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IMPROVING THE OPERATIONAL EFFICIENCY OF DIESEL-POWERED GAS ENGINES THROUGH THE USE OF ENERGY-SAVING ENGINE OILS

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ANNOTATION

The article considers the possibility of increasing the operational efficiency of gas engines converted from diesel engines by using energy-saving engine oils with improved viscosity-temperature and tribological properties. The relevance of the study is related to the fact that when a diesel engine is switched to gas fuel, the combustion conditions, the thermal stress of the cylinder-piston group parts, the nature of oil aging and the mode of formation of the lubricating film change. Unlike the diesel mode, where soot is one of the main factors of oil pollution, the processes of thermal oxidation and nitration are more pronounced in gas engines. This requires not only the correct choice of the viscosity class of the oil, but also the use of additives capable of reducing friction, stabilizing the oil film and slowing down oil degradation.

A comprehensive approach to the assessment of energy-saving oils is proposed, including an analysis of kinematic viscosity, viscosity index, alkaline and acid numbers, engine temperature conditions, and tribological parameters. It is proved that for city buses running on compressed natural gas, the effectiveness of the oil should be assessed not only by reducing fuel consumption, but also by its ability to maintain protective properties in conditions of frequent starts, stops, idling and increased thermal load. The practical significance of the work lies in the possibility of applying the obtained provisions in the selection and development of engine oils for gas-powered vehicles operated in urban transport conditions.

Introduction

The modern development of motor transport is accompanied by increased requirements for the efficiency, environmental friendliness and reliability of internal combustion engines.

Despite the active introduction of electric transport, gas-fueled engines remain of practical importance for city buses, utility vehicles, and trucks. This is especially true in countries and regions where there is a well-developed compressed natural gas infrastructure and where the conversion of diesel engines to gas fuel is considered as a way to reduce smoke, reduce particulate emissions and reduce operating costs.

However, converting a diesel engine to gas fuel is not a simple substitution of one type of fuel with another. When the type of fuel changes, the very nature of the workflow changes. A diesel engine is initially designed for compression ignition, high injection pressure, a certain temperature regime, and the presence of diesel fuel combustion products. After switching to methane, the engine operates under different conditions: the combustion rate, the thermal load on the combustion chamber parts, the exhaust gas temperature and the chemical composition of the products interacting with the engine oil change.

Under these conditions, engine oil becomes one of the factors affecting not only the lubrication of parts, but also the thermal regime, mechanical losses, engine life and stability of performance indicators. If the oil is selected incorrectly, accelerated aging, a decrease in the thickness of the lubricating film, increased wear, the formation of deposits and deterioration of the temperature condition of the engine are possible.

Energy-saving engine oils are of interest because they reduce friction losses in the mating parts of the engine. In this case, the effect is achieved not only by reducing viscosity, but also by using special antifriction, anti-wear and antioxidant additives. For diesel-based gas engines, this approach should be considered cautiously: excessive viscosity reduction can reduce the hydrodynamic protection of parts, especially in high temperature and variable load conditions.

The purpose of this article is to provide a scientific justification for the use of energy-saving engine oils to improve the operational efficiency of gas engines converted from diesel engines, taking into account thermal, tribological, and physico-chemical factors.

Gas engines based on diesel engines have a number of features that must be taken into account when choosing an engine oil. The main difference is the change in the combustion process. When running on diesel fuel, incomplete combustion products, soot, sulfur compounds and other pollutants enter the oil. When running on methane, the amount of soot is usually significantly lower, but this does not mean that the oil's working conditions become easier.

The following features are characteristic of a gas engine:

- increased temperature of individual combustion chamber zones;
- a more pronounced effect of nitrogen oxides on oil;
- reduction of soot formation with simultaneous intensification of oxidation and nitration processes;
- changing the operating mode of the piston rings and cylinder sleeve;
- high proportion of engine operation at partial loads in the urban cycle;

- frequent transients, starts, stops, and idling.

The operating conditions of city buses are particularly difficult. The bus engine rarely runs in a stable mode. On the route, there are constant acceleration, deceleration, downtime at stops, traffic jams and work under variable load. Under such conditions, the lubrication system is subjected to uneven thermal stress, and the oil must maintain sufficient viscosity both during heating and during prolonged operation at elevated temperatures.

When operating on methane, the amount of solid particles decreases, but the importance of chemical aging of the oil increases. First of all, this applies to oxidation and nitration. Oxidation is associated with exposure to oxygen at high temperatures, and nitration is associated with exposure to nitrogen oxides and combustion products of gas fuels. As a result, acidic compounds, resinous products and high molecular weight components can accumulate in the oil, which worsen the viscosity properties and contribute to the formation of deposits.

Therefore, the oil for a diesel-powered gas engine must have not only sufficient bearing capacity, but also high chemical stability.

Mechanical losses in the engine are formed due to friction in the cylinder-piston group, crankshaft bearings, gas distribution mechanism, oil pump and other components. Part of the fuel's energy is spent not on useful work, but on overcoming the resistance to movement of parts. Therefore, reducing friction is one of the ways to increase the effective efficiency of the engine.

