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Method of control the effect of temperature for the oxidation process of partially synthetic motor oils

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Abstract

This article presents the results of a study of the oxidation process partially-synthetic motor oils in the temperature range from 170 to 200 °C. The oxidation process of oils evaluated on indicators of thermo-oxidative stability which characterizes the oil resistance to temperature influences. As indicators of thermal oxidative stability of selected: the absorption coefficient of the light flux, evaporation, kinematic viscosity and potential resource.

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Keywords: absorption coefficient of luminous flux; a potential resource; temperature control; kinematic viscosity; volatility; oxidation resistance coefficient.

1. Main text

Thermo-oxidative stability of lubricating oils characterized by their resistance to aging. There are many methods of monitoring indicators, including changes in the definition of physical, chemical and performance properties, the amount of deposits, evaporation, optical density, kinematic viscosity, the induction period of precipitation, acidity, tar, carbon residue, etc. [1-5]. Most of the above methods are standardized, but the information on the resistance of the lubricating oil temperature influences are not available to consumers[6-8].

The objective of these studies is to expand the information on the resistance of the lubricating oil temperature effects with the use of simple means test and measurement, the use of which is possible both in the laboratory and in the conditions of the operating companies.

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To investigate the selected part-synthetic engine oil of the same viscosity grade: Mobil 10W-40 SJ/CH; Zic 5000 10W-40 CG4/SH and Zic A 10W-40 SL.

The checks provided for the use of the following means of test and measurement: temperature control device for oil; low-volume viscometer; photometer for direct photometry oxidation of oils and electronic scales. Technical characteristics of the instrument is shown in [9].

According to the method a sample oil weighing $100 \text{ g} \pm 0,1$ poured into a glass beaker for temperature control device at temperatures of 170 to 200 °C at atmospheric pressure while stirring with a glass stirrer speed of 300 rev/min. The temperature of incubation was set discretely and automatically maintained to within $-1 \dots + 2$ °C. Test duration was 2, 5 and 8 hereinafter hours.

After each test period glass beaker was weighed to determine the mass of evaporated oil was selected portion of the sample (2 g) for direct photometry at a thickness of the photo- metric layer of 2 mm and a determination of the absorption coefficient of the light flux, and a portion of the sample (8 g) were taken at the temperature for measuring the kinematic viscosity 100 °C. Testing continued until the value of the coefficient = 0.7-0.8. The experimental data change rate, volatility, kinematic viscosity obtained at temperatures of 170-200 °C built graphics depending on the test of time, which compared the studied oils.

Fig. 1a, b, c are presented depending on the time factor and the oxidation temperature of the studied part-synthetic motor oils. It is found that for oils Mobil 10W-40 SJ/CH; Zic 5000 10W-40 CG4/SH first test there is an area of resistance to oxidation, the duration of which increases with decreasing temperature thermostat. More resistant to temperature effects is oil Zic A 10W-40 SL, but less stable even at 170 °C, oil is Mobil 10W-40 SJ/CH.

A common feature of the dependences obtained (Fig. 1) is the presence of portions regardless of the temperature incubation with greater speed change ratio, confirming the formation of two kinds of degradation products with different optical density in the oxidation process, called primary (formed in the initial test period) and secondary causing bending dependencies [10-14].

In addition to oil Zic 5000 10W-40 CG 4/SH and Zic A 10W-40 SL set the stabilization and even decrease in the value of the coefficient of temperature thermostat 190 and 180 °C, which can be explained by the fact that the transition of primary oxidation products in secondary formed coagulation centers (insoluble degradation products) tightening secondary products on its surface lightening oxidized oil.

Initially, the formation of coagulation centers dimensions are such that the light beam encloses them (diffraction), so that the coefficient value decreases.

