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OXIDATION OF MOTOR OILS DURING OPERATION ENGINES IN MILITARY EQUIPMENT

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Annotation
The article analyzes the influence of the oxidation process of motor oils on the operation of the engine. The main reason leading to the formation of high-temperature deposits in engines is oxidation processes occurring in the volume of the oil and on the metal surface. These deposits negatively affect the reliability, efficiency, and durability of the engine.
Among the numerous properties on which the assessment of the quality of lubricants based on antioxidant properties are important.
Therefore, we suggested introducing detergent additives into the engine oil. The action of such additives gives the ability to loosen, wash away deposits from the surface of parts, and transfer insoluble substances into suspension. The results of laboratory studies of samples of industrial oils and samples with the addition of new additives and recommendations for their use are presented.

Keywords: oxidation, hydrocarbons, additives, engine sludge, chemical composition, lubricants, performance properties.

Introduction

The efficiency and reliability of the operation of military equipment for various purposes depends not only on its design and technological features, but also to a large extent on how well the lubricants are selected and on their quality. To ensure the operation of constantly upgraded engines, high-quality engine oils are needed.
Every engine, even of the same brand, works in different conditions and wears out differently. Modern internal combustion engines require high quality lubricating oils to ensure optimum operating conditions. The reliability and durability of the car depend on the quality of the lubricants used. In this regard, all lubricants without exception must meet the quality requirements of the standard.

The highest quality oils will not ensure the operation of mechanisms without wear if they contain at least a small amount of mechanical impurities.

The amount of mechanical impurities is strictly limited and for engines, oils should be no more than 0.015%. Studies of the contamination of lubricating oils in the operating conditions of machinery show that in hot climates and high dustiness of the air, engine oils are intensively contaminated with mechanical impurities, water, fuel and organic products, which leads to premature aging of the oil.

Oil oxidation occurs either in its entire volume or in a thick layer, or in a thin layer when the oil is pumping through the cylinder-piston friction units.

In the latter case, the hydrocarbons of the oil are in particularly difficult conditions of temperature and contact with atmospheric oxygen and metal.

Oil oxidation on heated engine parts occurs under two conditions - dynamic and static (inflow and at rest).

Oxidation of oil in the stream occurs during engine operation when the lubricating oil is continuously circulating and engine parts are constantly lubricating with new portions [1].

Analyze of Research

During the operation of internal combustion engines, their units and parts are contamination with various deposits. The process of formation of deposits is associated with thermo-oxidative transformations of products of incomplete combustion of fuel and oil components. The main reason leading to the formation of high-temperature deposits in engines is oxidation processes occurring in the volume of the oil and on the metal surface.

Oxidation products of hydrocarbons (resins, organic acids), present in the oil in a dissolved state, increase the viscosity and acid number, and asphalting compounds, which are the basis for the formation of varnishes and especially dangerous sticky deposits, contribute to the occurrence and burning of piston rings.

Products of deep oxidative polymerization, differing in high-temperature zones and returning to the crankcase, like other precipitated deposits, continue to have a negative effect on the oil. These deposits have a negative effect on the reliability, efficiency and durability of the engine.

Increased air pressure accelerates the oxidation process, as the process of mutual diffusion of oil with atmospheric air is enhance. In this case, the temperature has a decisive influence on the oxidation process.

The purpose of this work is to study the process of oxidation of engine oil during engine operation and suggests ways to improve antioxidant properties.

The primary products of hydrocarbon oxidation are hydroperoxides. The process develops according to a radical-chain mechanism, and, thus, it considered autocatalytic. Hydroperoxides further decomposed and converted into other oxygen-containing compounds. More and more oil hydrocarbons are involved in the oxidation reaction. As a result, depending on the conditions and chemical composition of the oil, the following products can accumulate in the oxidized oil: low and high molecular weight acids, hydroxy acids, alcohols, aldehydes, ketones, phenols, lactones and other substances [2].

The catalytic action of metals has an important effect on oil oxidation. The catalytic effect of metal ions on oil oxidation suppressed by metal deactivators, which are organic compounds that bind metal ions into inactive complexes. The catalytic action of metals ceases when it covered with a protective film created by oxidation products [3].

As a result of oxidation, the chemical composition of the lubricant and its physicochemical properties change. All this affects the ability of the lubricant to perform its intended functions, limits its service life, and worsens the technical condition of engines. Oils that are not resistant to oxidation tend to sludge more quickly and to a greater extent than stable oils. Oils with special additives are less prone to sludge formation than pure oils because additives allow better retention of insoluble impurities and better resistance to oxidation.

