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CALCULATION OF OIL CHANGE INTERVALS IN DIESEL-BASED GAS ENGINES

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Abstract: Ensuring the reliability of internal combustion engines during operation requires a comprehensive approach, addressed in various areas. Addressing these issues is a pressing, complex task. The main factors include operating conditions, the type of fuel used, monitoring engine oil performance, and developing validated service life estimates. In maintaining the performance properties of engine oils, monitoring the key characteristics of the oil and justifying replacement intervals is essential. It consists of a theoretical assessment of the estimated service life of M10G2 oil for diesel-based gas engines. Application of theoretical equations to assess changes in the performance properties of oils and estimate the expected service life of gas engine oils. The increase in the frequency of replacement of motor oils of gas engines is interconnected with the frequency of technical. There is a tendency in global practice that when engines operate on gaseous fuel, the quality reserve is maintained when changing oils. However, there is no clear hypothesis as to exactly how many engine hours a tractor has to operate or how many kilometers of mileage constitute a rational oil change interval. In literary sources there is data on the preservation of the physical, chemical and operational properties of oils closer to the limit values. During the research, the laws of lubrication theory, theoretical methods for assessing the condition of the oil, as well as methods based on existing regulatory documents were used.

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

Introduction. The decrease in natural oil resources and the increasing demand for it in energy facilities leads to a decrease and increase in the price of standard liquid fuel used in internal combustion engines. The increase in the frequency of oil changes for gas engines is related to the frequency of maintenance. There is a tendency in global practice that when engines operate on gaseous fuel, the quality reserve is maintained when changing oils. However, there is no clear hypothesis as to exactly how many engine hours a tractor has to operate or how many kilometers of mileage constitute a rational oil change interval. Literary sources contain data on the preservation of the physical, chemical and operational properties of gas engine oil based on diesel fuel closer to the limit values when replaced within the specified timeframes. Gaseous fuels have a number of well-known advantages over liquid fuels.

The frequency of oil changes refers to the change in oil parameters depending on the operating time. When establishing the frequency of oil changes, it is advisable to take into account the trouble-free operation of the engine.

Motor oil, as a non-structural element, must ensure trouble-free operation of the engine within the specified operating time.

To assess the service life of oil, the study adopted the oil contamination index. The frequency of oil change for a gas engine based on a diesel engine must be established taking into account the limiting conditions of the indicators.

Methods. The frequency of oil changes in gas engines depends on many factors. The most important of these is engine oil aging. Oil aging is a complex, still poorly understood set of physical and chemical processes, the speed of which is influenced by a large

number of different factors. It should be noted that these processes are closely related to each other, and absolute differentiation of one from the other is often impossible [1,2]. However, to study the basic patterns of oil aging in diesel engines, and in particular to study quantitative, i.e. mathematical dependencies, it is advisable to break them down into simpler processes, although this requires some conditional assumptions [3,4].

The suitability of oil is assessed based on operational and physicochemical properties such as kinematic viscosity, insoluble impurity content, contaminant content, flash point, water content, alkaline and acid numbers, fuel fraction content, and wear metal and silicon content. The performance of a gas engine oil, based on a diesel engine, is also affected by the amount of oil burnt.

Results. To bring theoretical dependencies closer to actual patterns, it is necessary to take into account the two-stage nature of the oil aging process. In this case, the best approximation is provided by the following expression:

$$\varepsilon = Ath(kt) \quad (1)$$

where: ε - is the concentration of mechanical impurities in the oil without the influence of cleaning agents, A - is the maximum concentration to which increasing values of E asymptotically tend,

k - is the coefficient characterizing the kinetics of the process.

The accumulation of impurities in the actual process is influenced by the means of oil purification: centrifuges and filters.

In accordance with the accepted assumptions, impurities continuously enter a container containing Q units of oil, forming a concentration in the oil equal to

$$\varepsilon = Ath(kt) \quad (2)$$

Mathematical models currently used to determine the timing of oil changes in power units vary greatly in both type and other characteristics: the accuracy of the mathematical models and parameters used, the degree of complexity, etc.

Analyzing existing mathematical models for determining the oil change period, it can be concluded that no model takes into account the influence of the relationship between energy costs for the performance of transport work, the individual characteristics of the power unit and the quality of the oil on the nature of the change in its rejection indicators.

The service life of engine oil depends on the degree of oil refreshment, i.e., it is closely related to oil top-up and its consumption due to oil burnout. Let's consider the theoretical dependence of the service life of diesel oil (based on its content of insoluble impurities x) on the rate of oil consumption due to oil burnout with a top-up equal to the oil burnout.

$$(Q_o = Q_y). \quad (3)$$

The service life of the oil under these conditions can be determined by the expression:

$$\tau = \frac{G}{Q_y} \ln \frac{A}{A - x_{def}}, \quad (4)$$

With continuous operation of the oil, i.e., at the $\tau = \infty$ maximum content of impurities will be

$$x_{def} = A = \frac{100a}{Q_y} \quad (5)$$

Hence, the oil consumption for burning, which ensures sufficient refreshment of the oil for its continuous operation

$$Q_y = \frac{100a}{x_{def}} \quad (6)$$

According to [3] and others, for diesel engines the pollution rate is $a = 0.01-0.06$ g/hp.h. However, when the engine is running with smoky exhaust, the pollution rate can increase to

$$a = 0.02-0.03 \text{ g/hp.h. [3-7, 8-12].}$$

The study of the patterns of oil contamination in engines has been the subject of a number of studies [3].

One of the first studies in this area was conducted by Z.M. Minkin [3,13-17]. The relationship between the possible contaminant content in oil, the rate of contamination, the oil system parameters, and the diesel engine operating time is shown below, based on the work of G.A. Morozov [3,18-20].

