THE OPERATING PREPARATIONS USED IN LUBRICATING OILS

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Abstract

Lubricating oils are characterized by improving quality. It is obtained by additives which are the integral part of the lubricants. Nevertheless, in extreme hard working conditions of the tribological systems (high pressures, velocities and temperatures, temporary lubricating lack during starting) the machine elements are not secured enough. Consequently the idea to introduce the additional substance - operating preparation into tribological systems (with the lubricating oils) appeared a few years ago. Owing to that, the lubricating oils with better antiwear and antiseizure properties are obtained. The boundary layers created on cooperating elements surfaces are able to carry bigger load and also friction resistance and wear of these elements decrease.

The paper presents literature review concerning the operating preparations used in lubricating oils. Different opinions about operating preparations functioning can be found in the professional literature - from harmfulness or weak effectiveness to good efficiency and big technical, economical and ecological meaning. In author's opinion, in extreme working conditions of tribological systems the operating preparations (especially the chemical interaction preparations) ensure additional and effective protection of machine elements. The functioning efficiency of the operating preparations is usually the highest in case of deteriorating technical condition of tribological system elements.

Keywords: *lubricating oils, operating preparations, boundary layer, tribological systems*

1. Introduction

The proper lubrication assurance is one of the most important problems in machines construction and operation. Common lubricants (oils and greases) are characterized by still improving properties. Lubricants quality improvement is obtained by additives which are their integral part. Nevertheless, in extreme hard working conditions of the tribological systems (high pressures, velocities and temperatures, temporary lubricating lack during starting) the machine elements are not secured enough. In connection with the above mentioned the idea to introduce the additional substance - operating preparation into tribological systems (with the lubricating oils) was put forward. The application of operating preparations in lubricating oils production process was presented in Fig.1.

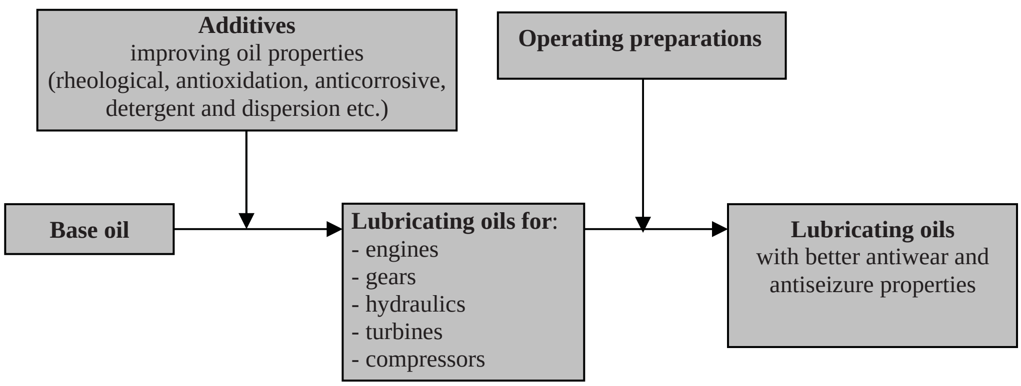

Fig. 1. Application of the additives and operating preparations in lubricating oils production process [8]

According to [8] ”*the operating preparations are chemical compounds or mixtures of chemical compounds prepared for some special aim for example to improve working conditions of tribological systems by increasing boundary layer stability*”. Owing to that, the lubricating oils with better antiwear and antiseizure properties are obtained. The boundary layers created on cooperating elements surfaces are able to carry bigger load and also friction resistances and wear of these elements decrease.

2. Classification and principle of operation of the operating preparations

Operating preparations may be divided into three main groups:
- chemical interaction preparations;
- preparations which contain molecules of solid lubricants;
- preparations which are able to form conditions for selective transfer lubrication in tribological system.

Chemical interaction preparations are lubricating oil soluble long chain compounds with a polar group at the end or compounds based on zinc ditiophosphate which contain fine selected extreme pressure (EP) phosphoric, sulpheric or chloric additives. They are characterized by big molecular weight, high chemical and thermal stability. The operating preparations are introduced into machine tribological systems with different kinds of lubricating oils (Fig. 1). The operating preparation molecules in increased temperatures react with metallic foundation. Finally the boundary layer resulting from sorption and chemisorption phenomenon and self-regenerating diffusion layer, which is as an additional protection of cooperative elements, are obtained. So, the boundary layers on machine elements arise similarly in case of lubricating oils with chemical interaction preparation as well as lubricating oils without it (with additives only). The difference is that the operating preparation added to lubricating oil increases active matter concentration, so thicker and faster boundary layer can be formed (Fig. 2). The boundary layer formed in that way is able to withstand considerable higher dynamic and thermal load [5].

