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WAYS TO IMPROVE THE ANTIOXIDANT PROPERTIES OF HYDRAULIC OILS FOR GROUND EQUIPMENT

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ABSTRACT

This article suggests ways to improve the antioxidant properties of hydraulic oils by using additives. Physico-chemical and operational properties of modern hydraulic fluids are significantly improved by the introduction of functional additives into them - antioxidant, anticorrosive, anti-wear. An increase in the antioxidant properties of hydraulic oils is achieved by introducing antioxidant additives.

We conducted a study of samples of MG-32 industrial oils with the addition of zinc dithiophosphate DPZn-11 additives. To do this, the main indicators of MG-32 base oil were determined in accordance with GOST 305-2013 in laboratory conditions. Then preliminary experiments were carried out to determine the effectiveness of the additives. From the results of the analysis, we selected the content of DPZn-11 additives of 1.5%, which shows the optimal value of viscosity and flash point.

The results of laboratory studies of oils with an additive based on zinc dithiophosphate DPZn-11 and recommendations for their use are given.

Key words

hydraulic systems, hydraulic oils, physical and chemical properties, additives, zinc dithiophosphate, research, flash point, alkaline number, flash point.

INTRODUCTION

Modern models of hydraulic systems used in road construction equipment are characterized by low weight, increased operating pressures and temperatures, reduced gaps between working elements.

The operation of hydraulic systems is based on the transfer of energy through a working fluid located in a closed volume. When transferring the force to the actuators, due to the practical incompressibility of the fluid, the force is uniformly and instantly transmitted in all directions.

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The hydraulic drive cannot operate without a liquid working medium, which is a necessary structural element of any hydraulic system.

During operation in hydraulic systems, the oil is heated and intensively mixed with air. The main conditions under which oils in hydraulic systems operate are characterized by: a wide fluctuation in ambient air temperature, the transfer of large forces and the impact of high specific loads in pumps, dustiness and humidity of the ambient air.

Increased air pressure accelerates the oxidation process, as the process of mutual diffusion of oil with atmospheric air increases. At the same time, temperature has a decisive influence on the oxidation process.

In order to meet the requirements, modern hydraulic oils must have certain characteristics:

- have an optimal viscosity level and good viscosity-temperature properties over a wide temperature range, i.e. a high viscosity index;
- have a high antioxidant potential, as well as
- thermal and chemical stability, providing
- long-term continuous operation of the fluid in the hydraulic system;
- protect hydraulic drive parts from corrosion;
- have good filterability;
- protect hydraulic system parts from wear;
- be compatible with hydraulic system materials.

OBJECTS AND METHODS OF RESEARCH

Hydraulic fluids for ground vehicles are one of the main requirements for the ability to withstand mechanical destruction. In working conditions, the oil is under the influence of a number of factors that dramatically accelerate the oxidation processes, namely: elevated temperature, the catalytic effect of various metals, contact with air. Under the influence of high temperatures, oxygen in the air and condensing water, the catalytic action of metals dramatically changes the chemical composition of oils and their operational properties. This leads to an increase in the viscosity of the oil and to the accumulation of oxidation products in it. Low-molecular and high-molecular acids, aldehydes, ketones, phenols, lactones accumulate in the oil. All this leads to an increase in energy costs for the hydraulic system drive.

This article suggests ways to improve the antioxidant properties of hydraulic oils by using additives. Physico-chemical and operational properties of modern hydraulic fluids are significantly improved by the introduction of functional additives into them - antioxidant, anticorrosive, anti-wear.

Antioxidant properties characterize the oil's resistance to oxidation during operation under the influence of temperature during pump operation. The

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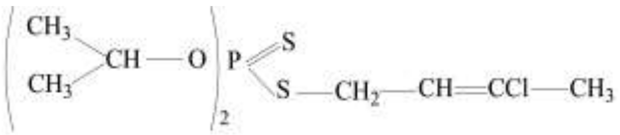
oxidation of the oil leads to a change in viscosity (to an increase) and to the accumulation of oxidation products in it, forming sediments and slag deposits on the surfaces of hydraulic system parts, which complicates its operation. Before giving recommendations on the use of any additives, it is necessary to study their mechanism of action, without knowledge of which their effective use is impossible. The hydraulic systems of machines and mechanisms contain parts made of different metals: different grades of steel, bronze, which can be subjected to corrosion and chemical wear.