If the impurity content is expressed in %, then the formula will look like [3]:

$$x = \frac{100a}{Q_y} \left(1 - e^{-\frac{Q_y \tau}{G}}\right) \quad (7)$$

The actual rate of contaminant penetration directly into the oil will be, and (1- f). Then formula (1) will take the form [7,8,9,11,12]:

$$x = \frac{100a(1-f)}{Q_y} \left(1 - e^{-\frac{Q_y \tau}{G}}\right) \quad (8)$$

In addition to the formulas discussed above, a number of researchers have proposed other expressions for the dependence of the contaminant content in oil on the engine operating time and oil exchange conditions.

For example, [3] proposed a simplified formula for determining the concentration of pollution:

$$x = \frac{a\tau}{G + Q_y \cdot \tau} \quad (9)$$

When calculating the concentration of oil contamination, the results of calculations of changes in the concentration of contamination depending on the duration of oil operation were used.

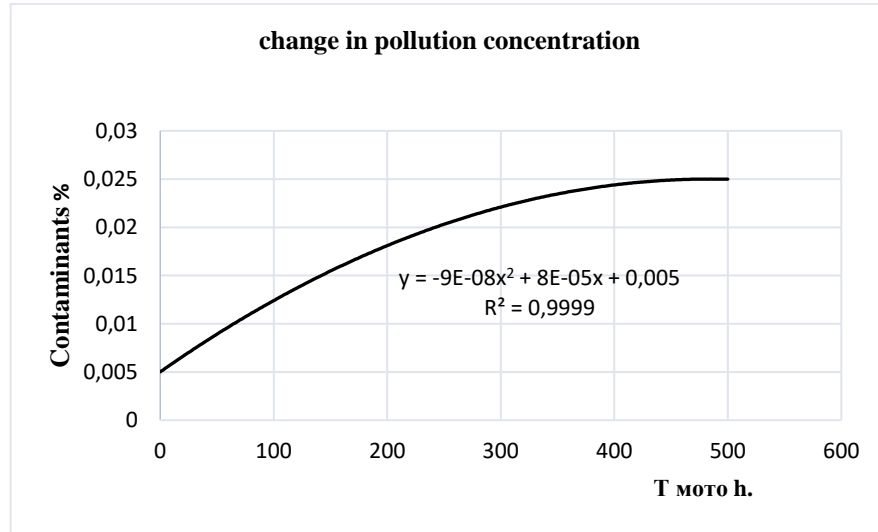


Fig. 1. Graphic dependence of the change in the concentration of contaminants on the duration of oil operation

To calculate the life of oil in the lubrication system of a gas engine, one can use the theoretical formulas proposed by S.V. Wenzel [1].

Let us assume that after time t the amount of impurities is equal to x units then $x = \varepsilon \cdot v(t) - gt$

where: v is the variable volume of oil in the system; the amount of impurities can be expressed differently:

$$x = E \cdot v(t) \tag{10}$$

where: E is the concentration of impurities taking into account cleaning agents.

By equating the right-hand sides and determining the rate of accumulation of impurities, we obtain:

$$\frac{dx}{dt} = \frac{dE}{dt} v + E \frac{dv}{dt} = \frac{d\varepsilon}{dt} v + \varepsilon \frac{dv}{dt} - g \tag{11}$$

let's denote $E - \varepsilon = \varphi$

Then
$$\frac{d\varphi}{dt} = \frac{dE}{dt} - \frac{d\varepsilon}{dt} \tag{12}$$

hence :

$$v \frac{d\varphi}{dt} + \varphi \frac{dv}{dt} = -g \tag{13}$$

decreasing amount of oil in the system:

$$v = Q - dt \text{ and } \frac{dv}{dt} = -g \tag{14}$$

Then:
$$(Q - qt) \frac{d\varphi}{dt} - q\varphi = -g \quad (15)$$

The general integral of the resulting first-order differential equation will be:

$$E = Ath(kt) + \frac{c - gt}{Q - qt} \quad (16)$$

We set the boundary condition

$$E = 0; \text{ Then } c = 0;$$

finally

$$E = Ath(kt) - \frac{gt}{Q - qt} \quad (17)$$

Discussion: Thus, when operating gas engines based on diesel, the oil change period increases on average about three times relative to liquid fuel.

When assessing the timing of oil changes in gas and diesel engines, factors influencing changes in the physicochemical and operational properties of oils should be taken into account. When determining service life, important parameters include oil contamination products, viscosity, alkalinity, density, flash point and water content. A decrease in viscosity leads to wear of the cylinder-piston group parts.

Oil burnout affects the condition of engine parts; oil burnout, depending on the engine's thermal stress, affects the engine's operation and main performance indicators.

Conclusions. A reliable assessment of the rational service life of oil in diesel-based gas engines is made based on the results of operational tests. In this case, the physical and chemical parameters of the oil are assessed using laboratory analysis and tests are carried out to determine the impact of oil service life on the main characteristics of the engine.

Theoretical studies have established a relationship between oil parameters such as the content of contaminants and oil consumption with the frequency of oil changes.

The frequency of oil changes is determined based on the results of analyses of the physical and chemical parameters and the oil content in the lubrication system, taking into account the technical condition of the engine.

One of the ways to save on motor oils is to increase the intervals between their replacement, while at the same time reducing labor costs for engine maintenance. The frequency of oil changes is related to the operating conditions of gas engines. The motor oils and fuel used met the requirements of the standards. The extension of the oil change interval must be determined based on the operating time, and the actual quality of the oil must be taken into account.

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