fuel consumption, combustion stability, and exhaust gas emissions. Comparative analysis was carried out by evaluating engine indicators before and after the addition of the additive. The collected data were analyzed to assess the impact of the additive on engine efficiency, operational reliability, and environmental performance.

ANALYSIS AND RESULTS

The reviewed literature indicates that improving fuel quality through the use of additives is an effective method to enhance engine efficiency, reduce fuel consumption, and improve environmental performance. Therefore, the issue addressed in this thesis is both scientifically and practically relevant.

Fuel Quality Indicators – fuel quality is one of the key factors ensuring the efficient and reliable operation of internal combustion engines. Fuel quality is evaluated based on several important indicators, which directly affect the combustion process, engine components, and environmental performance.

Octane Number – this is the primary indicator describing the fuel's resistance to knocking. The higher the octane number, the more stable the combustion process, and the lower the likelihood of engine knocking. Fuel with a low octane number can lead to reduced engine power and accelerated wear of mechanical components.

Combustion Completeness – this indicates how efficiently the fuel burns in the cylinder. Complete combustion increases engine power and reduces fuel consumption. Incomplete combustion, on the other hand, results in higher levels of harmful exhaust emissions.

Volatility – this reflects the fuel's ability to vaporize under different temperature conditions. Volatility affects engine start-up in cold conditions and the stability of the combustion process. Fuel with insufficient volatility can cause difficulties in engine ignition.

Corrosive Activity – this shows the extent to which fuel can damage fuel system components. Fuel with high corrosive activity accelerates the wear of metal parts, reducing fuel system reliability and increasing maintenance costs.

Environmental Indicators – these are assessed based on the amount of exhaust gases produced during fuel combustion. Using high-quality fuel reduces emissions of carbon monoxide (CO), hydrocarbons (HC), and nitrogen oxides (NOx), which is important for environmental protection and compliance with ecological standards.

Additives are special chemical substances added in small amounts to improve the physicochemical and operational properties of fuel. In modern automotive engines, additives are widely used to enhance combustion efficiency, protect engine components, and improve environmental performance. Additives positively influence key fuel quality indicators without altering the main composition of the fuel.

Additives are incorporated into fuel for several purposes: increasing the octane number, stabilizing the combustion process, cleaning fuel system components, reducing corrosion, and lowering the amount of harmful exhaust emissions. Based on these functions, additives are classified into several main types.

Octane-boosting additives are used to increase the fuel's resistance to knocking. These additives ensure smooth and stable combustion, resulting in increased engine power and reduced mechanical stress. Octane-boosting additives are particularly important for engines with high compression ratios.

UNG Petro Octane-boosting additive is an octane-enhancing additive for gasoline produced by UNG Petro, a part of "O'zbekneftgaz." When added to fuel, this product facilitates easier engine ignition, reduces emissions, and increases engine power [12].

Detergent additives are used to reduce and prevent deposits in fuel system components, particularly in injectors and valves. These additives improve fuel spray quality and enhance combustion completeness, ensuring stable engine operation.

In reducing fuel consumption, BG 44K Fuel System Cleaner is a widely used professional-grade cleaning additive [13], produced under the Liqui Moly brand (SKU: 7986, 500 ml, Germany). It is employed as a professional cleaner for optimizing the fuel system.

Antiknock (detonation-inhibiting) – additives help minimize the occurrence of engine knocking during combustion. Knocking can damage engine components and reduce their service life. Antiknock additives improve engine reliability by controlling the combustion rate. For example, metalloorganic compounds of various metals (lead, manganese, iron, chromium, etc.) can be used as antiknock agents.

The most widely used antiknock agent is tetraethyl lead (TEL), $Pb(C_2H_5)_4$, a dense, colorless, transparent liquid that dissolves well in hydrocarbons but not in water (boiling point = 200 °C, $\rho_{293} = 1652 \text{ kg/m}^3$). TEL is toxic, and proper safety precautions must be observed when handling it.

The mixture of TEL with exhaust gases is referred to as ethyl fluid, and its mixture with gasoline is called leaded gasoline. Ethyl fluid is oily, has a characteristic odor, and can be red, dark blue, or pink in color depending on the manufacturer. The amount of ethyl fluid added to automotive gasoline must not exceed 0.82 g per 1 kg of gasoline [1,2].

Anticorrosion – additives reduce the impact of fuel on metal surfaces, preventing corrosion. These additives extend the service life of fuel system components and help reduce maintenance costs. Their importance is especially high in conditions with high humidity.

Environmental Additives – environmental additives are aimed at reducing the amount of harmful exhaust emissions produced during fuel combustion. These additives limit the release of carbon monoxide (CO), hydrocarbons (HC), and nitrogen oxides (NOx) into the atmosphere. As a result, the ecological safety of the vehicle is improved, and modern environmental standards are met.

The SulNOxEco additive is an organic, biodegradable fuel-enhancing agent added to gasoline [14]. It is used to improve the combustion process, reduce harmful emissions, decrease fuel consumption, and protect the engine.

By adding additives to fuel, the following effects can be achieved. Experiments were conducted on a Chevrolet Cobalt engine on a laboratory test bench using AI-92 gasoline with the MN-9950 fuel additive to evaluate its impact (Figure 1).



Figure 1. Test bench of the Chevrolet Cobalt engine

The main objective of the experiment was to evaluate the efficiency of the fuel system, engine performance characteristics, and the amount of exhaust emissions. During the study, the engine's operating process, fuel consumption, and harmful gas emissions were monitored. The results allowed assessing the effectiveness of the MN-9950 additive in optimizing the combustion process and reducing emissions. Additionally, the laboratory tests provided an opportunity to systematically analyze the effect of the additive on the engine under various operating modes.

