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OPERABILITY OF THE BOUNDARY LAYERS OF LUBRICANTS DURING OPERATION

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Abstract:
The article analyzes the study of the operability of the boundary layers of lubricants during operation. The operability of the oil boundary layer is determined by the interaction of the molecular oil film with the rubbing surface of the metal. During operation, the composition of lubricants becomes more complicated due to the oxidation of thermochemical decomposition of hydrocarbons and additives. These products enter into physical and chemical interactions with each other and with pollutants coming from outside. Lubricants containing surfactants have the ability to adsorb on the interface surfaces of two media: liquid and solid.

Keywords: Lubricants, viscosity, temperature, engine, hydrocarbons, boundary layer strength, layer thickness, molecular film, surfactants, adsorption, chemisorption.

The durability of engines and the reliability of their operation is greatly influenced by the quality of the engine oils used. The main purpose of the lubrication system is the timely supply of clean and, if necessary, cooled engine oil to the rubbing parts to reduce friction. Under pressure, oil enters almost all the sliding bearings of the engine.

The main lubricated components and parts of a piston engine are: main and connecting rod bearings, camshaft bearings and gears, piston pins, valve rods and pushers, plunger pairs of a high-pressure pump, cylinder walls, pistons. The piston-cylinder interfaces also belong to the responsible lubrication units. Each of these units differs in dynamic and thermal loads, which, due to the presence of unified engine oil systems, increases the complexity of the effective use of engine oils.

The thickness and strength of the oil boundary layer during friction of the working surfaces of engine parts depends on the chemical composition of the oil and its additives.

The load and speed modes of the engines lead to a decrease in the specific capacity of the lubrication system, as well as to an increase in the temperature of the main parts and assemblies. At the same time, the working conditions of the oil are tightened, which leads to an intensive process of its oxidation.

The operability of the boundary layer of oil depends on its viscosity and is determined by the interaction of the molecular film of oil with the rubbing surface of the metal. The resulting molecular oil films of physical origin are called adsorption, and films of chemical origin are called chemisorption.

The formation of lubricating films by adsorption forces is due to the presence of surfactants (surfactants) in lubricants that carry an electric charge. Such substances include compounds containing carboxyl groups, alcohols, various esters, resins, sulfur compounds.

Lubricants containing surfactants have the ability to adsorb on the interface surfaces of two media: liquid and solid.

Sorption phenomena play an important role in many industrial processes. Sorption (at the liquid–gas, liquid–liquid or solid–solid boundary) · the most important factor determining the properties of systems with a large specific surface area.

There is a relation between the adsorption value and the surface tension at constant temperature and pressure

$$G = -\left(\frac{a}{RT}\right)\frac{dy}{da}$$

where:

G – surface concentration; a – the activity of the solute; dy – the change in surface tension; R – the universal gas constant; T– the absolute temperature.

If an increase in the concentration of the solute leads to a decrease in the surface tension, then the solute accumulates on the interface (positive adsorption). On the contrary, if the surface tension increases with an increase in the concentration of the dissolved substance, then the dissolved substance is removed from the interface (negative adsorption).

Chemisorbed films are stable chemical films of phosphates, chlorides or sulfides. They are created on the metal surface due to the presence of the corresponding chemical elements in lubricants. The high rate of formation of these films ensures their rapid recovery in the places of destruction of the boundary layer. Films of this type also include various soaps, which are formed from organic acids contained in oil.

Adsorbed and chemisorbed films, having a certain strength and durability, protect friction surfaces from mechanical and thermal influences, and also prevent mutual adhesion of rubbing surfaces.

When operating a car under the influence of various factors, the oil loses its original properties. Pollutants (their proportion reaches 0.08-0.23%) entering the engine together with fresh oil accumulate in the oil during its transportation, storage and directly during refueling of the lubrication system.

When there is a bound or adsorbed film of water on the metal surface, then low-polar media, which include petroleum products, will not wet the metal surface well.

The introduction of surfactants into hydrocarbon media should, therefore, first of all increase the wettability of metals by them and create conditions for the manifestation of inhibitors (protective additives) of the main functional property.

The ability of lubricants containing surfactants to form sufficiently strong layers of oriented molecules on lubricated surfaces is called oiliness or lubricating ability of oils.

When the lubricating layer completely separates the working surfaces that move one relative to the other, and this layer has a thickness at which normal volumetric properties of the oil appear, then such friction is called liquid. The coefficient of liquid friction is in the range of 0.003・ 0.03, which is 50・ 100 times less than with friction without lubrication. The friction force of this type of lubricant depends only on the inner layers in the lubricant.

The wetting ability of surfactants can be manifested due to the formation of strong hydrogen bonds of surfactants with water and the displacement of water from the metal surface.

In the process of oil aging, changes in the concentration, structure and effectiveness of additives are observed. This occurs as a result of decomposition, interaction with fuel combustion products and oil oxidation, filter elements and car parts.

The elevated temperature and oxygen of the air with which the oil comes into contact cause oxidation and oxidative polymerization of its molecules. Hydrocarbon oxidation products such as resins, organic acids present in the oil in the dissolved state contribute to an increase in viscosity and acid number, and asphaltene compounds that cause the formation of varnish deposits, the occurrence and burning of piston rings.

A fine stable mechanical mixture of oxidation products leads to the formation of carbon deposits and sludge. The products of deep oxidative polymerization, which differ in high temperature zones and flow back into the crankcase, as well as other precipitated deposits, continue to have a negative effect on the oil.

Thus, a complex mixture of the starting oil with a wide variety of aging products is formed in the crankcase of a running engine, from which it is not possible to completely clean the oil by filtration.

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