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The Mechanism of Lubricants Protective Layers Formation in Friction Sliding

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Abstract

The article presents the results of a study of the temperature degradation of motor oils of various basic framework and lubricity when the load changes, which have established a process flow thermal degradation of engine oils, comprising the sequential formation of primary and secondary degradation products, different optical density, and the impact of these products on the processes forming a boundary lubricant layer. The dependences of the wear parameters of temperature and temperature control loads on the basis of which identified education adsorption, chemisorption and modified layers. There are three characteristic temperature range of the parameter-dependent wear degradation products thermostatically controlled oil and load.

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Keywords: motor oil; thermal degradation; the absorption coefficient of the light flux; wea; lubricant boundary layer.

Impact of oil on the durability and reliability of the machine parts is determined by their ability to protect the friction surfaces against wear, to provide the necessary friction characteristics. Therefore, consider the impact of oil on the durability and reliability of machine parts - it means to discuss issues of their lubricating effect and influence on friction and wear in the lubricated surfaces of concrete machinery parts. The friction in the boundary lubrication conditions always leads to wear of the rubbing bodies, and the wear mechanism is determined by the nature of the boundary layer, and the latter is determined by the nature of the lubricant and the material contacting bodies and the conditions of the formation of boundary layers [1]. The theory of boundary lubrication was developed by U.B. Hardy, V.G. Deryagin, A.S. Akhmatova, F.F. Bowden, D. Tabor, G.V. Vinogradov, R.M. Matveevski et al. [2-6].

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Conventional theory of friction are adhesively-deformation theory Bowden-Tabor [6] and the kinetic theory of friction, proposed I.V. Kragelsky [7]. At the heart of these theories is the concept of convergence of two rough surfaces upon contact. Even at very low load, due to the discrete nature of contact, pressure is very high roughness. As a result of deformation of the contacting materials begin to approach the contact surface, resulting in an increasing number of contact asperities. This process continues until the area of contact will not be enough to carry the load.

The aim of this work is to establish the connection between the processes of thermal degradation occurring in the volume of motor oils of various core framework when thermostating and wear processes.

The test is subjected to: commodity motor oil based on mineral M-8G2k, but partial-synthetic TNK Super 5W-40 SL/CF and synthetic ESSO Ultron 5W-40 SL/CF. These oils thermostatted in a special apparatus for 8 h in a temperature range from 140 to 300 °C with increasing temperature at 10 °C at atmospheric pressure. Each temperare-tested a new oil sample. After every 8 hours of testing with thermostat-foot oil sample photometrically at thicknesses photo-metric layer 8 and 2 mm in order to determine the absorption coefficient of the light flux K_a [8] and tested on three ball friction machine with friction scheme "ball-cylinder" with the following parameters: the load 13, 23 and 33 H, the sliding speed of 0.68 m/s, the oil temperature of 80 °C, 2 h testing time. Antiwear properties were appreciating-on arithmetic mean wear scar diameter on the three balls.

In contrast to the methods for determining the thermal stability of the developed R.M. Matveevski [9] in this study when tested engine oils are preincubated in the temperature range from 140 to 300 °C and then held tribological tests.

In the study of optical properties depending on temperature thermostat motor oils of various core framework (Fig. 1) are installed the temperature field of education of primary and secondary degradation products. For the mineral oil temperature range of formation of primary thermal decomposition products ranges from 160 to 240 ^{o}C, but partial-synthetic from 160 to 210 ^{o}C, and synthetic from 170 to 220 ^{o}C. The transition from primary education to secondary degradation products is characterized by a critical temperature T_{cr} and is mineral oil of 240 ^{o}C, partly synthetic - 210 ^{o}C, synthetic - 220 ^{o}C.