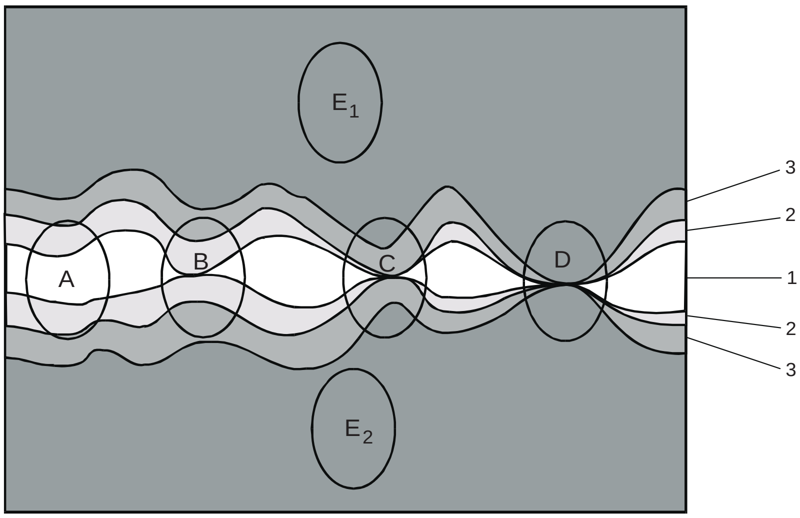

Fig. 2. Model of tribological system with operating preparation [2]: E_1, E_2 – friction elements, 1 – lubricant with operating preparation, 2 – boundary layer formed by lubricant, 3 – boundary layer formed by lubricant with operating preparation (the so called “substitute boundary layer”), A – fluid friction phase, B – boundary friction phase, C – boundary friction phase with “substitute boundary layer”, D – dry friction phase

The operating preparations which contain molecules of solid lubricants can be divided as follow:
- substances with laminar structure for example: graphite, molybdenum disulfide (MoS_2), wolfram disulfide, nitrides, sulphates etc.
- substances with small internal cohesion for example: soaps, solid waxes, plant fats, soft polymers (teflon) and soft metals (copper, tin, lead, silver) usually in powder.

Among laminar structure substances - graphite and MoS_2 are the most often used. The laminar structure of the lattice is characterized by easily polarized small positive and big negative ions in lattice points. The atoms lying in flat layer are interconnected by strong covalent bonds whereas between the layers there are weaker electrostatic bonds. On account of it, these substances are characterized by clear determined cleavage planes and slip planes which proceed along separate layers. The lattice of graphite was presented in Fig. 3.

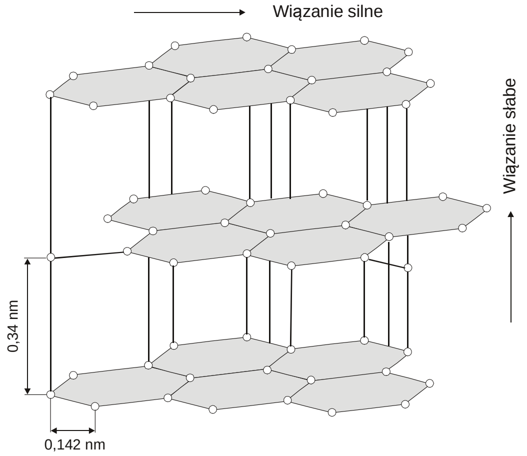

Fig. 3. Lattice of graphite

Two theories – structural and adsorbent try to explain the idea of lubrication with laminar structure substances. The first one explains lubricating properties by laminar structure of the lattice (slip planes), the second one explains it by adhesion of the substance molecules on the metal surface. Presumably, good lubricating properties are obtained when both of the above mentioned requirements are performed. Lubrication with the aid of graphite was presented in Fig. 4. The graphite molecules operating in lubricating oil create, as a result of sorption, surface-active film which attracts the next graphite molecules till irregularity of both cooperating surfaces is filled (smoothing the surfaces). From that moment, mutual displacement of the friction elements takes place in the graphite layer (along slip planes). That layer is characterized by good adsorptive properties and next oil parts are attracted creating thicker and thicker surface-active film which improves tribologic system working conditions.