The addition of special fuel additives has a significant positive impact on engine performance. Firstly, stabilizing the combustion process leads to increased engine power. Additives improve the fuel's resistance to knocking and ensure uniform combustion in the cylinders. This contributes to more efficient engine operation and enhanced dynamic performance.

The use of additives also promotes complete fuel combustion, resulting in reduced fuel consumption. Cleaning and combustion-activating additives improve fuel injection and increase the proportion of energy converted into useful work, thereby enhancing the vehicle's economic efficiency.

Optimizing the combustion process reduces the amount of harmful exhaust gases produced during engine operation. Specifically, reductions in carbon monoxide (CO), unburned hydrocarbons (HC), and other toxic compounds contribute to improved environmental performance. Environmental additives further enhance the effectiveness of this process.

Additives contribute to increasing the engine's service life by maintaining the cleanliness of the engine and fuel system components and protecting them from corrosion. Wear of metal parts is reduced, and maintenance intervals are extended. This ensures the long-term reliable operation of the engine (Figure 2).

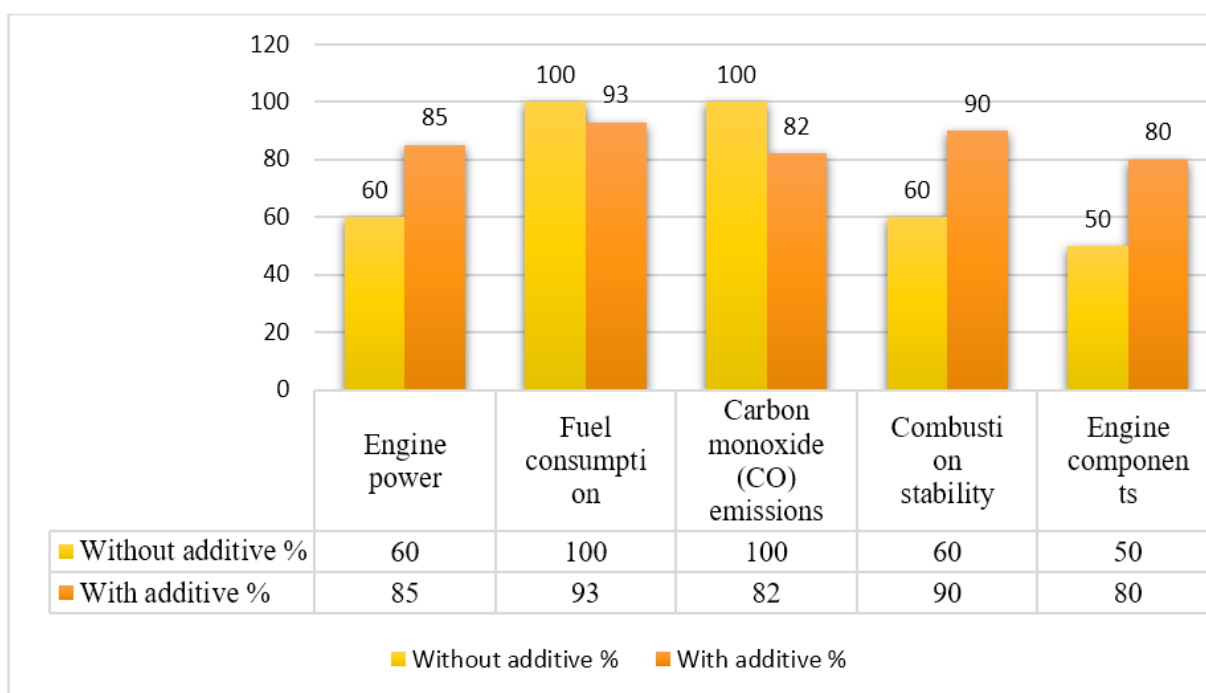


Figure 2. Performance indicators of fuels with and without additives

The following table presents the comparative analysis of engine and fuel indicators before and after the addition of additives, averaged based on scientific literature and practical observations (Table 1).

Table 1. Fuel indicators before and after the addition of additives

Indicator	Without additive	With additive
Engine power	Medium	High
Fuel consumption, %	100	93-95
CO emissions, %	100	80-85
Combustion stability	Medium	Good
Combustion stability	Medium	Good

CONCLUSIONS AND SUGGESTIONS

In conclusion, an experiment was conducted on a laboratory test bench using a Chevrolet Cobalt engine, where MN-9950 additive was added to AI-92 gasoline. The results of the study showed that the additives had a significant effect on improving engine performance, reducing fuel consumption, and decreasing the amount of exhaust emissions.

As a result, the combustion process became more stable, resistance to knocking increased, combustion in the cylinders became more uniform, and engine power improved. Additionally, the additives clean the fuel system and engine components and protect them from corrosion, which extends maintenance intervals and ensures long-term reliable engine operation. The experimental results demonstrate that the MN-9950 additive is beneficial not only technically but also environmentally, thereby enhancing the economic efficiency of the vehicle.

The analysis confirmed that the addition of special fuel additives stabilizes the combustion process in the engine, reduces the likelihood of knocking, and increases engine power. Complete fuel combustion is achieved, leading to a significant reduction in both fuel consumption and harmful exhaust emissions. Additives also protect the fuel system and engine components, contributing to an extended service life.

The findings of this study can be practically applied to improve the efficiency of automobile engines, reduce fuel consumption, and enhance environmental performance. These conclusions are also valuable for developing recommendations on vehicle operation and for assessing and improving fuel quality.

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