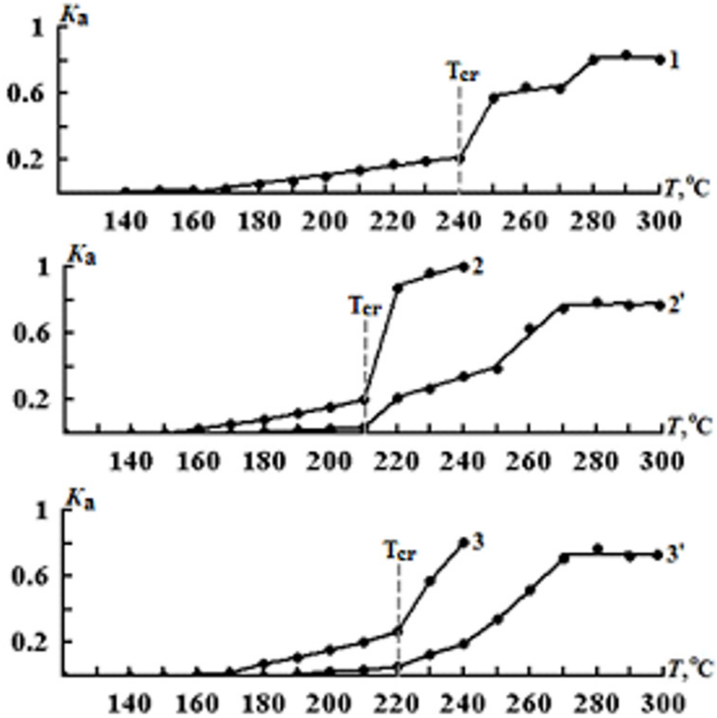

Fig. 1 - Dependence of the absorption coefficient of the light flux on the temperature thermostatic motor oils: a - M-8G2k; b - TNK Super 5W-40 SL/CF; c - ESSO Ultron 5W-40 SL/CF (1, 2, 3 - layer thickness of the photometric 8mm, 2 'and 3' - 2 mm)

At the same time, a sharp increase in the absorption coefficient of the light flux, which is explained by the formation of secondary degradation products with a higher optical density. Moreover, the starting material for the formation of secondary products of degradation products are formed before the primary temperature T_{cr}. Thus, the process temperature destruction is periodic with a change in the concentration of the primary products and increase in the concentration of the secondary.

The results correspond to the basic laws of thermodestructive processes of lubricating oils, which flow through the serial or parallel-sequential stages of formation and consumption of intermediate condensation products according to the scheme: light oils → polycyclic arenas → resins →asphaltenes → carbenes → karboidy → coke. At this stage, each formed on at least the low molecular weight liquid products compared to products formed seal [10].

Anti-wear properties thermostatically controlled oil were studied depending on the load to detect changes in the processes occurring in the frictional contact. If the selected pair of friction "ball-cylinder" with the wear increases wear scar area, thus decreasing the pressure in the contact, which determines the friction zone temperature, which affects the properties of the lubricating oil, the rate of formation of boundary layers and their strength. In addition to the friction surface under the influence of temperature chemical reactions, the rate of which depends on the temperature and the activity of the degradation products of additives [11,12].

Figures 2-4 shows the dependence of the diameter of the wear scar on the incubation temperature and the load of mineral, partially synthetic and synthetic motor oils.

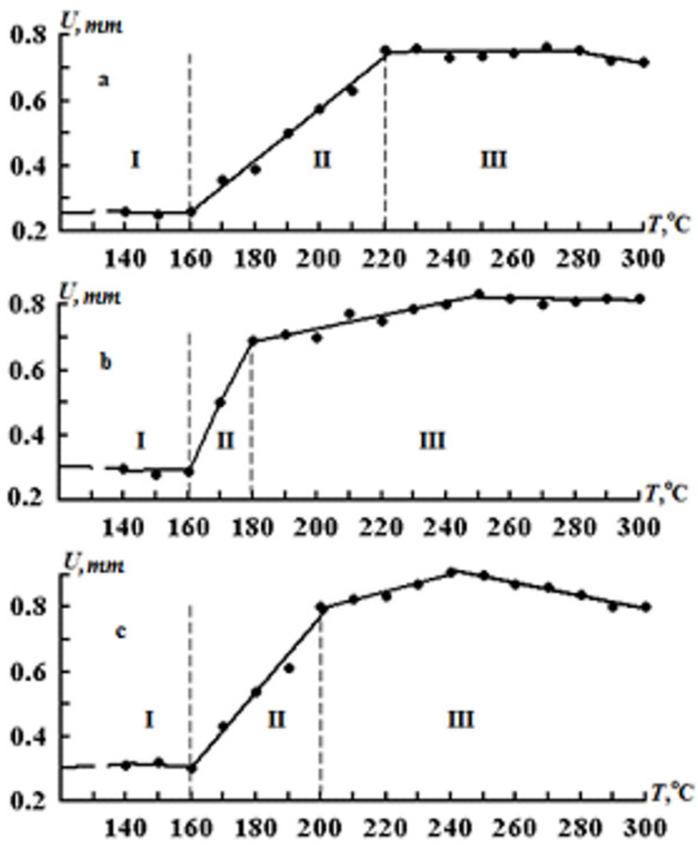

Fig. 2 - Dependence of wear on thermostatic temperature mineral motor oil M-8G2k and load:
a - 13H; b - 23H; c - 33H

