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IMPROVING THE LUBRICATING PROPERTIES OF TRANSMISSION OILS USED IN AGRICULTURAL MACHINERY

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ABSTRACT

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.

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.

The processes occurring in the transmission units of a car during their operation are somewhat different from the nature of the processes occurring in internal combustion engines. The maximum temperature of the friction surfaces of transmission parts does not exceed 300°C, but the contact stresses reach 2000-4000 MPa. Therefore, the physicochemical and operational properties of transmission oils should fully guarantee the durable and reliable operation of vehicle transmission units.

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

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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. 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 150ºC, and under extreme conditions and in units of heavy multi-axle machines and up to 200ºC.

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 . For example, the lower the viscosity of the oil, the shorter the contact time.

Jam 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 (seizure) 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 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 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:

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

where:

υ - 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.

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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. From substances containing both sulfur and chlorine in the molecule, we chose the additive LZ-6 (Sulfur 1.7%, chlorine 2.7 %, phosphorus 1.6 %).

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 LZ-6. 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 overcome friction. As the object of the study was chosen: transmission oil TCp-14, TAp-15, and additive LZ-6 (2-6%). To carry out the experiments, oils TCp-14, TAp-15 with an additive LZ-6 (2-6%) were analyzed for physical and chemical indicators in accordance with the requirements and standards of GOST 10541.

The temperature and viscosity values of the oil affect: the ability to continuously lubricate the rubbing surfaces of transmission parts; the ability to start moving the car at low ambient temperatures, when the oil has its temperature; power indicators of transmission units.

For example, when the viscosity of the transmission oil changes from 5 mm^2/s at a temperature of 100°C to 30 mm^2/s in urban driving conditions, the transmission efficiency decreases by almost 2%, in addition, as the oil temperature decreases, the resistance to rotation of the transmission parts sharply increases.

Chlorine compounds are corrosive, especially when in contact with water. Chlorine-containing additives are most often used in combination with other additives that eliminate this drawback. Phosphorus-containing additives effectively increase the seizure load of rubbing surfaces at low sliding speeds. However, they are not efficient enough at high speeds and shock loading. Therefore, we suggested using the additive with several active elements at once (S-C1, S-P, C1-P). In this case, the action of one active element when the friction conditions change is complemented by the action of another.

Analyzes show that the use of an additive with several active elements, even at elevated temperatures, does not increase the coefficient of friction. From the results of the analysis, we selected the content of additives LZ-6 5%, which shows the optimal value of viscosity and flashpoint. With a further increase in the concentration of LZ-6, the viscosity increased significantly, which can lead to

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increased friction losses. The higher the viscosity, the better the anti-wear properties and the greater the load the rubbing parts can withstand.

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