EFFECT OF ACTIVATION OF ALKALINE ADDITIVES IN OILS FOR WEAR OF ENGINE PARTS

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https://doi.org/10.5281/zenodo.7553274

Annotation: The article analyzes the effect of the actuation of engine oil additives on the process of wear of the cylinder piston group of the engine.
Reducing the effectiveness of additives, reducing the neutralizing ability (alkaline number) up to a critical value for working conditions, they are accompanied by a multiple acceleration of the formation of deposits on engine parts, oil filter elements, and a sharp acceleration of wear of cylinder-piston group parts. During the operation of additives, the oil loses the properties that are given to it by these additives.
Keywords: engine oils, additives, viscosity, temperature, wear of parts, engine, hydrocarbons, additive actuation, oil consumption.

Introduction.

During operation, the composition of motor oils becomes more complicated due to the oxidation products of thermal or thermochemical decomposition of hydrocarbons and additives. These products enter into physical and chemical interactions with each other and with pollutants coming from outside.

Reduction of the effectiveness of detergents-dispersants, reduction of neutralizing ability (alkaline number) to a critical value, they are accompanied by a multiple acceleration of the formation of deposits on diesel engine parts and a sharp acceleration of the wear of parts of the cylinder piston group and other components. These negative phenomena, which reduce the resource and operational reliability of diesel engines, are primarily associated with the accumulation of neutralizable strong acids in the oil, oxy–acids - oil oxidation products that determine oil contamination.

When the detergent-dispersing additives are triggered, the content of mechanical impurities in the oil increases. At the same time, the pollution particles are enlarged. A decrease in the effectiveness of dispersants is accompanied by an acceleration of the formation of deposits on diesel engine parts, oil filter elements, a sharp acceleration of the wear of parts of the cylinder piston group and other components.

In engine parts running on oil with a neutralizing additive that has worked, wear increases, violation of the mobility of piston rings and carbon formation, as well as wear increases on pistons in proportion to the concentration of strong acids.

When the engine is running on a constant mode, the rate of depletion of the alkalinity of the oil is proportional to the fuel consumption and the sulfur content in it. Factors contributing to the condensation of acids from combustion products and the contact of condensate with an oil film on the parts of the cylinder-piston group accelerate the actuation of alkaline additives. In the high temperature zone of the engine, hydrocarbons and other components of oils are oxidized and form poorly evaporating, highly viscous, practically

IBAST | Volume 3, Issue 1, January

insoluble in oil oxy-acids, asphaltenes and acid resins, which are deposited on the parts in the form of a thin shiny layer called a varnish deposit.

With an increase in the temperature of the oil film on the cylinder wall and in the piston ring zone, the proportion of alkaline additives consumed to neutralize acids formed from fuel combustion products decreases markedly, but the consumption of alkaline additives to neutralize acids formed as a result of high-temperature oxidation of oil increases. At the same time, engine oil consumption increases significantly, wear increases, even bullying on cylinder mirrors and piston rings breakage with piston jamming are possible. The indicator of the antioxidant properties of motor oils is the alkaline number, which can vary from 5-10 mg KOH/g. When establishing the service life of oil in engines, so-called rejection indicators are used, when reaching the maximum permissible values of which it is necessary to replace the oil. Rejection indicators are usually: changes in viscosity, flash point, alkalinity, the content of contaminants, water.

Research analysis.

The developed mathematical models of the operation of alkaline additives in oil during engine operation allow predicting the quality of additives for their operation and the service life of the oil before replacement.

Operation of alkaline additives when the engine is running at a constant mode, the rate of depletion of the alkalinity of the oil is proportional to fuel consumption and sulfur content in it. The proportionality coefficient significantly depends on a number of design and operational factors. All factors contributing to the condensation of acids from combustion products and the contact of condensate with the oil film on the parts of the cylinder piston group accelerate the actuation of alkaline additives. To the greatest extent, this process is negatively affected by the operation of the engine at low loads and at low coolant temperature. With an increase in the temperature of the oil film on the cylinder wall and in the piston ring zone, the proportion of alkaline additives consumed to neutralize acids formed from fuel combustion products decreases markedly, but the consumption of alkaline additives to neutralize acids formed as a result of high-temperature oxidation of oil increases.