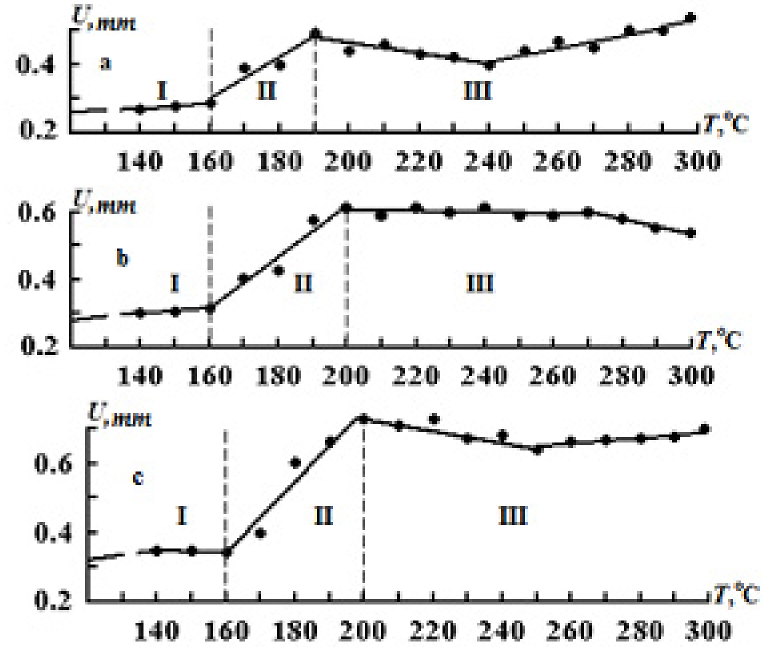

Fig. 3 - Dependence of wear from the thermostatic temperature partly synthetic motor oils TNK 5W-40 SL/CF and the load: a - 13H; b - 23H; c - 33H

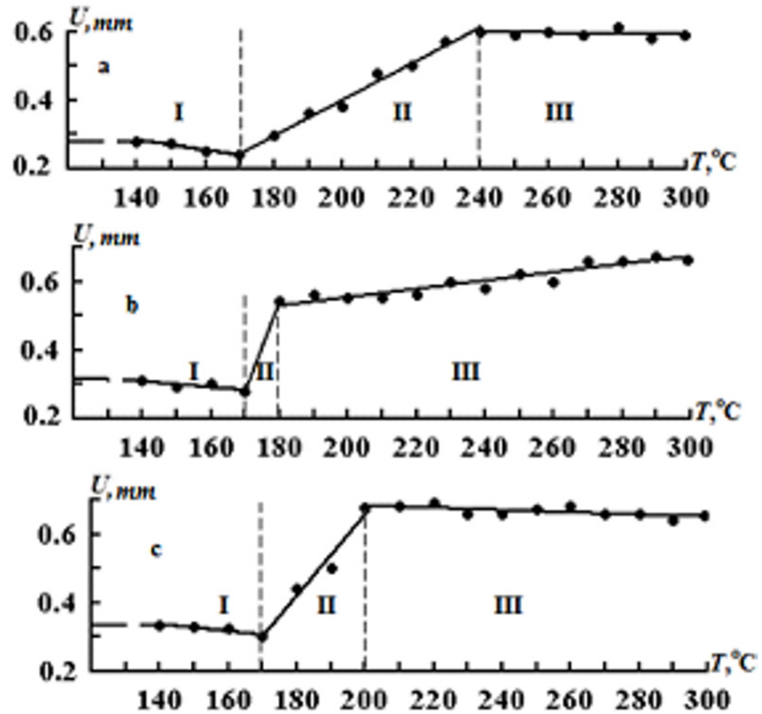

Fig. 4 - Dependence of wear from the thermostatic temperature synthetic motor oil ESSO Ultron 5W-40 SL/CF and the load: a - 13H; b - 23H; c - 33H

According to the data depending on the diameter of the wear scar on the thermostat temperature engine oil regardless of the underlying fundamentals and the load is characterized by three temperature regions, differing amounts of wear and temperature range.

