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# PERFORMANCE ANALYSIS OF MINERAL AND SEMISINTETIC, SYNTHETIC OILS USED IN GAS PREPASSION AGGREGATES

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**Abstract**

This article analyzes the thermal oxidation resistance and operational properties of mineral semi-synthetic and synthetic oils used in gas pumping units at three different temperatures, analyzes their effect on compressor oil by changing the flow part in SGT-400 gas pumping units, and as a result, it was determined that expanding the flow part of the impeller extends the oil's operating time and does not negatively affect quality indicators.

**Keywords:** *oil, oxidation, mineral, semi-synthetic, synthetic, aviation fuel, temperature, density, optical density, logarithm*

Mineral and semi-synthetic aviation fuel oils used in practice were selected for the study.

A graphical method was proposed, allowing for the analysis of the subsequent dependence using graphical model calculations without long-term experimental studies obtained after the oxidation resistance test of oils, which allows for a reduction in costs and time by reducing the testing time (Mohammad Maher Kallas, Mohammad Saed Al Sabek, and Younes Saoud. 2024).

This method is aimed at determining the optical density *D*, evaporability *G*, and the temperature change indicator *Ptos*.

To increase the oil testing time at the selected temperature and to analyze the oxidation stability indicators of the lubricant, the results obtained over the same time interval are used. The decimal logarithm of the thermal energy absorbed by oxidation *ND* and evaporation products is then calculated (Kallas M. M., Sallam T., and Saoud Y., 2013). Evaporation is shown in Figures 1–3 based on the indicator of temperature changes $NPtos \cdot lgND = f(lgt)$, $lgNG = flgt$, $lgNPtos = f(lgt)$ a graph is generated based on the equation data. The values of optical density, evaporability, and temperature changes as the test time interval increases are analyzed according to the dependencies (Sangram J., Patil D., and Shrotri A., 2014).

Figure 1 shows the dependence of the decimal logarithm of the thermal energy absorbed by the oxidation products on the decimal logarithm of the time and temperature of the test oils under study. $lgND–f(lgt)$.

**Figure 1. Temperature dependence on oxidation at test temperatures for mineral and semi-synthetic oils:**
1 – MS –20 (180 °C);
2 – MS –20 (170 °C);
3 – MS –20 (160 °C);
4 – AeroShell Oil W l5W-50 (180 °C);
5 – AeroShell Oil W 15W-50 (170 °C);
6 – AeroShell Oil W 15W-50 (160 °C);
7 – MS-8P (180 °C);
8 – MS –8P (170 °C);
9 – MS –8P (160 °C)

The dependencies are described by linear equations for the studied temperatures:

For MS-20 oil:

160 °C $gN_D = 2{,}22\ lgt - 0{,}379$ (1)

170 °C $lgN_D = 2{,}41\ lgt - 0{,}286$ (2)

180 °C $lgN_D = 2{,}767\ lgt - 0{,}422$ (3)

The coefficient of determination is (160 °C) = 0,995; (170 °C) = 0,992; (180 °C) = 0,997.

AeroShell Oil W15 for W-50 oil:

160 °C $lgN_D = 2{,}734\ lgt - 1{,}705$ (4)

170 °C $lgN_D = 2{,}726\ lgt - 1{,}354$ (5)

180 °C $lgN_D = 3{,}05\ lgt - 1{,}401$ (6)

Coefficient of determination (160 °C) = 0.995; (170 °C) = 0.996; (180 °C) = 0.992.

For MS-8P oil:

160 °C $lgN_D - 2{,}269\ lgt - 1{,}037$ (7)

170 °C $lgN_D - 2{,}671\ lgt - 1{,}196$ (8)

180 °C $lgN_D - 3{,}189\ lgt - 1593$ (9)

Coefficient of determination (160 °C) = 0.992; (170 °C) = 0.998; (180 °C) = 0.998.

The calculation of the decimal logarithm analysis of the thermal energy absorbed by oxidation products for MS-20 oil at a test temperature of 170 °C is performed as follows: the *lgND* dependence for five values obtained from the oil test at 170 °C over the same time interval (8, 16, 24, 32, 40 hours) is as follows:

170 °C $lgND - 2{,}293\ lgt - 1{,}149$ (10)

can determine *lgND* values for subsequent test hours, e.g. 48 hours

$lgND - 2{,}293 \cdot 1{,}681 - 1{,}149 = 3.705$ (11)

Comparing the calculated values of *lgND* = 3.705 with the experimental value of *lgND* = 3.777, it was found that the relative error of the calculated value from the experiment is 1.9%.