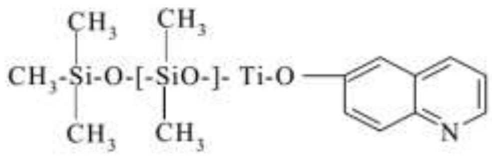
A new class of organic compounds, fluorocarbons, an analogue of hydrocarbons, have many exceptional properties. They are more resistant to oxidation at high temperatures. However, the lubricating properties of these oils are small. In addition, their big disadvantage is poor viscosity-temperature properties. Fluorocarbon-based liquids are capable of interacting with the non-oxidized surface of metals. With prolonged contact, they corrode copper and its alloys, especially in the presence of moisture.

Phosphorus-containing additives have a higher resistance to all types of oxidation compared to other additives. They have incomparably greater chemical and thermal stability and therefore can come into contact with aggressive environments in hot temperature conditions.

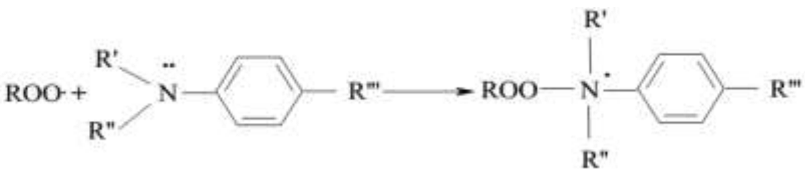


Organic phosphoric acid esters are chemically inert to metals under normal conditions. However, during thermal decomposition or hydrolysis, they form substituted phosphoric acids, which corrode metals, especially copper.

Polyorganosiloxane liquids have unique physicochemical properties: viscosity-temperature, high thermo-oxidative and thermal stability. Polysiloxane liquids practically do not cause corrosion of metals.



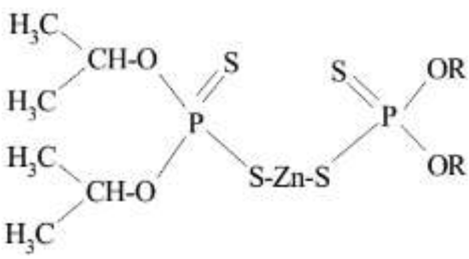
However, insufficient lubricity and high cost limit the widespread use of these liquids. Some nitrogen-containing compounds, mainly aromatic amines, deserve considerable attention as antioxidants.



The most effective anti-oxidizing properties were additives containing metal, sulfur and phosphorus in the molecule at the same time. Testing of several dozen of these compounds as additives to oils has shown that they are very effective not only in fresh oils, but in spent and regenerated ones. Therefore, we chose dialkyldithiophosphate additive.

RESULTS AND THEIR DISCUSSION

We conducted studies of samples of MG-32 industrial oils with the addition of dialkyl dithiophosphate additive DPZn-11.



The mechanism of action of dialkyldithio-phosphate is associated with their thermal decomposition and the formation of a polymer film on the friction surface. The decomposition of dithiophosphate can take place both by radical and by ionic mechanism.

To do this, the main indicators of MG-32 base oil were determined in accordance with GOST 305-2013 in laboratory conditions. Then preliminary experiments were carried out to determine the effectiveness of the additives.

For better solubility, the additive was injected into oil heated to 125°C. To achieve the desired effect, it was necessary to apply it in quantities of 0.5-3%. The following hydraulic oil – MG-32 with different contents (0.2 – 3 %) of DPZn-11additives were selected as the object of the study.

The mechanism of action of zinc dithiophosphate is associated with their thermal decomposition and the formation of a polymer film on the friction surface. The force of adhesion between the oil molecules and the material of the lubricated surface exceeds the force of mutual adhesion of the oil molecules, as a result of which a strong layer of lubricant is formed on the metal surface.

At high temperatures in the zinc-sulfur-air system, reactions between the solid phase and the environment are the main ones. In the process of further decomposition, O-S-S is formed, the interaction of which with the decay products leads to the formation of disulfide.

The effectiveness of this action is characterized by the formation of metal sulfides and disulfides. This model assumes the adsorption of the metal surface and

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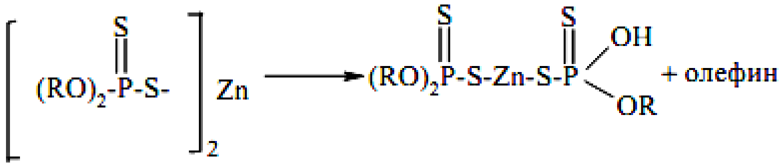
the subsequent dissociation of molecules by S-S bonds with the formation of sufficiently strong compounds with metal.

The decomposition of zinc dithiophosphate molecules by the P-S-Zn bond is also not excluded. In the process of further decomposition, O,S,S-tri-n-alkyltrithiophosphate is formed, the interaction of which with the decay products leads to the formation of disulfide.