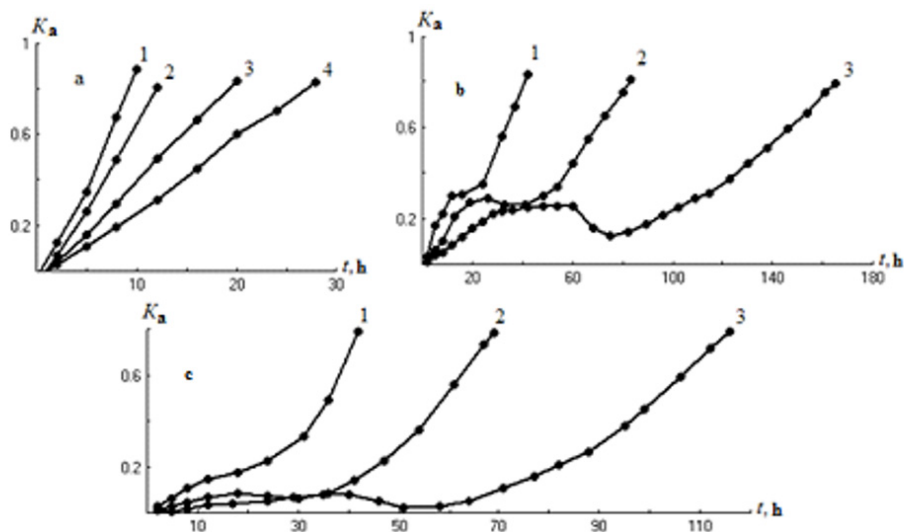


Fig. 1. The dependence of the absorption coefficient of the luminous flux of time and incubation temperature of partially-synthetic motor oils: a - Mobil 10W-40 SJ/CH; b - Zic 5000 10W-40 CG4/SH; c - Zic 5000 10W-40 CG4/SH; 1 - 200 °C; 2 - 190 °C; 3 - 180 °C; 4 - 170 °C

For comparison, the test oil at a rate suggested a potential resource, determined by the time to achieve the coefficient value of 0.7. Dependencies of the resource potential of the incubation temperature for the studied oils are presented in Fig. 2 a, b, c.

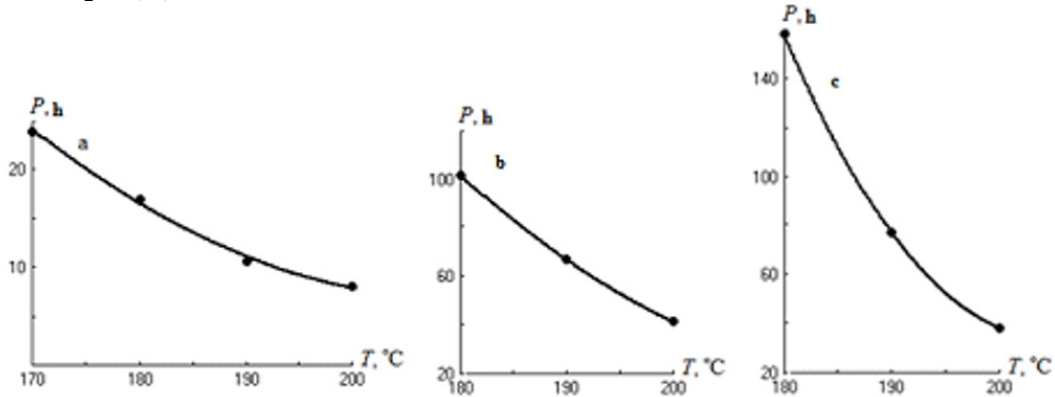


Fig. 2. Dependence of the potential resource, measured when the absorption coefficient of the color flow values equal to 0.7, the temperature of incubation partially-synthetic motor oils: a - Mobil 10W-40 SJ/CH; b - Zic 5000 10W-40 CG4/SH; c - Zic A 10W-40 SL

Oil Mobil 10W-40 SJ/SH maximum potential resource is set at a temperature of 170 °C thermostat and was 24 hours. The highest potential resource 158 hours is set for oil Zic A 10W-40 SL at 180 °C.

Dependencies $P = f(T)$ are described by second-order polynomial

$$P = a_p T^2 + b_p T + c_p, \quad (1)$$

where a_p , b_p , c_p – factors which characterize the magnitude of the potential resource, depending on the oxidation temperature, h.

Regression equations for the studied oils has the form

$$\text{Mobil 10W-40 SJ/CH } P = 0,011T^2 - 4,614T + 490,64; \quad (2)$$

$$\text{Zic 5000 10W-40 CG4/SH } P = 0,0475T^2 - 21,075T + 2356; \quad (3)$$

$$\text{Zic A 10W-40 SL } P = 0,21T^2 - 85,8614T + 8798. \quad (4)$$

The correlation coefficients of 0.9996 to 1.0.

Dependency ratio relative kinematic viscosity of the test of time and temperature are presented in Fig. 3 a, b, c. The coefficients of relative kinematic viscosity K'_μ determined by the ratio of oxidized oils to trade viscosity, allowing to determine the amount of viscosity change.

Thus, the oil Mobil 10W-40 SJ/SH thermostating at 170 °C kinematic viscosity (curve 4) is almost stable, but as the temperature rises sharply reduced, and time and the rate of reduction depends on the temperature.