Calculations were performed for all oils according to test values from three to ten for the decimal logarithm *lgND* absorbed by oxidation products of thermal energy (Singh G., Wani M. F., and Wani M. M., 2021).

The approximate results of the experimental and computational methods for determining the *lgND* indicator, with a relative error of no more than 6%, are presented in Formula 1.

Thus, to analyze the indicators of heat energy absorbed by oxidation products, it is sufficient to conduct five experiments, the duration of which is 40 hours (Dautrebande O. and Desreumaux B., 2003).

Figure 2 shows the dependence of the decimal logarithm of the thermal energy absorbed by the evaporation products on the decimal logarithm of the testing time and temperature of the studied oils. $lgNG = f\,(lgt)$

The dependencies are expressed by linear equations of the studied temperatures:

For MS-20 oil:

160 °C $lgNG = 2{,}018\ lgt + 0{,}705$ (12)

170 °C $lgNG = 1{,}768\ lgt + 1{,}137$ (13)

180 °C $lgNG = 1{,}386\ lgt + 2{,}009$ (14)

The coefficient of determination is (160 °C) = 0.994; (170 °C) = 0.994; (180 °C) = 0.999.

For AeroShell Oil W15W-50 oil:

160 °C $lgNG = 1{,}694\ lgt + 1{,}405$ (15)

170 °C $lgNG = 1{,}872\ lgt + 1{,}184$ (16)

180 °C $lgNG = 1{,}804\ lgt + 1{,}484$ (17)

The coefficient of determination is (160 °C) = 0.997; (170 °C) = 0.998; (180 °C) = 0.999.

For MS-8P oil:

160 °C $lgNG = 1{,}726\ lgt + 2{,}726$ (18)

170 °C $lgNG = 1{,}712\ lgt + 2{,}901$ (19)

180 °C $lgNG = 2{,}132\ lgt + 2{,}456$ (20)

The coefficient of determination is (160 °C) = 0.999; (170 °C) = 0.999; (180 °C) = 0.991.

**Figure 2. Time dependence of thermal energy absorbed by evaporation products at test temperatures for mineral and semi-synthetic oils:**
1 – MS-20 (180 °C);
2 – MS-20 (170 °C);
3 – MS-20 (160 °C);
4 – AeroShell Oil W l5W-50 (180 °C);
5 – AeroShell Oil W 15W-50 (170 °C);
6 – AeroShell Oil W 15W-50 (160 °C);
7 – MS-8P (180 °C);
8 – MS-8P (170 °C);
9 – MS-8P (160 °C)

Aero-Shell Oil W l5W-50 oil at a temperature of 160 °C according to five values obtained at the same time intervals (8, 16, 24, 32, 40) *lgNz=f(lgt)* the relationship has the following linear form:

160 °C $lgNG = 1{,}555\ lgt + 1{,}582$ (21)

*lgNG* value can be determined for subsequent test hours, e.g. 48 hours:

$lgNG = 1{,}555 \cdot 1{,}582 + 1{,}582 = 4{,}195$ (22)

Calculated *lgNG(hisob)*= 4,195 value obtained experimentally *lgNG(tajriba)*=4,252 value, it was determined that the relative error of the calculated value from the experiment is 1.3%.

Similarly, calculations were performed for the decimal logarithm of the thermal energy absorbed by the evaporation products using test values from three to ten. The results of the verification of the compatibility of the experimental and calculation methods are presented in Table 1, which show that the error does not exceed 4%.

Thus, to analyze the indicators of thermal energy absorbed by evaporation products, five experiments are sufficient, the duration of which is 40 hours.

The dependencies are described by linear equations for the studied temperatures.

For MS-20 oil:

160 °C $lgNPtos = 2{,}304\ lgt - 0{,}517$ (23)

170 °C $lgNPtos = 2{,}384\ lgt - 0{,}241$ (24)

180 °C $lgNPtos = 2{,}687\ lgt - 0{,}303$ (25)

The coefficients of determination are respectively (160 °C) = 0.996; (170 °C) = 0.991; (180 °C) = 0.995.

For AeroShell Oil W 15W-50 oil:

160 °C $lgNPtos = 2{,}833\ lgt - 1{,}89$ (26)

170 °C $lgNPtos = 2{,}923\ lgt - 1{,}706$ (27)

180 °C $lgNPtos = 3{,}085\ lgt - 1{,}46$ (28)

The coefficients of determination are respectively (160 °C) = 0.996; (170 °C) = 0.992; (180 °C) = 0.995.