Phenols and amines used as antioxidants, and organic compounds of sulfur and phosphorus used as metal deactivators. Antioxidant additives also include substances that reduce the activity of the catalytic action of metals, their oxides and salts on the oxidation process - metal passivators. However, the existing antioxidant additives cannot to the required extent inhibit the oxidation of oils in the medium-temperature zone and completely prevent the formation of varnish-forming substances in it [5].

Before giving recommendations on the use of any additives, it is necessary to study the mechanism of their action, without the knowledge of which their effective use is impossible.

Analyzes show that substances containing both sulfur and nitrogen are very effective against oxidizing properties. Tests of several dozen of these compounds as oil additives have shown that they are very effective not only for fresh oils, but also for used and recovered oils.

As antioxidant additives, we used an additive As antioxidant additives, we used the addition of barium alkylphenol with formaldehyde (ABF):

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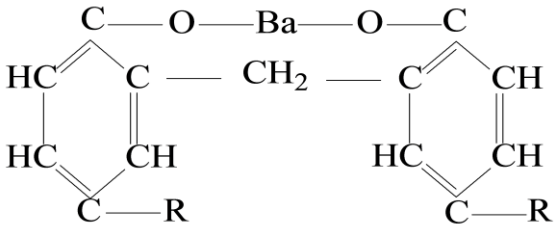


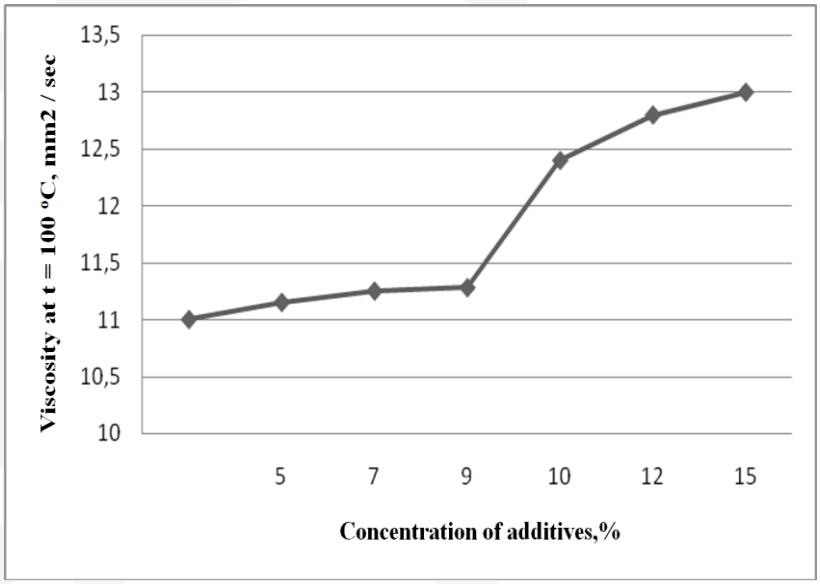
These additives have the ability to improve the quality characteristics of oils. In the oxidation of mixtures of hydrocarbons, aromatic hydrocarbons have an inhibitory effect on the oxidation of naphthenes. This is because the oxidation products of aromatic hydrocarbons, phenols, have antioxidant functions.

Thus, the best group composition of the oil from the point of view of its chemical stability corresponds to a mixture of low-cycle naphthenic, aromatic and hybrid hydrocarbons with long saturated side chains [4].

This additive protects oils from oxidation by a chain-breaking action by reducing the number of radicals generated. The effect of such additives based on their ability to loosen, wash away deposits from the surface of parts, transfer insoluble substances into a suspension, and keep these particles in this state without coarsening.

Method of Research

The action of such additives mainly aimed at preventing the formation of the primary oxidation products - peroxides. Based on this, we analyzed M-10V_2 motor oils and addition of barium alkylphenol with formaldehyde (ABF). From literary sources, it known that antioxidant additives introduced into oils up to 15%.



