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RESULTS OF A STUDY OF THE INFLUENCE OF CHANGES IN OILS CHARACTERISTICS ON WEAR OF DIESEL AND GAS ENGINE CYLINDER LINERS

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Abstract: Research on changes in the characteristics of oil in diesel and gas engines based on diesel. During the research, the laws of lubrication theory, methods of planning experiments and mathematical statistics, as well as methods based on existing regulatory documents were used. When processing experimental data, processing methods using Microsoft Office Excel application packages were used. The alkaline number in samples of used oils varies from 2.24 to 1.4, which indicates the emergency condition of the used oil. The results of analyzes of the alkaline number of the studied motor oils show that when the engine is running on gaseous fuel it decreased on average from 6.0 to 2.24 mg KOH/g, and when running on diesel fuel from 6.0 to 1.4 mg KOH/g g i.e. below the permissible level. According to the research results, we can say that in gas diesel engines, the content of mechanical impurities is less compared to diesel, the alkalinity after operation of 500 engine hours is closer to the maximum value of 2.24, the oil viscosity decreases insignificantly and after 500 engine hours is 9.3 mm^2 /s, the oil service life increases by an average of 25%; in diesel engines, one of the main oil indicators, alkalinity and kinematic viscosity, are below acceptable values.

Keywords: engine, pollution, concentration, oil, reliability, additive, product, wear.

Introduction. When operating a diesel engine, compared to a gas-diesel engine, the main oil indicators such as viscosity, density, mechanical impurities, high- and low-temperature characteristics, chemical characteristics such as base number have lower limit values, and the oil service life can be considered 1.5 times higher when operating at gaseous fuel.

Motor oils are considered an important non-structural element in ensuring engine reliability. In the lubrication system of diesel and gas engines, qualitative and quantitative changes occur in motor oils. The quality of lubricating oil is assessed by its physical, chemical and operational characteristics. Meeting the performance requirements for motor oils is achieved by selecting the optimal composition of the base oil and using a set of functional additives.

Quantitative changes occur due to waste in the cylinder-piston group and due to a violation of the tightness of the lubrication system.

Qualitative changes are summarized from many chemical and physical processes occurring in the oil system, such as pollution by dust from the atmosphere, wear products, solid, liquid and gaseous particles formed during fuel combustion and due to the formation of substances from hydrocarbons of the base oil and additives as a result their chemical and physicochemical transformations. As a result, such profound qualitative changes may occur that the oil will become unsuitable for further provision of reliable engine lubrication and will need to be replaced with fresh one [1-2].

Materials and methods. Purpose of the study: Research on changes in the characteristics of oil in diesel and gas engines based on diesel and the effect on cylinder liner wear.

During the research, literature data on changes in the characteristics of oils and methods for studying changes in the characteristics of oils and the nature of wear of the cylinder liners of diesel engines and gas engines based on diesel were analyzed.

Ensuring the reliability and durability of internal combustion engines is an important task in the vehicle operating industry.

A number of researchers, based on the design features and operating modes of diesel engines, suggest four main zones of oil oxidation [1,4-6].

Oils in the lubrication system are affected by temperature differences. When operating diesel engines and gas diesel engines, the presence of oil in the engine can be conditionally divided into the following zones: the crankcase space zone - the crankcase space of the engine - where the oil, depending on the operating mode of the engine, is influenced by different temperature conditions.

The thermal load of the engine and the temperature of hot gases intensively influence the oxidation of oil; this process occurs in the annular zone of the pistons. The operating conditions are harsh in the working surface of the cylinder in the piston stroke zone, in this zone the oil is subject to thermal decomposition and high oxidation intensity. In this zone, the oil is heated under the influence of hot gases, the temperature of the oil is heated to 300... 3500 C to a depth of 1...3 microns [1,2,4].

Determined: when heating the oil in an open crucible according to GOST 4333 and when heating the oil in a closed crucible - according to GOST 6356. In laboratory conditions, the oil temperature was determined when operating on standard diesel and gaseous fuel.