For MS-8P oil:

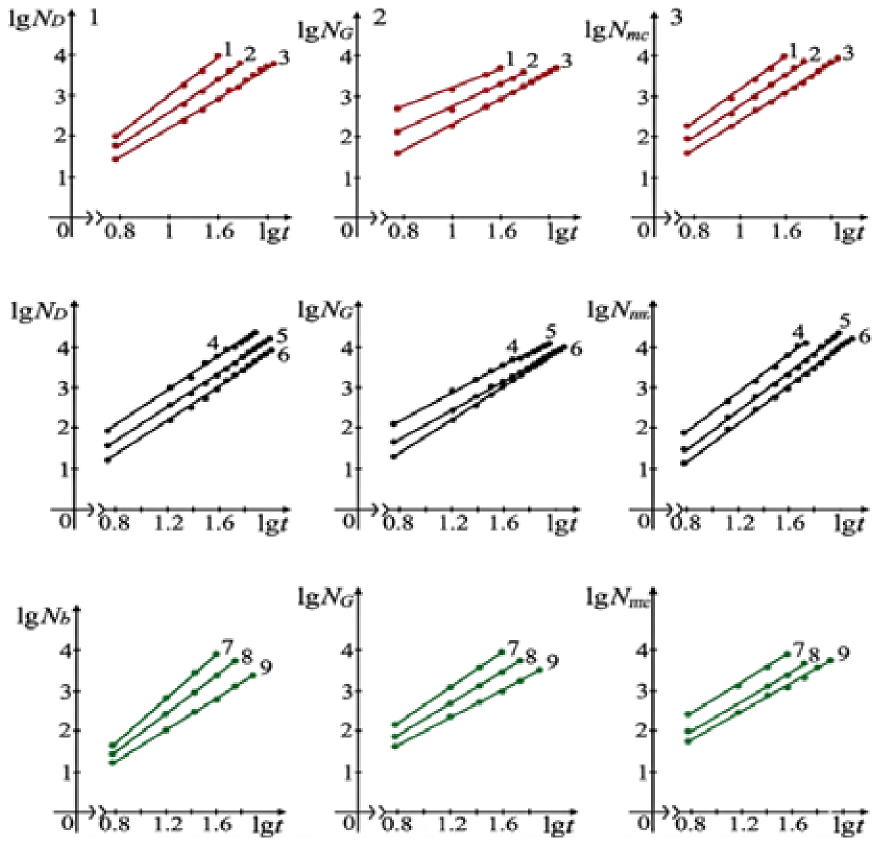
160 °C $lgNPtos = 2{,}221\ lgt - 0{,}307$ (29)

170 °C $lgNPtos = 2{,}196\ lgt - 0{,}089$ (30)

180 °C $lgNPtos = 2{,}342\ lgt - 0{,}233$ (31)

The coefficients of determination are respectively (160 °C) = 0.991; (170 °C) = 0.985; (180 °C) = 0.994.

**Figure 3.** *Shows the dependence of the decimal logarithm of the temperature change indicator on the decimal logarithm of the test time and temperature of the studied aviation fuel oils. lgNPtos=f(lgt)*



Dependence of the decimal logarithm of the temperature change indicator on the decimal logarithm of time under the conditions of testing mineral and semi-synthetic oils:

1 – MS-20 (180 °C); 2 – MS-20 (170 °C); 3 – MS-20 (160 °C); 4 – AeroShell Oil W 15W-50 (180 °C); 5 – AeroShell Oil W 15W-50 (170 °C); 6 – AeroShell Oil W 15W-50 (160 °C); 7 – MS-8P (180 °C); 8 – MS-8P (170 °C); 9 – MS-8P (160 °C)

Decimal logarithm of the temperature change indicator of MS-8P oil at a test temperature of 160 °C *lgNPtos* by five values (8, 16, 24, 32, 40) obtained as a result of oil testing at 160 °C *lgNPtos f(lgt)* the relationship has the following linear form:

$lgNPtos\ 2{,}089 \cdot lgt - 0{,}153$ (32)

lg*NPtos* in the next test hours, e.g. 48 hours:

$lgNPtos\ 2{,}089 \cdot 1{,}681 - 0{,}153 = 3{,}258$ (33)

Calculated $lgN_{Ptos}^{(hisob)}$= 3,358 value obtained experimentally $lgN_{Ptos}^{(tajriba)}$ = 3,405 compared to the value, the difference between the calculated value and the experimental value with a relative error is 1.39%.

Similarly, calculations were performed using test values from three to ten for the decimal logarithm of the temperature change indicator. $lgN_{Ptos}$

The results of the verification of the convergence of experimental and calculation methods are presented in Table 1, which show that the relative error does not exceed 5%.

