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IMPROVING THE PERFORMANCE OF TRANSMISSION OILS

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This article explores the ways of improving the performance properties of transmission oils. The operating conditions of the gears are characterized by high loads in the contact zone of the teeth, relatively high speeds of mutual movement of rubbing surfaces and significant temperatures in the contact zone. The anti-wear properties of oils should protect transmission parts from wear and the undesirable phenomenon of galling and abrasion of gear drives. In complex sulfur-chlorine additives, sulfide films prevent scuffing, while chloride films, due to their elasticity, reduce wear and energy consumption to overcome friction forces.

Transmission oil must provide reliable lubrication not only of the gear teeth themselves, but also of the plain bearings. Specific pressures and speeds of relative sliding in friction pairs of transmission units are important operational factors that necessitate the provision of high anti-wear properties of transmission oils.

This article proposes ways to improve the performance properties of transmission oils used for agricultural machinery. The operating conditions of gears are characterized by high loads in the contact zone of the teeth, relatively high speeds of mutual displacement of the rubbing surfaces and significant temperatures in the contact zone.

Energy losses in the transmission account for up to 20 % of the total power consumption of the vehicle. If 25 % of the so-called net engine power goes to the transmission without taking into account losses, then in the general system of transmission units due to its own losses in the units, this power transmitted to the drive wheels is already reduced to 12 %.

During the operation of gears, bearings and other transmission units, an increase in oil temperature is observed due to friction and mixing. This temperature can reach 150 ºC, and under extreme conditions and in units of heavy multi-axle machines and up to 200 ºC.

Transmission oils must, on the one hand, maintain a high viscosity at operating temperatures so that the film does not break and gaps are normally sealed, and, on the other hand, must not become too viscous, so that at the beginning of the operation of the mechanism, the cold oil in the unit would not interfere with the free rotation of the gears.

Wedge wear is the result of the combined action of mechanical wear with molecular forces. In this case, deep pulling out of the material occurs, local connection (setting) of two solids, metal transfer from one friction surface to another and the impact of the resulting irregularities on the mating surface.

At high temperatures, the oil must be sufficiently viscous to maintain the strength of the highly loaded oil film.

The temperature dependence of the viscosity of transmission oils is quite severe. Reducing the viscosity of transmission oils is one of the main ways to increase the efficiency of a vehicle. The viscous oil makes it difficult for the smooth movement of a cold car, it is more difficult to penetrate into narrow gaps between friction surfaces.

With an increase in viscosity, the thickness and resistance to mechanical stress of the oil layer between the rubbing surfaces increases. The viscosity of the transmission oil is the most important physical and chemical property that affects the friction force *F*:

$$F = \eta \frac{VS}{h},$$

where *V* – is the relative speed of movement of surfaces; *h* – is the thickness of the lubricant layer; *S* – is the sliding area.

The viscosity value affects the intensity of fatigue wear of transmission parts, which causes failures and breakdowns of transmission parts

Anti-wear properties consist in the ability of oils to reduce the process of wear of rubbing parts due to the formation of a boundary layer on them, which prevents direct contact of rubbing parts. The anti-wear properties of gear oils are improved by increasing the viscosity, retaining or adding naturally occurring polar active substances.

To form a polishing film on the metal, chemically active substances such as phosphorus, sulfur, chlorine, etc. are required. However, there are no such components in transmission oils. They are introduced with additives that have polishing properties.

As a result of the chemical interaction of these substances with the metal surface, new products are formed, characterized by a lower melting point and an increase in plasticity. For example, sulfur forms metal sulfides. The melting point of iron sulfide is 350 °C lower than that of iron, and iron phosphide is 515 °C lower. As the temperature rises, the iron sulfide film is an additional lubricant that prevents wear and tear. The flow of the alloy at the contact points produces a chemical polishing of the surface, as a result of which the specific pressure and temperature decrease.

Sulfide and chloride films have lower melting points in comparison with metals, therefore, in the contact zone of parts, they easily pass into a molten state. The presence of a melt of sulfides or chlorides in the gap between the parts reduces the coefficient of friction, and the spreading of the melt between the surfaces leads to an expansion of the contact zone of the parts. Substances containing sulfur, chlorine, phosphorus in one combination or another are currently used as polishing additives – all of them are capable of giving compounds with metals with more favorable antifriction properties.

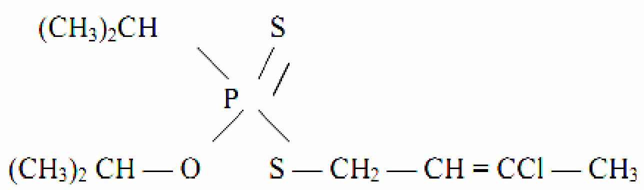
The combination of propping and polishing is especially effective when the effect of chemical polishing agents and polar substances with long chains is simultaneously manifested. This circumstance is a consequence of the formation of an adsorbed film of polar substances on a chemically polished surface.

The adsorption layer, getting into the micro cracks of a solid, quickly spreads deep into the crack and exerts a significant wedging effect on the walls, contributing to the destruction of the surface layers.

The best extreme pressure properties are possessed by bromine compounds, however, they are scarce, therefore, and compounds of the more accessible element chlorine are practically used. During the decomposition of chloride compounds, free chlorine or hydrogen chloride is liberated, which form chlorides with the metal. The advantages of chlorides include plasticity at elevated temperatures.

From substances containing both sulfur and chlorine in the molecule, we chose the XlSP additive (chlorine 2,7 %, sulfur 1,7 %, phosphorus 1 %). Testing several dozen of these compounds as oil additives has shown that they are very effective for gear oils used for agricultural machinery.

We have studied samples of industrial oils, and samples with the addition of the XlSP additive:



In complex sulfur-chlorine additives, sulfide films prevent scuffing, while chloride films, due to their elasticity, reduce wear and energy consumption to overcome frictional forces.

As an object of research were selected: transmission oil TAP-15, TSp-14 and additive XlSP (3–6 %). To carry out the experiments, the oils TAp-15 and TSp-14 with the additive were analyzed for physical and chemical indicators in accordance with the requirements and standards of GOST 10541.

The results of testing gear oils with an additive are shown in table 1.

Table 1 – **Test results for gear oils with an additive**

Quality indicators	TAP 15				TSp-14			
	additiveXlSP content, %							
	3	4	5	6	3	4	5	6
Viscosity , mm^2/s at t = 100 °C	15	16	17	18	14	16	15	17
Anti-wear properties, %	20	25	35	45	19	22	33	42

SUMMARIZING.

According to the results of laboratory studies, when the additive was introduced into the oils TAp-15 and TSp-14, the physicochemical indicators gave positive results in comparison with the base oils.

From the results of the analysis, we have selected the additive content of 5 %, which shows the optimal viscosity and flash point. With a further increase in concentration, the viscosity increased significantly, which can lead to increased frictional losses. The higher the viscosity, the better the anti-wear properties and the higher the load rubbing parts can withstand.

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

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