The effect of such additives is based on their ability to loosen, wash off deposits from the surface of parts and transfer insoluble substances into suspension and keep these particles in this state without enlargement.

The formation of such complexes facilitates the effect of oxygen at the site of attachment of hydrocarbon radicals to sulfur. The decomposition of dithiophosphate can occur both by radical and by ionic mechanism:



RESULTS AND THEIR DISCUSSION

The presence of such a layer eliminates the possibility of dry friction, and since the coefficient of friction between the layers of liquid lubricant is several tens of times lower than the coefficient of dry friction, the energy costs of overcoming friction forces when using such oil are significantly reduced.

The figure shows the changes in the physico-chemical parameters of the tested oil depending on the percentage concentration DPZn-11.

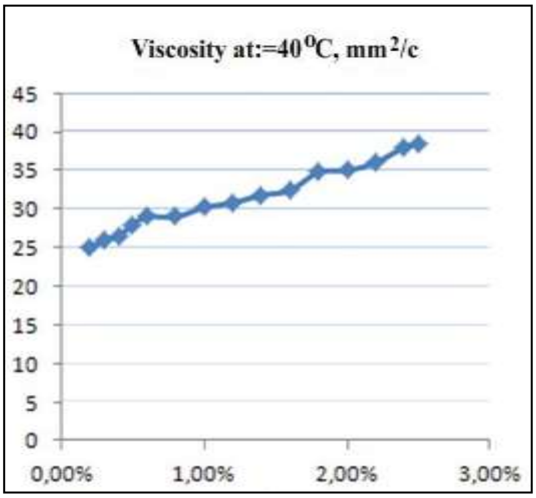


Figure 1

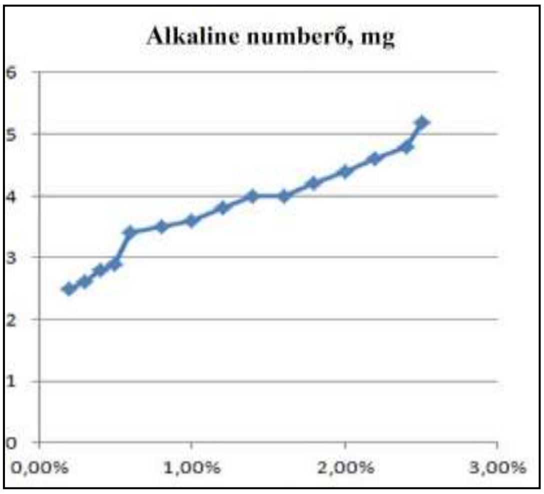


Figure 2

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Figure 1 **Figure 2**

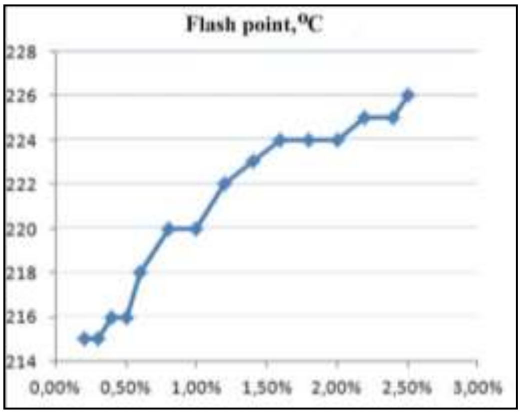

Figure 3

Fig.1,2,3 - Change of physico-chemical parameters of the tested oil depending on the concentration DPZn-11.

From the results of the analysis, we selected the content of DPZn-11additives of 1.8%, which shows the optimal value of viscosity and flash point. With a further increase in the concentration of DPZn-11, the viscosity increases greatly, which can lead to increased friction losses. With increasing viscosity, the thickness and resistance to mechanical influences of the oil layer between the rubbing surfaces increases. In our example, the alkaline number increased from 4.8 to 6; and the flash point rose to 2240C, which indicates the effectiveness of the added additive. This means that when using such an additive, the service life oil will increase.

The results of laboratory studies showed that the addition of DPZn-11to the base oil MG-32 gave an improved result compared to the oils used for agricultural machinery MG-32. Due to the harsh working conditions, oils for hydromechanical transmissions must have appropriate viscosity and anti-wear properties.

CONCLUSION

From the results of the comparison, it can be seen that the operational properties of the obtained hydraulic oil sample far exceed the domestic MG-32 and comply with GOST standards.

This is the effectiveness of the possible application of the new sample obtained by us. In the future, these oils can be admitted to the next stage – to operational tests on special equipment.

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