The effect of engine oil on mechanical losses can be explained through three main mechanisms:

- Reduction of hydrodynamic resistance.
- When using oil with optimal viscosity, mixing and pumping losses are reduced. This is especially noticeable at low temperatures and during engine warm-up.
- Stabilization of the lubricating film.

The oil must form a sufficient film between the friction surfaces. If the film collapses, the proportion of boundary friction increases, which leads to wear.

Antifriction and anti-wear additives can form thin films on metal surfaces. These films reduce the coefficient of friction and protect the parts from micro-scuffing.

To assess the effect of viscosity on the lubrication regime, a simplified dependence of the thickness of the oil film can be used:

$$h \sim \frac{\eta \cdot U}{P}$$

where:

h - is the nominal thickness of the lubricating film;

η - is the dynamic viscosity of the oil;

U - is the relative velocity of the surfaces;

P - is the specific load in the contact area.

From this relationship, it can be seen that reducing the viscosity reduces the resistance to movement, but at the same time can reduce the thickness of the film. Therefore, an energy-saving oil should have an optimal viscosity rather than a minimum one. This is especially important for a gas engine, since high temperatures reduce the viscosity of the oil, and the load in the area of piston rings and bearings remains significant.

The energy-saving effect of oil can be roughly estimated through a change in specific fuel consumption.:

$$\Delta G = \frac{G_0 - G_1}{G_0} \cdot 100$$

where:

ΔG - is a reduction in fuel consumption, %;

G_0 - fuel consumption when using base oil;

G_1- fuel consumption when using energy-saving oil.

However, reducing fuel consumption alone cannot be considered a sufficient criterion. If at the same time the wear increases or the aging of the oil accelerates, such an oil cannot be considered effective for long-term operation.

Materials and methods of research

To evaluate the effectiveness of energy-saving engine oil, it is proposed to use a comprehensive methodology, including laboratory, tribological and operational tests.

The gas engine of a city bus, converted from diesel and running on compressed natural gas, can be used as an object of research. Such an object is practically significant, since city buses operate in harsh conditions.: frequent stops, slow movement, prolonged idling, variable load and significant thermal stress.

Engine oil of class 15W-40 used in bus fleets can be considered as a base oil. An oil with an energy-saving additive package can be used for comparative evaluation. Boron-containing compounds, calcium stearate, zinc stearate, or other antifriction additives can be considered as promising components. It is necessary to take into account their solubility in oil, compatibility with the basic additive package, the effect on ash content and stability at elevated temperatures.

For an objective assessment of the oil condition, it is recommended to monitor the following indicators:

Indicator	**Purpose of the indicator**	**Practical significance**
Viscosity at 40 °C	Assessment of oil behavior during warm-up	Affects engine starting and the initial lubrication mode
Viscosity at 100 °C	Assessment of properties at operating temperature	Characterizes the ability to maintain the oil film
Viscosity index	Temperature stability of viscosity	Important under variable thermal load conditions

TBN	Reserve of alkaline properties	Shows the ability to neutralize acids
TAN	Accumulation of acidic products	Indicates oxidation and oil aging
Flash point	Indirect assessment of volatility and contamination	Important for oil safety and stability
Mechanical impurities	Oil contamination	Associated with wear and external contaminants
Oxidation	Thermal degradation of oil	Affects viscosity and deposit formation
Nitration	Effect of nitrogen oxides	Especially important for gas engines

Tribological tests

A four-ball friction machine can be used to evaluate the anti-wear properties of the oil. During the tests, the following parameters are determined:

- diameter of the wear spot;
- critical load;
- welding load;
- The badass index;
- oil film stability under increased load.

Comparing the base oil and the modified oil allows you to determine how much the additive affects the wear resistance. If, after adding the additive, the diameter of the wear spot decreases and the critical load increases, this indicates an improvement in the protective properties of the oil.

The operational check should be carried out on the actual bus route. To do this, it is recommended to take oil samples at certain mileage intervals.:

Sample No.	**Mileage, km**	**Purpose of analysis**
0	0	Initial condition of the oil
1	3000	Initial stage of aging
2	6000	Middle stage of operation
3	9000	Assessment of property stability
4	10000–12000	Limit condition of the oil

This procedure allows us to evaluate not only the initial properties of the oil, but also the dynamics of their changes. For dissertation research, it is especially important to analyze not just one value, but the rate of change in mileage indicators.

For example, the viscosity coefficient can be calculated using the formula:

$$K_\nu = \frac{\nu_i - \nu_0}{\nu_0} \cdot 100$$

where: K_v - change in viscosity, %;

ν_0 - the initial viscosity of the oil;

ν_i - viscosity after a certain run.

Similarly, you can calculate the change in the base number.:

$$K_{TBN} = \frac{TBN_0 - TBN_i}{TBN_0} \cdot 100$$

where:

TBN_0 - initial base number;

TBN_i - base number after use.

Expected results and their analysis

When using energy-saving oil in a gas engine, a reduction in mechanical losses, a more stable temperature regime and a slowdown in oil degradation are expected. However, these results are possible only if the additive package does not impair the protective properties of the oil.

