Study of the effect of the synthetic additive Monnol Elite 5W-40 SL/CF on the quality indicators of mineral motor oil M-10G2k

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Abstract. The results of a study of mixtures of mineral motor oil M-10G2k with 5% by weight of synthetic oil Monnol Elite 5W-40 SL/CF are presented. The effect of a synthetic additive on the optical properties, volatility, and coefficient of thermo-oxidative stability is established when testing a mixture in the temperature range from 180 to 160 °C.

Widely used in the operation of internal combustion engines are partially synthetic engine oils, starting properties of which exceed mineral oils. However, at present, there is no methodological basis for substantiating the ratio of the concentration of the components of the mixture. Therefore, the purpose of this study is to determine the effect of a synthetic additive not only on the starting properties of the oil, but also on their potential resource [1], [2], [3], [4], [5].

The purpose of these studies is not only to determine the effect of synthetic additives on starting properties, but also to determine the possibility of increasing the resource. The mineral oils M-10G2k and their mixtures with 5% by weight of Monnol Elite 5W-40 SL/CF synthetic oil were examined. [6].

The research technique is as follows [7-8]. A sample of the oil or a mixture of constant mass was subsequently thermostatically controlled at temperatures of 180, 170 and 160 °C with stirring by a mechanical stirrer with a rotation speed of 300 rpm. The temperature and speed of the mixer during the test were maintained automatically. The tests were terminated when the light absorption coefficient reached a value of 0.7-0.8. After every eight hours of testing, the samples of thermostated oils (commodity and mixtures) were weighed, the mass of the evaporated oil was determined and was taken for direct photometry, for calculation of the absorption coefficient of the light flux $K_a$ [7].

Figure 1 shows the results of the study of mineral motor oil M-10G2k and its mixture with 5% of the mass of synthetic motor oil Monnol Elite 5W-40 SL/CF in the temperature range from 180 to 160 °C. It was found that the synthetic additive reduces the rate of oxidation processes at a temperature of 180 °C, increases at a temperature of 170 °C and practically does not affect it at a temperature of 160 °C. Therefore, the synthetic additive is effective at high test temperatures. The dependences of the absorption coefficient of the light flux on time and temperature of the test undergo bending, regardless of temperature. This explains the presence of two types of oxidation products (primary and secondary) in oil with different optical densities. The beginning of the formation of secondary products is determined by the extension of the dependences after the bend point to the intersection with the abscissa.
axis. It can be seen that with a decrease in the test temperature, the beginning of the formation of secondary products increases. Moreover, the primary oxidation products are the basis for the formation of secondary products.

![Figure 1](image1.png)

**Figure 1.** Dependences of the light absorption coefficient on the time and temperature of testing the mineral motor oil M-10G2k (curve 1, 2, 3) and its mixture with 5% of the mass of synthetic Monnol Elite 5W-40 SL/CF (curve 1', 2', 3'): 1 – 180 °C; 2 – 170 °C, 3 – 160 °C.

The evaporation of mixtures (figure 2) decreases at temperatures of 180 °C and 160 °C, increases at 170 °C (curve 2').

![Figure 2](image2.png)

**Figure 2.** Dependence of volatility on time and temperature of evaporation of mineral motor oil M-10G2k (curve 1, 2, 3) and its mixture with 5% synthetic Monnol Elite 5W-40 SL/CF (curve 1', 2', 3'): 1, 1' - 180 °C, 2, 2' – 170 °C, 3, 3' - 160 °C.

The redistribution of thermal energy between the products of oxidation and evaporation was studied by increments of the absorption coefficients of light flux and volatility (figure 3 a and b). It is established that these indicators change either synchronously or asynchronously. Asynchronous changes in one of the indicators in the direction of increase indicates a more intense absorption of thermal energy in the direction of the oxidation or evaporation process. Synthetic additive increases the value of $\Delta K_a$ and $\Delta K_G$ at 170 °C.

The change in the viscosity of the M-10G2k oil and its mixture was estimated by the coefficient of relative viscosity $K_\mu$ (Figure 3c), determined by the ratio of the viscosity of oxidized oil and the viscosity of marketable oil.