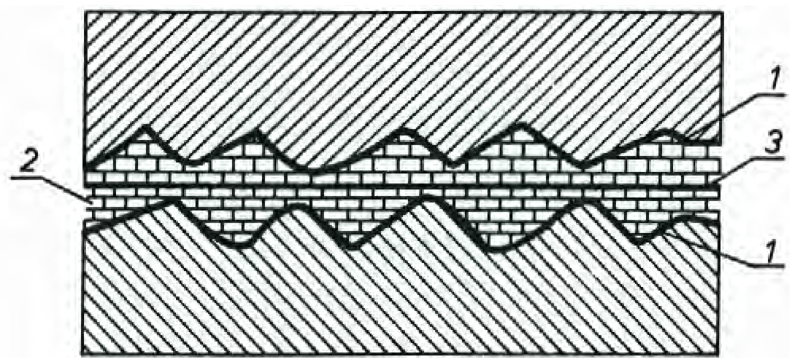

Fig. 4. Lubrication with the aid of graphite [11]: 1 – graphite layers on friction surfaces, 2 – irregularity of surfaces filled by graphite, 3 – sliding surface of the graphite layers

Lubrication with the aid of molybdenum disulfide (MoS_2) is similar. The difference is that the boundary layer is created also as a result of chemical reaction of sulphur ions with metal atoms (chemisorption). When that layer is formed, the MoS_2 molecules fill the irregularities of both cooperating surfaces until mutual displacement of the friction elements takes places between MoS_2 layers (Fig. 5).

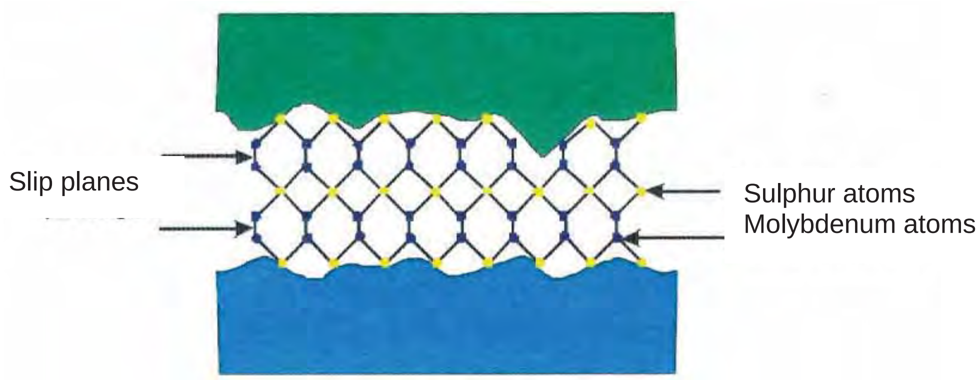

Fig. 5. Lubrication with the aid of molybdenum disulfide MoS_2 [8]

The politetrafluoroethylene (PTFE), known also as teflon, is an example of small internal cohesion substance. The PTFE is inserted into tribological system in the form of sub-microscopic spherical particles. The way of its action depends on particles electrical activity. The particles which have positive charge will be connected with metal surface (as a result of electrostatic interaction). If the distance between cooperating elements is radically reduced the PTFE particles adsorbed on roughness tops will be rolled. The PTFE films formed in that way are 1-2 μm thick and have great adhesion to metal surfaces, so their removal is possible only by grinding. The particles which are electrically neutral will not form the above mentioned films on metal surfaces. In that case the spherical teflon particles operate as the ball bearings in tribological systems. Their operation is presented in Fig. 6.

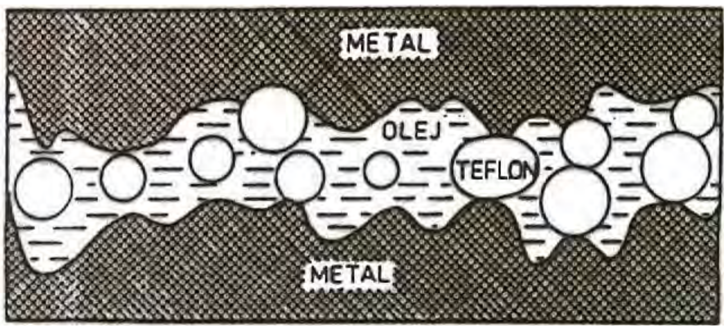

Fig. 6. Lubrication with the aid of oil with politetrafluoroethylene (PTFE) addition [8]

