Analysis of antifriction additives to lubricants materials

Vaschishina Anna
Bryansk state technical University
7, 50 let Oktyabrya Boulevard, Bryansk region, Central Federal district, Bryansk region, 241035

Abstract: *The article is devoted to the analysis of the most used additives for lubricants. The principle of their operation and the result of their work are considered. The effect of additives on the structure of surface layers on the surface of friction pairs is estimated. The analysis showed the use of only a limited number of principles of the action of antifriction additives. Theoretically promising antifriction additives for base oils, relevant for use in railway transport, have been proposed.*
Keywords: *ADDITIVES, ANTIFRICTION EFFECT, LUBRICANTS, CHEMICAL PROPERTIES, FRICTION, WEAR, COEFFICIENT OF FRICTION, PHOSPHATES, SULFATES.*

Introduction

The introduction of effective antiwear, extreme pressure and antifriction additives into lubricants has stimulated interest in the study of existing analogues. This has generated interest in the development, testing, application of new compounds and the study of their properties. Lubricant additives play an important role in increasing the service life and reliability of machines and mechanisms.

Additives have been discovered that effectively increase the thermal stability of lubricating layers, reduce the coefficient of friction and reduce wear even at high temperatures. To implement external friction, it is necessary to create a layer on the friction surfaces that has a small value of τ and a value of σx that is less than that of the base material. From the consideration of the molecular component of friction, it follows that for the implementation of external friction, the shear resistance in the contact zone of the bodies must be less than in their volume. In other words, on the surface of a solid, there must be a layer with a reduced shear resistance (the rule of I.V. Kragelsky).

A positive gradient of mechanical strength can be created by applying various lubricating films on the surface at a small value of τ, which is exactly what solid lubricants have. In the structure of layered and solid lubricants, the relative strength of bonds between atoms in different directions varies greatly. This is due to the presence in solid lubricants of the difference in interatomic distances between atoms in one layer relative to others. In the structure of solid lubricants, two types of bonds are usually combined - very weak (van der Waals) between the layers and strong (covalent, metallic) within the layer. In the process of friction, the layers of the solid lubricant shift, while due to the weak van der Waals interaction between the layers, the shear resistance will be very small. Different surfaces of layered crystals determine their surface sliding process [1]. One of the main properties that ensures the high lubricity of solid lubricants is their high adhesion to metal surfaces. Solid lubricants that do not have a layered structure (metals, polymers) exhibit a lubricating effect as a result of low shear resistance of the resulting adhesion bridges - they create a positive gradient of the mechanical strength of rubbing materials, which ensures stable external friction with low friction forces.

Special attention was paid to the study of the ability of various compounds to modify the rubbing surfaces of various metals under boundary conditions and the ability of surfactants (surfactants) to exhibit a noticeable antifriction effect due to the adsorption of polar molecules on the rubbing surfaces [2]. It is necessary to observe the correct technology for the production of lubricants, because the colloidal stability of the resulting oil depends on it. A deeper understanding of the mechanisms of action of additives will help the development of more effective, in order to increase the antifriction properties of lubricants.

In [3], a study is carried out of the effect of molybdenum complexes with dithiophosphine and dithiocarbamine on the structure and thickness of the layers that they form on the surfaces of friction pairs. MoS_2 - a lamellar solid lubricant based on molybdenum disulfide as an additive - consists of individual asymmetric planes that slide easily relative to each other [4]. Each MoS_2 layer consists of S - Mo - S stacks (molybdenum atoms are located between two layers of sulfur atoms), in which one molybdenum atom is surrounded by six sulfur atoms. Testing was carried out on a friction four-ball machine under normal load in the temperature range 25-350 ° C. The results showed that molybdenum-containing additives provide lower values of the coefficient of friction than their zinc counterparts [5]. Molybdenum disulfide forms a tough cohesive film, smoother than the working surface. The resulting film of molybdenum disulfide on the friction surface has high adhesive properties to metal surfaces, which significantly reduces surface wear.