When operating engines at low ambient temperatures, along with the viscosity-temperature characteristics of the oil, its pour point is also important, i.e. the temperature at which, under experimental conditions, the oil thickens so much that when the test tube with it is tilted at an angle of 450, the oil level remains motionless for 1 minute.

The pour point of motor oil can change significantly depending on how the analysis is carried out.

Pour point (pour point) is the temperature at which the oil loses its mobility and passes from a liquid to a plastic state (GOOST 20287-2000).

During engine operation, solid carbonaceous substances in the oil are deposited on the surface of the combustion chamber and on the surface of the piston. Substances called carbon deposits form on the surface of the piston in the area of the upper compression ring, on the grooves, valves and injector. Carbon deposits are formed as a result of floor combustion of fuel, as well as as a result of oil decomposition. In addition, a thin film, the so-called varnish, forms on the surface of the parts. Varnish forms on the piston, the rings and piston skirt, and the inside of the piston. As given in the literature, almost 50% of deposits consist of soot and varnish.

As is known from studies by other authors, the oil temperature in the crankcase space should be in the range of 80-100 0 C, in the bearing area 150-1700 C, and the bushing has an oil temperature of 150-300 0 C.

Zones of the cylinder in different planes contribute to the heating of the engine oil, as a result of which temperature changes affect changes in the characteristics of the oil. The change in cylinder oil temperature depends on the thermal stress of the engine and operating mode.

One of the main ways to reduce increased wear and carbon formation in engines is the addition of additives to the engine oil that can neutralize the corrosive and carbon-forming effects of sulfur combustion products, i.e. with high antioxidant and detergent properties [5-6].

The thermal intensity of the engine can be denoted by – q, the amount of heat Q, the surface of the cylinder wall F. The thermal intensity is characterized by the amount of heat per hour on the surface of the cylinder [6].

$$q = \frac{Q}{F} \quad ккал/м^2 \qquad (1)$$

To compare the thermal stress of diesel and gas engines, you can use the formula:

$$K_f = P_e C_m Z \qquad (2)$$

where: P_e- average effective pressure in кГ/см^3

C_m- average piston speed in m/sec

Z- engine stroke ratio

The process of formation of such deposits can be observed using a microscope or optical instruments. The resulting deposits in the cylinder contribute to the aging of the oil, in turn to increased wear on the surface of the parts of the cylinder-piston group.

Wear details of the cylinder-piston group depend on acceleration and load modes. Thus, the average wear rate at idle speed is 6.2...9.9 times less than at maximum load.

At the maximum speed mode and load, the concentration of iron (Fe) in the composition of engine oil running on standard fuel increased from $1.1 \bullet 10^{-4}$ to $7.8 \bullet 10^{-4}$ g/hour, which is 8-12% more, than when working on conventional fuel.

When operating diesel engines, cylinder liners are exposed to high temperature and pressure, as a result of which microroughness appears on the working surface under the influence of tribomechanical and tribotechnical influences. To determine the amount of wear on the working surface of engine cylinder liners, linear and weight methods, as well as the micrometer method, are widely used.

Wear of the cylinder liner occurs in its working surface. As a result of wear, the diameter of the working surface increases and the shape of the surface is disrupted. The inner surface of the sleeve loses its taper along its length and its ovality along its circumference.

The amount of wear is greater than the upper part of the liner due to greater contact with the upper compression rings. When the fuel in the upper part of the cartridge burns, the temperature and pressure of the gases increases. Combustible gases penetrating under the piston rings contribute to an increase in ring pressure on the working surface of the liner[7-12].

As practice shows, the use of sulfur fuel increases wear. When operating engines, oil selection is an important factor. Engine oils are selected based on operating conditions.

When operating diesel and gas engines, compliance with maintenance regulations is required. During maintenance, the engine oil and filter are replaced.

Motor oil is a non-structural element of an internal combustion engine. The amount of wear on engine parts largely depends on the quality of the oil. Therefore, the main indicators characterizing the quality of the oil must correspond to standard values [13-20].