PTFE is characterized by the smallest values of friction factors among solid substances (for PTFE/PTFE – 0.04, for steel/PTFE – 0.09-0.14 [15]) and complete chemical inertness in relation to lubricants and metals, rubbers etc. So, the PTFE film formed on the metal surfaces considerably decreases friction resistances and wear (in boundary friction conditions) and additionally protects against corrosion and different disadvantageous chemical processes. On the other hand that film decreases clearances between tribological system elements which is a disadvantageous effect because it may cause temperature rise in friction area and extreme seizing. Additionally, in lubricating oil systems the ball-shaped PTFE particles precipitate on the filters. Finally, the filters are fouled and the substance which was expected to perform a specified task is eliminated from lubricating oil. These factors resulted in the fact that PTFE preparations are not used in practice.

The soft metals (copper, tin, lead, silver) are different example of the substances with small internal cohesion. Lubrication with the aid of oil with copper addition was presented in Fig. 7a. The copper spherical particles with a few micrometers in diameter are circulating together with lubricating oil and in the places where the distance between cooperating elements is radically reduced they are pressed and rolled forming the thin layer which has great adhesion to the metal surface. The so called friction surfaces plating takes place (Fig. 7b).That layer is able to withstand higher mechanical load at lower friction coefficient. The particles which were not pressed and rolled operate as the ball bearings in tribological system. So the soft metals operate similarly to PTFE and are characterized by the same faults as PTFE. Additionally the soft metals (especially copper) strongly catalyze the disadvantageous process of lubricating oil oxidation. These factors caused the lack of application of soft metals preparations.

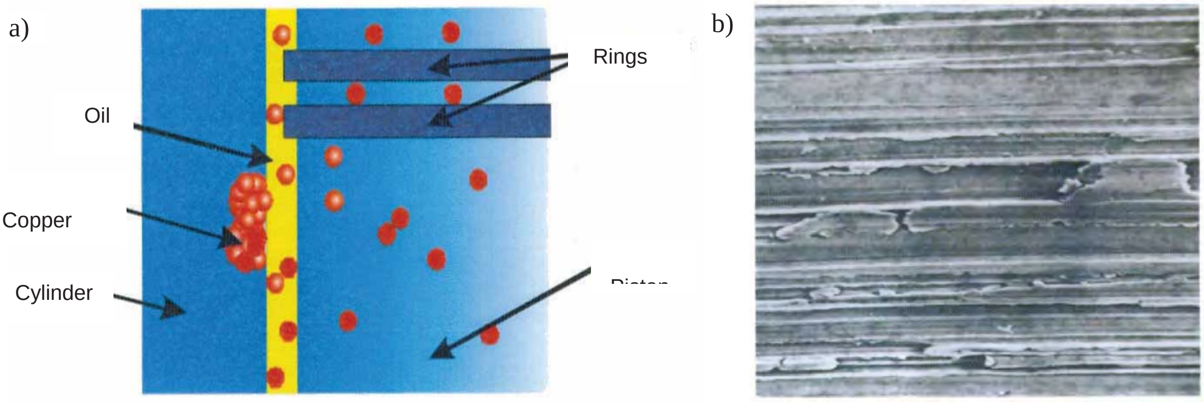

Fig. 7. Operating of copper operating preparation [8]: a) lubrication with the aid of oil with copper addition, b) friction surfaces plating

The third group of operating preparations contains the substances which are able to form conditions for selective transfer lubrication in tribological system. These substances, for example: glycerine and its alcoholic solution, weak organic acids formed by lubricating oil oxidation process, are characterized by reduction properties. They reduce cupric oxides to pure copper which causes atomic transfer. As a result of friction which causes micro-plastic deformations of the surface layer and temperature raise, the cooper ions are able to diffuse into steel surface free from oxides. The copper layer, 1-2 μm thick, formed in this way is strongly bounded with metal surface. The example of the above mentioned layer formed between steel and polymer filled with copper powder is presented in Fig. 8. The friction coefficient and wear decrease about 2-3 orders of magnitude.