For oils Zic 5000 and Zic A first trend is reducing the kinematic viscosity of 15 - 20%. Then there is a sharp increase and decrease with increasing incubation time depends on the temperature, the higher it is, the less time. Considering allowable increase in viscosity by 40%, the potential resource Zic oil 10W-40 5000 CG4 / SH limited time to a temperature of 190 °C - 70 hours and a temperature of 180 °C - 100 hours. Oil Zic A 10W-40 SL limited potential resource for the temperature of 190 °C of less than 90 hours and a temperature of 180 °C - 140 hours.

To evaluate the effect of incubation temperature on evaporation provided a potential resource defined time achieving volatility oils equal to 9 g (Fig. 4 a, b, c). These dependences $P_g = f(T)$ are described by second-order polynomial

$$P_g = a_g T^2 + b_g T + c_g, \tag{5}$$

where a_g, b_g, c_g – coefficients characterizing volatility studied oils.

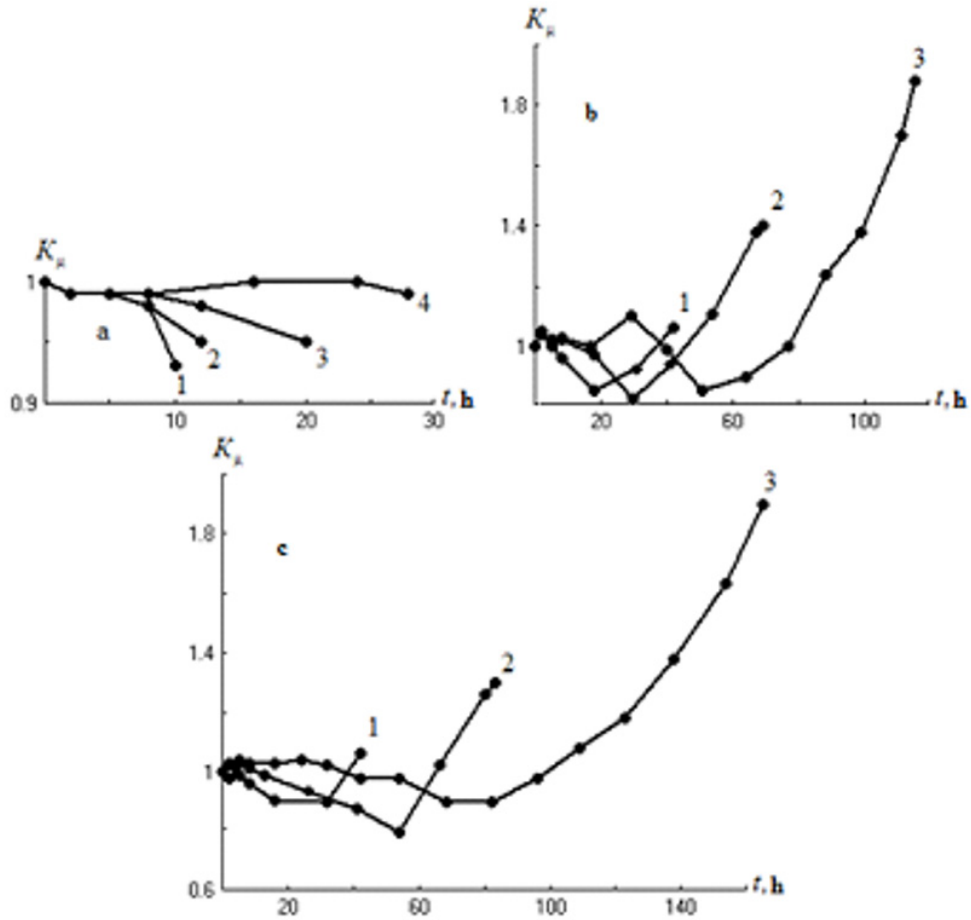


Fig. 3. The dependence of the coefficient of relative kinematic viscosity of the incubation time and temperature partially-synthetic motor oils: a - Mobil 10W-40 SJ/CH; b - Zic 5000 10W-40 CG4/SH; c - Zic A 10W-40 SL; 1 - 200 °C; 2 - 190 °C; 3 - 180 °C; 4 - 170 °C

Regression equations have the form presented dependences for oils

$$\text{Mobil 10W-40 SJ/CH } P_g = 0,01625T^2 - 6,7475T + 704,475 \tag{6}$$

$$\text{Zic 5000 10W-40 CG4/SH } P_g = 0,07T^2 - 28,2T + 2856 \tag{7}$$

$$\text{Zic A 10W-40 SL } P_g = 0,09T^2 - 36,7T + 3759 \tag{8}$$

The correlation coefficients of 0.9999 to 1.0.

According to the largest potential resource for volatility is set for oil Zic A 10W-40 SL, and the lowest oil Mobil 10W-40 SJ/CH.