The most effective antifriction behavior is achieved when the formation of secondary structures is localized in thinner metal layers on friction surfaces. Molybdenum-containing complexes form thinner films of S-S layers than their zinc analogs; this corresponds to lower values of the coefficient of friction [6].

Polytetrafluoroethylene has no layered structure. Its high lubricating properties are due to its high softening point. The polymer exhibits an extremely low coefficient of friction due to the smooth molecular structure of the polymer chains, which are oriented in such a way as to facilitate sliding. PTFE leads to the formation of rod-shaped macromolecules that can slide over each other. Thus, fluorine-containing acids in an organic solvent reduce the coefficient of friction, and the larger the carbon chain, the lower the value of the coefficient; friction polymers also, due to the large branching of the carbon chain, reduce the coefficient of friction.

In [7], the authors used hydrocarbon lubricants and found that there is a decrease in surface wear during the formation of organic products, which were called "friction polymers". The wear of metal surfaces is reduced due to the formation of friction polymers by lubricants, which indicates a positive effect of friction polymers on the fatigue life of high-temperature bearings and on the contact strength of machine parts.

As a result of strong intermolecular interaction between the surfaces of friction pairs, molybdenum complexes form thinner SS layers, which corresponds to lower values of the friction coefficient. Various additives (surfactants - surfactants) in lubricants are capable of exhibiting an antifriction effect due to the adsorption of polar molecules on rubbing surfaces. The wear mechanism in the case of ionic liquids based on fatty acids is adhesive in nature. The result of the adhesion interaction of the rubbing bodies is the destruction of the subsurface layers of materials, the frictional transfer of wear particles. Lubricant molecules are adsorbed on the friction surface and create a protective layer.

After studying the additives, we can say that the most promising will be organic compounds containing sulfur and phosphorus. The proposed additives may be relevant for reducing the wear of the surfaces of the friction pair rail - wheel flange of a locomotive.

Results and Discussion.

Sulfonated oils impart good antiwear properties to the lubricant. Using sulfonated hydrocarbons supposes that the active sulfur will react with rubbing surfaces to form thick iron sulfide films that reduce the surface wear. The sulfate ability as additives improves the antiwear, anti-friction and extreme pressure characteristics of lubricants. This is due to forming low-energy films on rubbing metal surfaces under heavy loads because of chemisorption, as a result of which friction and wear between the mating surfaces decrease. It can be assumed that the resulting surface films are easily shear, have their own slip planes and changes in the structure. But this effect has its own peculiarity, namely the degree of forming surface reactions and iron sulfide chemisorbed films, iron oxide does not correlate with the degree of antiwear, antifriction and antiscuffing action. Compounds (iron sulfide, iron oxide) resulting from concomitant chemical reactions do not have the properties of low shear strength, ductility, good fission and low melting points, which are considered important for low wear and friction properties under boundary conditions. This factor can affect the properties of the formed films and have a temporary effect. Figure 1 shows by adding sulfoadditives to the material, the wear decreased and amounted to 30 microns. Thus, the additives reduce wear on the friction pair. The wear rate decreased by 76% when adding a sulfo-containing agent.