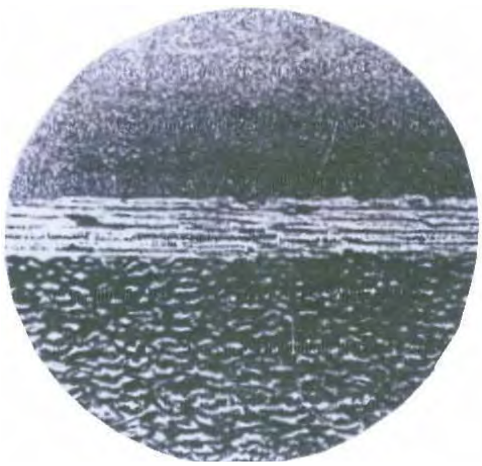

Fig. 8. The copper layer formed between steel and polymer filled with copper powder [7]

3. Summary

Two methods can be applied to improve lubricating oils operating properties: application of better additives which are integral parts of lubricating oils or introducing new substances into lubricating systems the so called operating preparations.

Scientific research does not result in unequivocal assessment of the operating preparations.

Different opinions about operating preparations functioning can be found in the professional literature - from harmfulness or weak effectiveness to good efficiency and big technical, economical and ecological meaning. So different opinions come from big variety of operating preparations and their various principles of operation. Among operating preparations presented in the article the chemical interaction preparations have the widest application now. These preparations join permanently with lubricating oil, so they do not precipitate on the filters and do not create heat-insulating layers unlike the preparations which contain molecules of solid lubricants. The chemical interaction preparations improve antiwear and antiseizure properties considerably and decrease temperature in friction area. The functioning efficiency of the operating preparations is usually the highest in case of deteriorating technical condition of tribological systems elements.

References

[1] Baczewski, K., *Wpływ preparatów teflonowych na filtracje oleju*, Paliwa, oleje i smary w eksploatacji, Nr 13, 1994.

[2] Białka, Z., *Badania dodatków eksploatacyjnych*, Paliwa, oleje i smary w eksploatacji, Nr 69, 2000.

[3] Białka, Z., Kędzierski, K., *Korektory do olejów smarowych*, Tribologia, Nr 5-6, 1997.

[4] Gutowski, J., Korycki, J., Wiślicki, B., *Efektywność działania dodatków PTFE w cieczach roboczych*, Materiały na IX Sympozjum Paliw Płynnych i Produktów Smarowych w Gospodarce Morskiej, Gdańsk 1991.

[5] Hebda, M., Wachal, A., *Trybologia*, Wydawnictwo Naukowo-Techniczne, Warszawa 1980.

[6] Kłopocki, J., Sikora, J., Majewski, W., *Wpływ dodatków uzupełniających na właściwości tribologiczne wybranych olejów smarowych*, Journal of KONES, Internal Combustion Engines, Warsaw 1995.

[7] Kragielski, J. W., Alisin, W. W., *Trenije, iznasziwanije i smazka*, Maszinostrojenie, 1978.

[8] Laber, S., *Badania własności eksploatacyjnych i smarnych uszlachetniacza metalu*, Uniwersytet Zielonogórski, 2003.

[9] Laber, A., *Analiza możliwości wykorzystania preparatu eksploatacyjnego Motor Life Professional w modyfikowaniu warunków pracy węzłów tarcia pojazdów samochodowych*, Tribologia, Nr 5, 2009.

[10] Laber, A., Adamczuk, K., *Analiza porównawcza własności smarnych oleju maszynowego AN-46 przed i po procesie eksploatacji*, Tribologia, Nr 5, 2009.

[11] Lawrowski, Z., *Tribologia – tarcie, zużycie i smarowanie*, Wydawnictwo Naukowe PWN, Warszawa 1993.

[12] Łuksa, A., Witkoś, A., *Dodatki uszlachetniające do olejów smarowych*, Paliwa, oleje i smary w eksploatacji, Nr 19, 1995.

[13] Mc Fall, D., *Dwugłos na temat dodatków wspomagających do olejów*, Paliwa, oleje i smary w eksploatacji, Nr 69, 2000.

[14] Shpenkov, G., *Selektywne przenoszenie w praktyce*, Paliwa, oleje i smary w eksploatacji, Nr 13, 1994.

[15] Wiślicki, B., Korycki, J., Gutkowski, J., *Laboratoryjne badania właściwości smarnych olejów z dodatkami PTFE*, Tribologia, Nr 5, 1991.

[16] Wiślicki, B., *Niekonwencjonalne dodatki do olejów smarowych*, Paliwa, oleje i smary w eksploatacji, Nr 17, 1995.