The studies found that in the oxidation of oils simultaneously change their optical properties (K_a) and evaporation, so these parameters characterize thermooxidative stability, in this case the kinematic viscosity, depends on the concentration of secondary oxidation products. Thus, the coefficient of evaporation K_g and oxidation resistance characterized oils currently oxidation time.

In [15-20] proposed a method for determining the coefficient of resistance to oxidation R_o , which is defined by the formula

$$R_o = 1 - \frac{K_a \cdot K_g}{K_a + K_g}, \quad (9)$$

where 1 – It determines the resistance to oxidation of commodity oils; K_a - absorption coefficient of the light flux after a certain incubation time at the selected temperature; K_g - volatility coefficient determined for the same time and temperature

$$K_g = \frac{m}{M}, \quad (10)$$

where m – mass of vaporized oil, g; M - mass of the sample after the test;

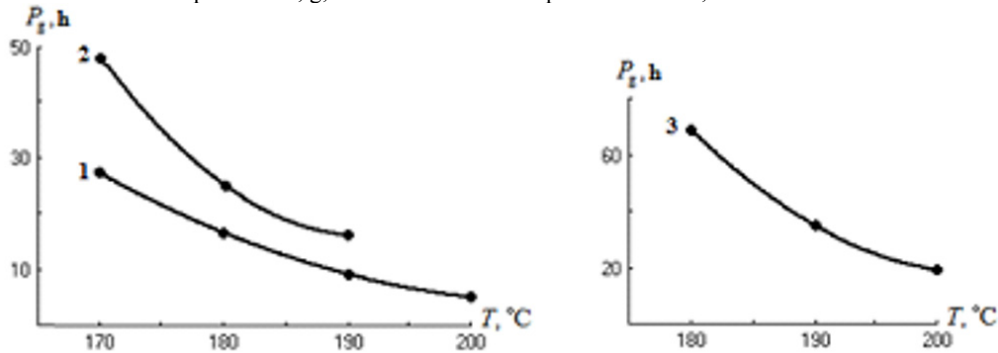


Fig. 4. Dependence of the potential resource partially-synthetic motor oils of incubation temperature on evaporation of 9 g of oil:
1 - Mobil 10W-40 SJ/CH; 2 - Zic 5000 10W-40 CG4/SH; 3 - Zic A 10W-40 SL

The dependences of the drag coefficient of the oxidation time, and incubation temperature are shown in fig. 5 a, b, c. According to incubation with increasing temperature and the test of time coefficient R_o decreases.

According to the largest potential resource to change the coefficient of resistance to oxidation of the oxidation temperature is set for oil Zic A 10W-40 SL, and the lowest oil Mobil 10W-40 SJ/CH.

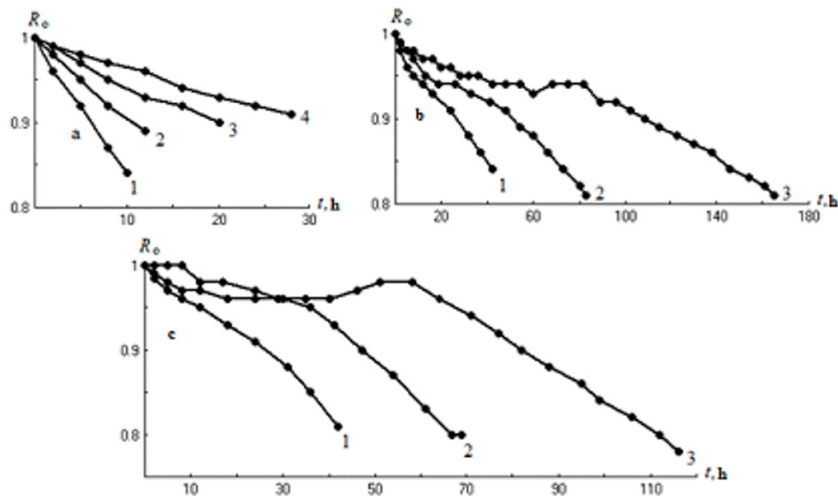


Fig. 5. Dependence of the coefficient of resistance to oxidation time and temperature incubation partially-synthetic motor oils: a - Mobil 10W-40 SJ/CH; b - Zic A 10W-40 SL; c - Zic 5000 10W-40 CG4/SH; 1 - 200 °C; 2 - 190 °C; 3 - 180 °C; 4 - 170 °C

2. Conclusions

1. On the basis of the research shows the effectiveness of the method and means of control, allowing to obtain additional information about the quality of part-synthetic engine oils, including determining the propensity of oils to oxidation, evaporation, kinematic viscosity coefficient, resistance to thermal effects and potential resource.

2. Among oils studied the best performance set for partially-synthetic motor oil Zic A 10W-40 SL.

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