The most likely positive changes:

Reduced friction in the mating parts.

Antifriction additives are able to reduce the resistance to movement in the zone of boundary and mixed friction. This is important for the cylinder-piston group, where the piston speed is low near the top dead center, and the load and temperature are high.

Reduction of heat generation from friction.

If the coefficient of friction decreases, some of the mechanical energy is less converted into heat. This can help reduce the local temperature of the oil and parts.

Stabilization of viscous properties.

Antioxidant components can slow down the increase in viscosity associated with oxidation and the formation of high molecular weight products.

Reducing the intensity of wear.

Anti-wear additives form protective layers on the metal surface, which is especially important under high loads and variable temperatures.

For clarity, the expected changes can be presented as follows:

Indicator	**Base oil**	**Oil with energy-saving additive**	**Expected effect**
Coefficient of friction	Higher	Lower	Reduction of mechanical losses
Oil temperature	Higher under load	More stable	Improvement of thermal regime
Viscosity after mileage	May change noticeably	Changes more slowly	Increased stability
TBN	Decreases faster	Decreases more slowly	Preservation of neutralizing ability
TAN	Increases faster	Increases more slowly	Slower acid accumulation
Wear scar diameter	Larger	Smaller	Improved anti-wear properties

Discussion of practical significance

For bus fleets, the use of energy-efficient motor oils may have several practical advantages. Firstly, it is possible to reduce the consumption of gas fuel. Even a small reduction in consumption per bus with an annual mileage gives a noticeable economic effect when scaled to the entire fleet.

Secondly, the stabilization of the temperature regime can positively affect the life of the engine. In urban traffic conditions, the engine operates in an unstable thermal mode, and reducing local overheating can reduce the rate of oil aging.

Thirdly, an increase in oil stability makes it possible to more accurately determine the rational maintenance interval. At the same time, the prolongation of the oil's service life should be performed only on the basis of an analysis of its actual condition. The replacement interval should not be extended only at the request of the additive or oil manufacturer. It is necessary to control viscosity, TBN, TAN, mechanical impurities, oxidation and nitration.

For the conditions of Uzbekistan, this problem is of additional importance. In summer, the high ambient temperature increases the thermal stress on the engine and the lubrication system. Therefore, the oil must retain its protective properties not only in standard laboratory conditions, but also during actual operation in hot climates, urban traffic jams and dusty environments.

Scientific novelty

The scientific novelty of the proposed approach is as follows:

The necessity of evaluating engine oils for diesel-based gas engines is substantiated, taking into account not only the viscosity, but also the processes of oxidation, nitration and changes in the thermal regime of the engine.

A comprehensive criterion for evaluating energy-saving oil is proposed, including physico-chemical, tribological and operational parameters.

It is shown that for urban gas buses, the energy-saving effect of oil should be considered together with the preservation of anti-wear properties and stability of the oil film.

A methodological basis has been formed for the comparative evaluation of base oil and oil with antifriction additives under compressed natural gas operating conditions.

Conclusions

Gas engines converted from diesel engines operate under specific conditions that differ from the classic diesel mode. They are characterized by a decrease in soot formation, but an increase in the importance of thermal oxidative aging and nitration of engine oil.

Energy-saving engine oils can reduce engine mechanical losses by optimizing viscosity and applying antifriction additives. However, the reduction in viscosity should be limited by the requirements for the bearing capacity of the oil film.

To objectively evaluate the effectiveness of the oil, it is necessary to use a set of indicators: viscosity at 40 °C and 100 °C, viscosity index, TBN, TAN, oxidation, nitration, oil temperature and tribological characteristics.

The most reliable assessment is possible with a combination of laboratory tests, a four-ball method and operational tests on buses with oil sampling every 3,000 km.

For urban transport conditions in Uzbekistan, the use of energy-saving oils is of practical interest, but requires experimental confirmation on real routes and taking into account climatic factors.

List of literature

1. Heywood J. B. Internal Combustion Engine Fundamentals. McGraw-Hill, 1988.
2. Taylor C. M. Automobile engine tribology — design considerations for efficiency and durability. *Wear*, 1998.
3. Tung S. C., McMillan M. L. Automotive tribology overview of current advances and challenges for the future. *Tribology International*, 2004.
4. Holmberg K., Erdemir A. Influence of tribology on global energy consumption, costs and emissions. *Friction*, 2017.
5. Besser C., Agocs A., Ristic A., Frauscher M. Implementation of nitration processes in artificial ageing for closer-to-reality simulation of engine oil degradation. *Lubricants*, 2022.
6. SAE J300. Engine Oil Viscosity Classification. SAE International.
7. ASTM D445. Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids.
8. ASTM D2896. Standard Test Method for Base Number of Petroleum Products by Potentiometric Perchloric Acid Titration.
9. ASTM D664. Standard Test Method for Acid Number of Petroleum Products by Potentiometric Titration.
10. ASTM D4172. Standard Test Method for Wear Preventive Characteristics of Lubricating Fluid.