It is known that the normal oil consumption of G_{oil} is directly proportional to the fuel consumption of G_f:

$G_{oil} = k \cdot G_f$,

where: k is the standard coefficient of oil consumption

(for gasoline engines k = 0.024; for four-stroke diesels k= 0.032).

Then the relative speed of the additive in the engine oil will be equal to:

$$V = \frac{dG_{np}}{dtG_{np}} = \frac{dC'G_{м}}{dtC'G_{м}} = \frac{dC'}{dtC'} \qquad (1)$$

where: G_{add} – the amount of additive in the oil;

t – the duration of oil operation in the engine;

C – the concentration of the additive in the oil in relative units;

G_{oil} – the amount of oil in the engine.

If each unit of oil volume is exposed to the same effect of some factor that causes the additive to trigger in the engine oil: V = const, then with an increase in the amount of oil in the engine, the relative speed of the additive in the oil should decrease, and the absolute speed should increase. When changing the amount of oil in the engine, the following equality takes place:

$$\frac{V_1}{V_2} = \frac{G^z_{oil_2}}{G^z_{oil_1}},$$

Let's make a balance of the amount of additive in the oil for a small time interval dt :

$$dq' = dq'_1 - (dq'_2 + dq'_3), \qquad (2)$$

where:

dq' – the change in the absolute amount of additive in the oil during dt;

dq'_1 – the amount of additive, respectively received in the oil,

dq'_2 – the amount of additive, triggered in the oil,

dq'_3 – the amount of additive left with burnt oil during dt.

If the amount of oil in the engine does not change, Then: $Q_s = Q_r,$

where: Q_s – oil topping speed; Q_r – the rate of oil burn.

Therefore,

$$dq = dCG_м,\ dq_1 = C_0 Q_s dt,\ dq_2 = \overline{V} C' G_м^{1-Z} dt,\ dq_3 = C' Q_r dt,$$

where: C₀ is the initial concentration of the additive in the oil.

Substituting the values of the terms into equation (2) after the transformations, we obtain a linear differential equation of the additive balance in oil:

$$\frac{dC'}{dt} + C'\frac{(\overline{V} G^{1-Z}_{oil} + Q_r)}{G_{oil}} - \frac{C'_0 Q_s}{G_{oil}} = 0 \qquad (3)$$

Integrating this equation, we get:

$$C' = C'_0 e - \frac{\left(\overline{V} C^{1-Z}_{oil} + Q_r\right)}{G_{oil}} + \frac{C'_0 Q_s}{\overline{V} G^{1-Z}_{oil} + Q_r}\left(1 - e - \frac{\left(\overline{V} G_м^{1-Z} + Q_r\right)}{G_{oil}}\right) \qquad (4)$$

It follows from equations (4) that the concentration of the additive in the oil changes over the engine operation time without topping up the oil more intensively than with topping up, at t =∞ reaches zero.

With an increase in the amount of oil in the engine, i.e. with an increase in the amount of oil in the lubrication system and topping up the oil instead of the burnt one, the additive concentration decreases less intensively in time t, but up to a certain limit. Then the additive concentration in the oil decreases more intensively.

To ensure the operation of the engine oil without replacement, it is necessary that the maximum concentration of the additive in the oil is not less than the minimum permissible, $C'_{\min}$: $C'_{add} \geq C'_{\min}$

$$, C'_{add} = \frac{C'_0 Q_s}{\bar{V} G_{oil}^{1-Z} + Q_r}.$$

An increase in the amount of oil in the engine lubrication system does not lead to a directly proportional increase in the service life of the oil before replacement in the engine, which is true even in the case when the maximum concentrations of the additive in the oil under conditions of continuous operation will be below the minimum permissible.

When a forced engine is running on fuel containing less than 0.2% sulfur, more alkalinity may be consumed to neutralize the oxidation products of oil than to neutralize sulfuric and sulfuric acids.

The dependences of the relative rate of reduction of oil alkalinity on the sulfur content in the fuel are equivalent in terms of the consumption of oil alkalinity to other sources of acids neutralized by alkaline detergents.

In high-powered diesel engines and gas engines, alkaline additives are used to neutralize nitric acid with the formation of metal nitrates in a fairly large amount. This is due to the formation of nitrogen oxides from the air during the combustion of fuel and a decrease in the temperature of gases during expansion.

Conclusion.

Thus, as a result of the proposed mathematical models, it is possible to calculate the operation of the additive in various engine oils.

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