A synthetic additive has practically no effect on the change in viscosity properties. There is a general tendency to increase viscosity both during testing of M-10G2k oil and its mixture.
Figure 3. Change in the increment of the light flux absorption coefficients $\Delta K_a$ (a), volatility $\Delta K_G$ (b), relative viscosity $K_\mu$ (c) versus the test time at temperature 1700°C of mineral motor oil M-10Г2к (curves 1) and its mixture (curves 2) with 5% by weight of synthetic Monnol Elite 5W-40 SL/CF.

The dependences of the thermal oxidative stability coefficient $K_{tos}$ on the time and temperature of the test (figure 4) have a similar tendency to change as the absorption coefficient of the light flux (figure 1). For a test temperature of 180 °C, the synthetic additive slows down the conversion processes, at 170 °C it accelerates, and at 160 °C it has no effect.

The relationship between the coefficients of thermo-oxidative stability and absorption of the light flux (figure 5) has a linear dependence and does not depend on the test temperature and the synthetic additive. This is due to the constancy of the composition of the resulting oxidation products.

Figure 4. The dependences of the coefficient of thermal oxidative stability on time and temperature of evaporation of mineral motor oil M-10G2k (curve 1, 2, 3) and its mixture with 5% synthetic Monnol Elite 5W-40 SL/CF (curve 1', 2', 3'): 1, 1' - 180 °C, 2, 2' - 170 °C, 3, 3' - 160 °C.
The regression equation has the form:

\[ K_{\text{tox}} = 1.08 \cdot K_a. \]

The rate of the conversion of thermal energy into conversion products is 1.08. The value of the coefficient of thermo-oxidative stability, at which the conversion of thermal energy begins, is zero. Thus, the synthetic additive does not affect the conversion processes, and the composition of the oxidation products does not depend on the test temperature or on the synthetic additive.

The ratio between the absorption coefficients of the light flux and evaporation was estimated by the coefficient \( K_E \) (figure 6). It was established that the dependences of the \( K_E \) coefficient on the test time are subject to fluctuations in its values both for M-10G2k oil and its mixture with a synthetic additive, which is caused by the redistribution of thermal energy. With a synchronous change in this indicator, thermal energy is simultaneously converted into the products of oxidation and evaporation, and with their non-synchronous change, thermal energy is spent on changing one of the indicators.

At a test temperature of 180 °C, the synthetic additive has an effect at the beginning of the test mixture, and at 170 °C it reduces the value of the coefficient \( K_E \) due to a more intensive increase in the evaporation process. At a temperature of 160 °C, the synthetic additive increases the \( K_E \) coefficient due to the less intensive evaporation process.

Fluctuations in the value of the coefficient \( K_E \) caused by the redistribution of thermal energy when testing engine oil and its mixture.

The effect of the synthetic additive to the mineral oil M-10G2k was studied by the coefficient of catalytic effect of \( K_{ce} \) (figure 7). It was shown that the synthetic additive is an inhibitor at a temperature of 180 °C and a catalyst at temperatures of 170 and 160 °C, and, at a temperature of 160 °C, the
The catalytic effect of the synthetic additive is insignificant (curve 3). In this regard, the synthetic additive Monnol Elite 5W-40 SL/CF is effective at temperatures below 160 °C and 180 °C and above.

Conducted experimental studies found:

- Based on the studies, it was found that the synthetic additive of motor oil Monnol Elite 5W-40 SL/CF to the mineral oil M-10G2k is an inhibitor at a test temperature of 180 °C and has virtually no effect on the conversion of thermal energy at a temperature of 160 °C and lower.
- A synthetic additive reduces the volatility of the mixture at test temperatures of 180 and 160 °C, and at a temperature of 170 °C it increases the volatility, in addition, it does not significantly affect the change in kinematic viscosity.
- At a test temperature of 180 °C, the synthetic additive slows down the oxidation processes, at a temperature of 170 °C it accelerates them, and at a temperature of 160 °C it has no effect.

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