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Paper Authors

Alimova Zebo Khamidullayeva, Fayzullayev Khaydarali,

Ismadiyorov Asrorjon Anvarjon o'g'li, Tojibayev Farkhad Obidjonovich

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IMPROVEMENT OF THE OPERATING PROPERTIES OF TRANSMISSION OILS USED IN AGRICULTURAL MACHINERY

Alimova Zebo Khamidullayeva[1]
Docent, Tashkent State Transport University, zeboalimova7841@mail.ru, +99890-320-78-41.
Fayzullayev Khaydarali
head teacher FerPI +99890-301-92-38
Ismadiyorov Asrorjon Anvarjon o'g'li
assistant FerPI +99890-361-61-14
Tojibayev Farkhad Obidjonovich
assistant FerPI +99893-972-70-04

Annotation

This article explores ways to improve the performance 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 antiwear 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 frictional forces.

Keywords: gear oil, gear drives, additives, wear, friction, physical and chemical properties, viscosity.

1. Introduction.

Transmission oil is the lifeblood of a transmission. It plays an extremely important role in its durability and performance.

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 the rubbing surfaces and significant temperatures in the contact zone.

Transmission oil must provide reliable lubrication not only of the gear teeth themselves, but also of the plain bearings. The quality of the lubricating oil plays an important role in preventing surface scuffing. To protect the rubbing surfaces from destruction, the binding energy of the additive molecules with the metal must provide such a shear strength of the boundary film so that it is less than the shear strength of the underlying metal layers. If this condition is not met, then plastic deformation is possible. The additives should form films of reduced shear resistance on the metal surface and thereby prevent plastic deformation of the metal.

2. Research methodology.

This article proposes ways to improve the performance properties of transmission oils used for agricultural machinery. 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.

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.

The time it takes for oil to enter the oil channels of the gearbox and drive axles bearings significantly depends on both the oil viscosity and its temperature (Fig. 1).

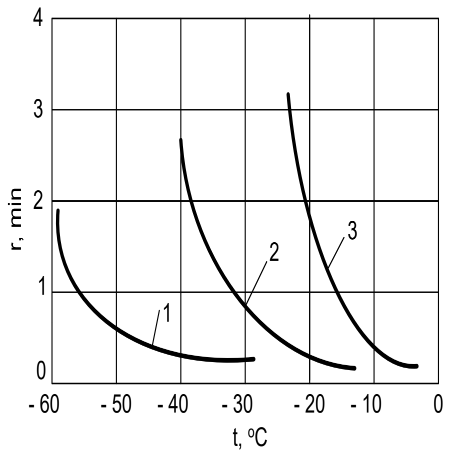


Fig. 1. Dependence of the time the oil reaches the bearing groove on the temperature t: 1– TM-5-9A oil; 2 – TM-5-12V; 3-TAD-17i.

At high temperatures, the oil must be viscous enough 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. Viscous oil makes it difficult for a cold car to move smoothly, 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 transmission oil is the most important physical and chemical property that affects the friction force F:

$$F = \eta \frac{V \cdot S}{h},$$

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 malfunctions and breakdowns of transmission parts. The antiwear properties of gear oils are improved by increasing the viscosity, preserving or adding naturally occurring polar active substances.

The scuffing load of the gear wheels R_{zad} increases with increasing viscosity:

$$R_{zad} = K \cdot \vartheta^{0,5},$$

where: ϑ - kinematic viscosity at the test temperature (60-90 ° C);

K- is a constant depending on the test conditions.

When establishing the requirements for the value of the viscosity of transmission oils, one proceeds from the need to ensure high antiwear properties and prevent leaks, on the one hand, to reduce energy consumption for friction and improve starting properties, on the other hand.

To form a polishing film on a 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. The flow of the alloy at the points of contact 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 compared to 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 producing compounds with more favorable antifriction properties with metals.

Under conditions of increased loads and temperatures, sulfur-containing compounds: disulfides, polysulfides compounds interact with the metal. On the rubbing surfaces, a film of iron sulfide is formed, which has a lower melting point than the base. As the temperature rises, this film melts and serves as an additional lubricant to prevent wear and tear.

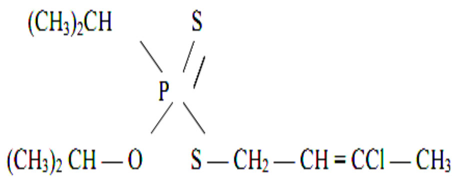
The combination of propping and polishing is especially effective when the effect of chemical polishing agents and polar substances with long chains is simultaneously manifested. This circumstance is a consequence of the formation of an adsorbed film of polar substances on a chemically polished surface.

The adsorption layer, getting into the microcracks of a solid, quickly spreads deep into the crack and has a significant wedging effect on the walls, which contributes to the destruction of the surface layers.

The best extreme pressure properties are possessed by bromine compounds, however, they are in short supply, therefore, the 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.

3. Results and discussion

From substances containing both sulfur and chlorine in the molecule, we chose the additive PSCl-7 (Phosphorus 1,5%, Sulfur 2,5%, Chlorine 3%,). Testing several dozen of these compounds as oil additives has shown that they are very effective for gear oils used for agricultural machinery. We studied samples of industrial oils, and samples with additives PSCl-7:



It is believed that the process of chemisorption of the additive on the metal plays an independent positive role, shielding the juvenile metal under moderate friction conditions.

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

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overcome friction.

As the object of the study was chosen: transmission oil TSp-14, TAp-15, and additive PSCl-7 (3-6%). To carry out the experiments, oils TSp-14, TAp-15 with an additive PSCl-7 (3-6%) 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.

Transmission Oil Test Results with PSCl-7additive

Quality indicators	**TAp-15**				**TSp-14**			
	PSCl-7 additive content,%							
	3	4	5	6	3	4	5	6
Viscosity, mm^2 / s at t=100°C	5	6	7	8	4	6	5	7
Antiwear properties,%	0	5	5	5	9	2	3	2

4. Conclusions.

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

From the results of the analysis, we selected the content of additives 5% PSCl-7, which shows the optimal value of viscosity and flashpoint. With a further increase in the concentration of PSCl-7, the viscosity increased significantly, which can lead to increased friction losses. The higher the viscosity, the better the anti-wear properties and the greater the load the rubbing parts can withstand.

Further, the physicochemical properties of the TAp-15 and TSp-14 transmission oils with 5 % PSCl-7 additive were determined.

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

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