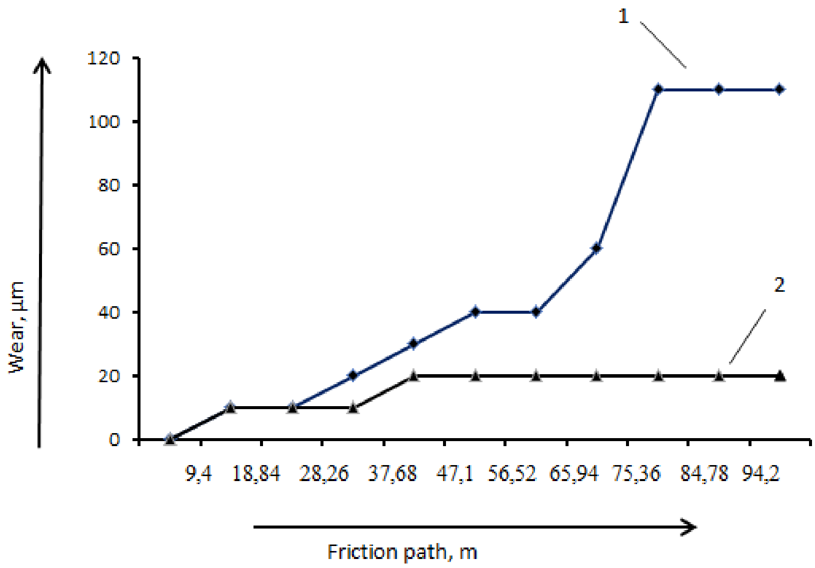

Figure 1. *Test results:*
1– Puma; 2 – Puma + sulfo compound

Based on the data obtained, it can be said that additives based on sulfo compounds have the most stable indicators of wear which is associated with the high activity of sulfur and stable compound formation on the friction pair surface. Also of interest is the behavior of a lubricant with additives under the action of magnetic amplifiers on a railway track or rolling stock.

Conclusion

The analysis and experiment have shown that the most effective will be additives consisting of organic and inorganic fillers. An inorganic agent based on sulfur compounds was used in the work. They show high chemisorption on rubbing surfaces, resulting in the formation of protective films that reduce friction. When using a mixed type additive - an organic agent and a non-organic agent - it can be assumed that the friction coefficient will noticeably improve. Based on this study, many factors must be considered to create a lubricant additive.

The most promising direction in the development of anti-degradation additives is the mixed method, which uses an organic agent and an inorganic one (sulfonyl additives). The most readily available organic filler is esters of polybasic acids. Sulfur and phosphorus are also widely available materials.

Bibliographic list

1. Белый В. А., Свириденок А. И., Крагельский И. В., Холодилов О. В. О механизме образования слоев фрикционного переноса // Матер. межд. симп. “Интертрибо–81”. – Чехословакия. – 1981 (1). –стр. 172–179
2. Physicul und Chrmical crsprcts inwlved in the design of’u lubricant und luhrictrred sy.~trm. Paisley College of Technology, England, Symposium, 7-9 September, 1971.
3. Vipper, A.B., Cook, S.J., Karaulov, A.K., Moreton, D.J., Mishuk, O.A., and Leahy, R., / Tribological performance and mechanism of action of overbased detergents // Lubricafion Science. -1997. –Vol.9 №2. –pp.207-17.
4. Teer, D.G. / New solid lubricant coatings // Wear. -2001. –Vol. 251. –pp. 1068–1074
5. Stoyanov, P.; Chromik, R.R.; Goldbaum, D.; Lince, J.R.; Zhang, X. / Microtribological Performance of Au–MoS2 and Ti–MoS2 Coatings with Varying Contact Pressure // Tribol. Lett. -2010. –Vol.40. –pp.199–211
6. Li, H.; Li, X.; Zhang, G.; Wang, L.; Wu, G. / Exploring the Tribophysics and Tribochemistry of MoS2 by Sliding MoS2/Ti Composite Coating Under Different Humidity // Tribol. Lett. -2017. –Vol.65. –p.38
7. Pisarova, L., Gabler, C., Do ¨rr, N., Pittenauer, E., Allmaier, G. / Thermo-oxidative stability and corrosion properties of ammonium based ionic liquids //b Tribol. Int. -2012. –Vol.46. –pp.73–83.
8. Шалыгин М.Г., Ващишина А.П. Недостатки систем смазывания гребня колесной пары локомотива // «Обеспечение и повышение качества изделий машиностроения и авиакосмической техники»: материалы международной научно-технической конференции (19-20 февраля 2020г.) / Брянск: БГТУ. – 2020. – С. 67-70