The first temperature range for mineral and synthetic oils is partially determined by the temperature range from 140 to 160 °C, and to synthetic - from 140 to 170 °C, owls, falls to the area prior to the formation of primary products of thermal destruction (see fig. 1). And mineral oil is virtually the same amount of wear of the tamper-temperature-range. To partially synthetic oil wear with increasing temperature insignificant-enforcement increases. For synthetic oils wear decreased with increasing incubation temperature. Effect on the load parameter of wear in that area is linear (Fig. 5). In this temperature range there is a formation of the adsorption layer which provides separation of the friction surfaces, so the wear in this area is minimal [13-16].

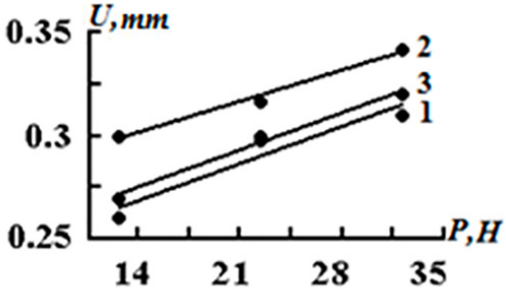

Fig. 5 - Dependence of wear scar diameter of the load in the absence of the formation of degradation products:
1 - mineral oil M-8G2k; 2 - partially synthetic oil TNK Super 5W-40 SL/CF; 3 - synthetic oil ESSO Ultron 5W-40 SL/CF

The second temperature range is characterized by the formation of primary products of thermal destruction (see. Fig. 1), which causes a sharp drop in anti-wear properties of engine oils, regardless of the base substrate. However, clear dependence on the wear parameter thermostating temperature and the load, depending on the basic framework is not set, i.e. load ambiguous effect on the amount of wear, but wear parameter increases a linear relationship. This is because a change in the concentration of the outcome, feedstock and primary degradation products, because of which an adsorption layer is not able to separate the friction surfaces and begins to occur the formation of stronger chemisorption layer, and a load affects the distribution of lubricating oil products involved the formation of a boundary lubricant layer [17-20].

Since the formation of the layer occurs simultaneously two processes: education and abrasion layer, until it is established wear (between plastic and elastoplastic deformation) is, the higher the load, the stronger the abrasion layer at the time of its formation, but with an increase in smoothing roughness load may occur, thereby increasing the actual contact area and, therefore, 33H temperature range in the second region larger in load than the load 23H, i.e. wear increases less rapidly. And therefore, the formation of the adsorption layer (a first region) that is not observed, i.e. the load does not affect the temperature range, because the adsorption layer promotes the complete separation of the rubbing surfaces and in the formation of the layer, i.e. when the processes of formation and abrasion layer occur, there is only destruction layer and the rubbing surface remains untouched.

A third temperature region determines the amount of wear and tear, which depends both on the primary and secondary degradation products, as well as the load, so the change in the depreciation of-field is characterized by two portions of workability and extreme pressure additives, averting-rotating grip. In this region, the modified layer is formed, i.e. unlike chemisorption layer is deeper penetration of the lubricating oil to friction surfaces, due to the formation of secondary degradation products and the actions of extreme pressure additives to prevent from setting, so in this area the maximum wear.

The studies established a common mechanism of thermal degradation of engine oils, regardless of the basic framework, which consists in the sequential formation of primary products transitioning to secondary differing optical properties and to determine the temperature field of education.

Three typical temperature range of variation of the wear parameter dependent on temperature-controlled oil degradation products and the load, and in the first temperature range, parameter wear from constant mineral oil; partially synthetic oil slightly increases; synthetic oil decreases linearly dependent on the load in the second temperature region wear increases linearly dependent on the concentration of primary degradation products and the load in the third temperature region of wear is dependent on the total concentration of degradation and the load of the primary and secondary products and characterizes the temperature range of the extreme pressure additives ensuring the setting preventing.

Studies have shown that the primary degradation products of lower anti-wear properties thermostatically controlled oil regardless of the underlying fundamentals and the formation of secondary products of destruction leads to deterioration of stabilization. This effect of secondary products of temperature destruction to anti-wear oils explains the mechanism of their action, consisting in to a slight change of wear over a wide temperature range due to the initiation of extreme pressure additives that provide prevention setting.

The results obtained prove the temperature region and efficiency of oils to use this indicator to improve the system of classification of lubricants that enable the consumer to exercise their informed choice.

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