Oil is mainly consumed due to waste and leakage of the lubrication system. More viscous oils make it difficult to start the engine. As we know from the literature, more wear and tear on engine parts occurs during the startup process. When operating engines in different types of fuel, attention must be paid to the combination of one or another brand of oil. In gas engines, unlike diesel engines, it is necessary to use special oils.

The anti-wear properties of oils are assessed during bench tests on single-cylinder and multi-cylinder engines. However, as a result of these tests, it is difficult to obtain reliable information on the anti-wear properties of oils - as a rule, the required accuracy in the convergence and reproducibility of parallel experiments is not achieved.

To obtain more reliable data, the anti-wear properties of oils are assessed sequentially (control, experimental, control oil), without disassembling the engine. In this case, the dynamics of wear of parts is determined by the metal content in the oil using one of the common methods of chemical analysis, radioactive isotopes, and spectral analysis.

The viscosity-temperature dependence of the oil is assessed by the viscosity index. The slower the viscosity increases with decreasing temperature, the higher the viscosity index. This property plays an important role when starting engines at low temperatures, when, due to the high viscosity of the oil, its supply to the friction units is delayed, pumping through the lubrication system is difficult, and thus conditions are created for oil starvation of bearings and other friction units. Therefore, starting wear is very significant. The flat viscosity-temperature dependence becomes especially important when operating engines in winter [2].

Oil contamination is generally characterized by mechanical impurities.

Fresh motor oils contain mechanical impurities in an amount of no more than 0.015-0.02%. Their content is determined according to GOST 6370-2000 by filtering a sample of oil diluted with gasoline. The sediment on the filter paper is washed with gasoline, dried, weighed, and impurities are expressed as a percentage.

It is known that with a carefully selected combination of detergent-dispersant additives in motor oils, it is possible to achieve a less intense alkalinity response of these additives; in particular, the use of ashless dispersants in motor oils, along with metal-containing detergent additives, which have an effective solubilizing effect, can significantly reduce response rate of alkaline additives (Figure 1.) [2].

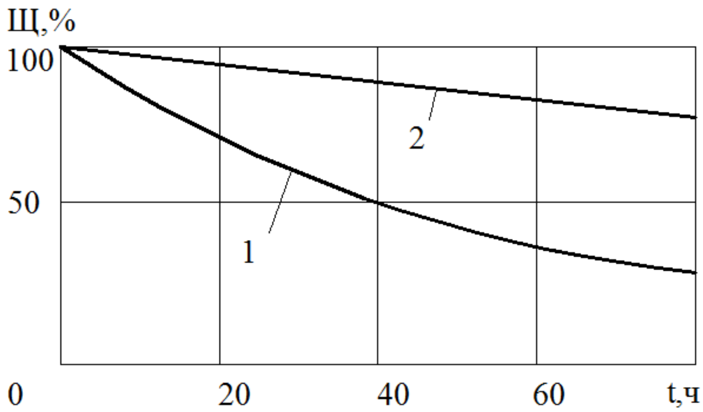

Fig. 1. Effect of additives on the change in alkalinity of oil running in a single-cylinder diesel engine using high-sulfur fuel.

1-Oil with a metal-containing detergent additive; 2-Oil with a metal-containing detergent additive and ashless dispersant.

To neutralize oil oxidation products and sulfur oxides formed during the combustion of sulfur-containing fuels, modern motor oils have a certain reserve of alkalinity imparted to them by sulfate, alkyl salicylate and other additives.

Based on the alkaline number of motor oils, their group can be determined with sufficient accuracy. The base number is determined by potentiometric titration according to GOST 11362-2000. The total number is taken to be the amount of potassium hydroxide in milligrams, equivalent to the amount of hydrochloric acid consumed to neutralize all the main compounds contained in 1 g of the analyzed oil.

The flash point characterizes the flammability of the oil and indicates the presence of flammable fractions in it, but does not give an idea of their quantity. Between the flash point and volatility, oils obtained from the same raw material with a similar fractional composition are observed; in other cases this dependence is violated.

The flash point is determined to control the quality of produced oils at oil refineries, as well as to determine the presence of fuel in the oil supplied during engine operation.