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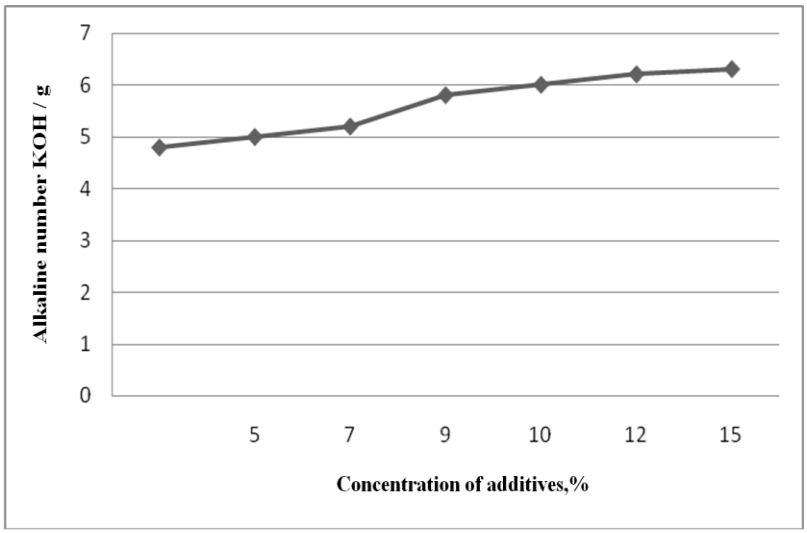

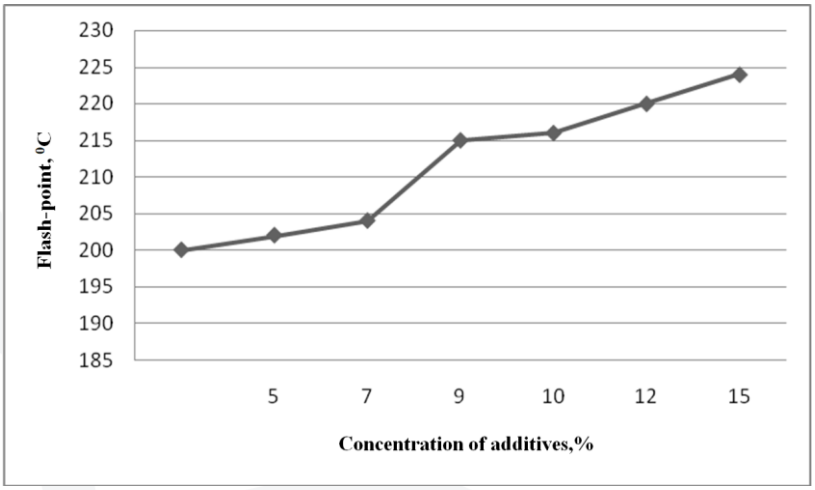

Fig. 1 Physicochemical indicators of engine oil for various concentrations of additives

According to the results of laboratory studies, when the additive introduced into engine oil, they gave a positive result. From the results of the analysis, we have selected the content addition of barium alkylphenol with formaldehyde (ABF) 3-15%, which shows the optimal value of viscosity and base number. With a further increase in concentration, the viscosity increases strongly, which can lead to increased frictional losses. With an increase in viscosity, the thickness and resistance to mechanical stress of the oil layer between the rubbing surfaces increases.

The reserve of neutralizing properties that characterizes engine oil, called the base number, can vary from 5-10 mgKOH/g. The oxidation products of hydrocarbons present in the oil in a dissolved state contribute to the reduction of the base number.

At the same time, acidic products accumulate in the oil, which increases the corrosive wear of parts. All this can lead to contamination of the parts of internal combustion engines with various varnish deposits. In our example, the base number increased from 4.8 to 6.2; and the flash point rose to 224°C, indicating the effectiveness of the additive added. This means that when using such an additive, the service life of the engine oil will increase.

Based on the analysis performed, it was found that the synthesized additive has a high detergency and can be used to effectively reduce the formation of varnish-forming substances arising on pistons and related parts.

According to the results of laboratory tests, when the additive introduced into M-10V_2 engine oil, the physicochemical indicators gave a positive result in comparison with M-10V_2 oils. TBN increased from 5.0 to 6; and the flash point rose to 224°C, indicating the effectiveness of the additive added. This means that when using such an additive, the service life of the engine oil will increase.

Based on the results of the analysis, we selected the additive content of 9%, which shows the optimal viscosity and base number. With a further increase in concentration, the viscosity increases strongly, which can lead to increased frictional losses. With an increase in viscosity, the thickness and resistance to mechanical stress of the oil layer between the rubbing surfaces increases.

Studies show that the addition of an additive reduces the process of piston ring wear by 3-4%, as well as an increase in efficiency by 1%, which leads to an increase in engine power by about 4%.

In the future, these oils can be admitted to the next stage - to operational tests on special equipment.

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