Thus, five experiments with a duration of 40 hours are sufficient to analyze the indicators of temperature changes.

The results of the convergence of experimental and calculation data for mineral and semi-synthetic oils are presented in Table 1.

**Table 1.** *Results of the correspondence between experimental and calculated data*

| Number of points | MS-20 | | | AeroShell Oil W 15W-50 | | | MS-8P | | |
|---|---|---|---|---|---|---|---|---|---|
| | 160 °C | 170 °C | 180 °C | 160 °C | 170 °C | 180 | 160 °C | 170 °C | 180 °C |
| *lgND,* Density % | | | | | | | | | |
| Point 1 | 3,767 | 4,553 | 1,444 | 5,142 | 3,415 | 1,965 | 3,127 | 1,608 | 1,279 |
| Point 2 | 3,624 | 2,650 | 0,697 | 4250 | 3.195 | 1,085 | 2,682 | 0,777 | – |
| Point 3 | 2,622 | 1,440 | - | 4,133 | 2,359 | 0,513 | 1,104 | - | – |
| Point 4 | 1,325 | 0,857 | - | 4,062 | 2,184 | 0,486 | - | - | – |
| Point 5 | 1,181 | - | - | 3,753 | 2,178 | - | - | - | – |
| Point 6 | 1,104 | - | - | 2.857 | 2119 | - | - | - | – |
| Point 7 | 0,864 | - | - | 2,591 | 1,804 | - | - | - | – |
| Point 8 | 0,458 | - | - | 2,067 | 1,263 | - | - | - | – |
| *lgNG,* Evaporability % | | | | | | | | | |
| Point 1 | 1,453 | 1,233 | 0,379 | 4722 | 3267 | 0,206 | 0,252 | 0,215 | 0,852 |
| Point 2 | 1290 | 0,778 | 0,092 | 2,689 | 1,309 | 0,185 | 0,206 | 0,018 | - |
| Point 3 | 1,230 | 0,185 | - | 1733 | 0,633 | 0,028 | 0,189 | - | - |
| Point 4 | 1,204 | 0,153 | - | 1,382 | 0,309 | 0,006 | 0,024 | - | - |
| Point 5 | 0,933 | - | - | 1,097 | 0,112 | - | - | - | - |
| Point 6 | 0,655 | - | - | 0,829 | 0,054 | - | - | - | - |
| Point 7 | 0,578 | - | - | 0,686 | 0,054 | - | - | - | - |
| Point 8 | 0,525 | - | - | 0,530 | 0,007 | - | - | - | – |
| *lgNPtos,* Temperature variability % | | | | | | | | | |
| Point 1 | 1,864 | 4,611 | 1,888 | 4,383 | 5,065 | 2,862 | 1.798 | 3,403 | 2,242 |
| Point 2 | 1,748 | 2,730 | 0,849 | 4,246 | 3.705 | 2,679 | 1,176 | 2,316 | – |

| Number of points | MS-20 | | | AeroShell Oil W 15W-50 | | | MS-8P | | |
|---|---|---|---|---|---|---|---|---|---|
| | 160 °C | 170 °C | 180 °C | 160 °C | 170 °C | 180 | 160 °C | 170 °C | 180 °C |
| Point 3 | 1,739 | 1,498 | - | 3,667 | 3437 | 1,581 | 0,868 | – | – |
| Point 4 | 1,597 | 0,876 | - | 3,455 | 3,074 | 0,489 | 0,162 | – | – |
| Point 5 | 1,509 | - | - | 2,341 | 3,064 | - | – | – | – |
| Point 6 | 1,289 | - | - | 2,185 | 2,446 | - | – | – | – |
| Point 7 | 0,952 | - | - | 1,681 | 1719 | - | – | – | – |
| Point 8 | 0,840 | - | - | 1,423 | 1,173 | - | – | – | – |

Casting stability of mineral and semi-synthetic oils depending on temperature and testing time. Thus, as seen from the table above, the oil samples taken for the study were tested at three temperature ranges and by three parameters (density, viscosity, changes under the influence of temperature). As seen from the test results, as a result of operating the unit under load, all three oil parameters change, which in turn has a serious negative impact on the friction parts of this unit; the oils cannot perform the functions of lubrication and cooling of the unit parts, and it should be noted that as the temperature increases, the indicators change in a negative direction. Based on the above, we conclude that the loads during the operation of the unit are directly proportional to the composition and quality of the oil, i.e., by reducing the load while maintaining the quality of the oil and increasing the operating time of its parts, it is possible to increase the intervals of repair work in the units.

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