To determine the flash point, there are two types of devices - with an open and closed crucible. In a Brinken apparatus with an open crucible, the flash point of oils is 20-250 higher than in a Martens-Pensky apparatus with a closed crucible.

When operating engines at low ambient temperatures, along with the viscosity-temperature characteristics of the oil, its pour point is also important, i.e. the temperature at which, under experimental conditions, the oil thickens so much that when the test tube with it is tilted at an angle of 450, the oil level remains motionless for 1 minute.

Results. Experimental assessment of changes in the basic properties of motor oils under operating conditions was carried out using standard research methods. Oil viscosity is one of the main characteristics of oil associated with wear. The use of more viscous oils, as a rule, entails reduced engine wear and reduced oil consumption due to waste. Oil consumption is the main indicator characterizing the amount of wear. The kinematic viscosity of the oil in laboratory conditions was determined using a viscometer at 1000 C. After a given operating time, the viscosities of diesel and gas engine oils were determined from the samples obtained in quantities for control.

Based on research results, it is known that the viscosity of gas engine oil remains within standard values compared to diesel oil.

It has been established that the content of mechanical impurities in samples of engine oil running on gaseous fuel is less than in samples of engine oil running on diesel fuel. The wear pattern of gas engine liners differs from diesel liners.

Oil contamination products can be divided into several products: mechanical impurities coming from outside, organic and inorganic products in the oil, wear products, soluble and insoluble impurities. Cleaning units in the lubrication system mainly retain insoluble impurities, partially bound and remove soluble oxidation products. In laboratory conditions, the content of wear products was determined by elemental composition.

Oil alkalinity is characterized by the neutralization of acidic oxidation products. In diesel engines, due to the higher concentration of oil contamination, the alkalinity is lower than in gas engines. As the results of the study show, the alkalinity of diesel oil at a given operating time turned out to be less than the limit value, and the alkalinity of the oil of a gas engine based on a diesel engine was closer to the limit value of 2.24 mgKOH/g, and oil refreshment is required by topping up or introducing additives into the oil.

The base number of gas engine oil is also 1.5 times higher than in the oil sample running on diesel fuel.

Table 1. Physico-chemical indicators of used diesel engine oils.

Operating, time moto-h	Characteristics of oils					
	Kinematic viscosity, at 100^0 C.	Oil alkalinity mgKOH/g	Content of mechanical impurities,%	Oil density, kg/cm^3	Flash point, ^{0} C	Pour point, ^{0} C
0	11	6	0,015	892	240	-18
100	9,4	4.0	0,019	886	237	-18
240	8,9	3.2	0,023	879	233	-17
360	7.6	2.4	0,026	878	231	-16
480	7,2	1,57	0,032	876	230	-16

Table 2. Physico-chemical indicators of used gas engine oils

Operating, time moto-h	Characteristics of oils					
	Kinematic viscosity, at 100^0 C.	Oil alkalinity mgKOH/g	Content of mechanical impurities,%	Oil density, kg/cm^3	Flash point, ^{0} C	Pour point, ^{0} C
0	11	6	0,015	892	240	-18
100	10	4.2	0,019	886	237	-18
240	9.7	3.4	0,023	883	235	-17
360	9.6	2.5	0,026	881	233	-16
480	9,2	2.2	0,032	879	233	-16

Based on the results of laboratory tests, the density of oil was determined for engines running on diesel and gaseous fuel. The analysis results show that the density of gas engine oil remains almost unchanged, and the density of diesel oil within 300-500 hours of operation decreases from 0.892 to 0.845.

Conclusion. Wear of the cylinder liner occurs in its working surface. As a result of wear, the diameter of the working surface increases and the shape of the surface is disrupted. In some areas the cylindrical shape becomes oval. On the inner surface of the sleeve there is a violation of taper along the length, and ovality along the circumference.

The amount of wear is closely related to the quality of the lubricating oil. In our case, the oil quality indicators seemed to be less than the maximum. To reduce the amount of wear, it is recommended to add fresh oil or improve the lubricating, anti-wear conditions of the oil by introducing stabilizers.

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CONTENTS