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# Control of indexes of thermal-oxidative stability of mineral engine oil in severe service conditions

V I Afanasov, A S Lunev, A N Sokolnikov, V I Vereshchagin and V V Abramov

Siberian Federal University, 79, Svobodny Avenu, Krasnoyarsk, 660041, Russia.

E-mail: Skg63@mail.ru

**Abstract** The power units of quarry machinery use hydraulic fluids having various bases. That increases the temperature range of the use of this equipment. The cornerstone affecting oil life is the boundary layer temperature on the friction surface while in operation. The catalysts of combustion are oxygen, destruction, and chemical reaction if the oil comes in contact with the metal.

## 1. Introduction

There is a limit to the temperature range of mineral oils. The lubricity of mineral oils sudden decline at high temperatures, and the viscosity increases rapidly at low temperatures. That makes it difficult starting of motor, reduces the lubricity, and it leads to flow fracturing. Mineral oils have a limited operating time range at high temperatures. That leads to the setting of tarry sediment. This sediment contaminates the filter elements, and it covers the internal walls of the system and on the working surfaces of the equipment. All of these things may result in equipment derangement. The ignition temperature of many hydraulic fluids based on mineral oils does not exceed 100-180 °C.

Engine oils having different bases extensive use in various self-propelled vehicles operating in severe conditions and a high-temperature range. There was research on mineral motor oil M-10G2k, as well as on M-8G2 that both produced in Russia for this purpose. Engine oils M-10G2k and M-8G2 are known as diesel ones because of the frequent use of this type of equipment operating in severe climatic conditions. The main difference between these types of oils is the presence of additives, their quantity, and quality. Oils differ according to operating temperature and viscosity.

## 2. Research subject and technique

The purpose of this research is the determination of the effect of temperature on oils life. These oils used in the equipment operating in severe conditions have a different makeup, for example, mineral oils M-10G2k using in summer and M-8G2 in winter. It is necessary to complete an action plan for warming up the hydraulic fluid before the operation when working in winter. The main difference between these oils is the temperature of its immobilization.

There are researches conducted at a temperature of 180 °C. That helps to reduce the testing timing and determine the necessary parameters to find the oil having the best operational capability. There are some researches to find differences in the oil performances in the high-temperature range [1].

There are testing means used for the research, such as an apparatus for thermal oxidation of oil, a photometric device. A low-capacity viscometer and an electronic scale can be the example of those means too. That allows performing the necessary calculations to determine the indexes [2].

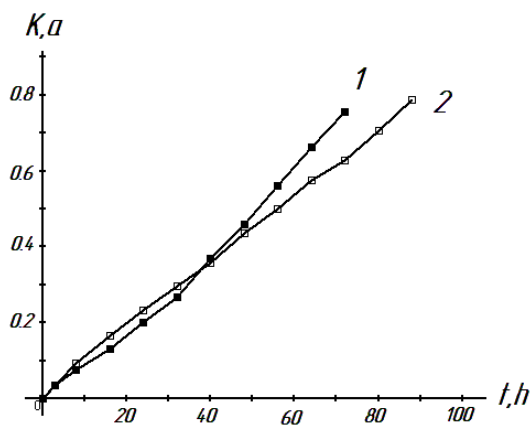
The research technique is as follows [2-6].



Fixed-mass oil sumps ages at a temperature of 180 °C while stirring by a mechanical agitator having a rotation speed within 300 rpm for uniform mixing. That helps to achieve the same temperature conditions throughout the oil volume with oxygen access. This test mode is in principle for machines having largish access to air as an oxidizer when operating by heavy equipment. The temperature and rotation frequency of the agitator hold automatically to achieve heating of the oil during the test. Moreover, after every eight hours of testing oxidized oils sumps scales, the evaporated oil mass was defined. About 2 g of the sump uses for direct photometry. That helps to calculate the light flux extinction coefficient  $K_n$ , the photometric layer thickness having an optimal means of 2 mm. When the absorbance is less than 80 upon photometer reading, the oil oxidation process stops figure 1.

$$K_n = \frac{300-P}{300}, \tag{1}$$

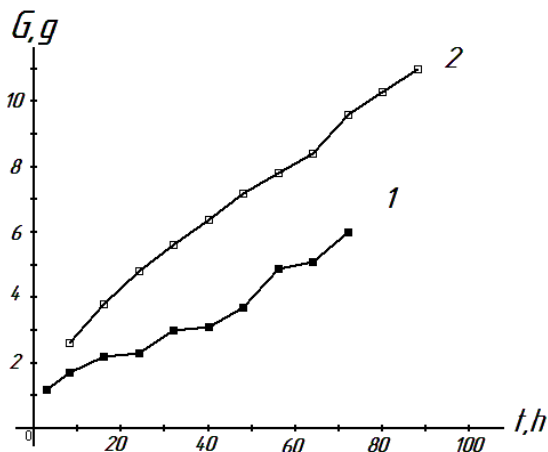
where 300 – readings by a candle power meter while there is no oil in the liquid cell,  $\mu A$ ; P – readings by a candle power meter with an oil-filled liquid cell,  $\mu A$ .



**Figure 1.** Dependence of light flux extinction coefficient on the time and testing temperature of 180 0C of mineral motor oil 1 - M-10G2k and 2 - M-8G2.

As a result of the graph construction, the correlation factor of the light flux assumes a value between 0.999 and 0.998, which makes it possible to talk about the linear dependence of the results [7].

9 g of the oxidized oil sump uses for measurements of the kinematic viscosity. After measuring, oil sumps flows down from a photometer cell and the viscosity meter into the cup of the device for further eight-hours testing. Part of the oil remains in the cells during the measurements, and repeated weighing of the glass with oil allows taking into account these losses figure 2.



**Figure 2.** Dependence of oil separation on time and evaporation temperature of mineral motor oil 1 - M-10G2k and 2 – M-8G2 equaling 180 °C.

The thermo-oxidative stability of the researched  $K_{tos}$  mixtures is defined by the sum of

$$K_{tos} = K_G + D \tag{2}$$

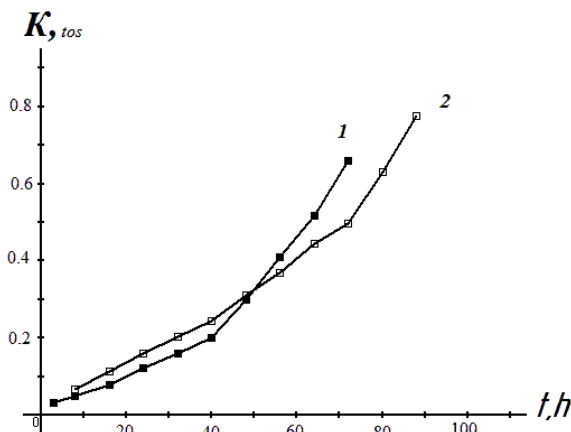
where  $K_G$  – evaporation number;  $D$  – density factor.

$$K_G = \frac{m}{M}, \tag{3}$$

where  $m$  – mass of evaporated oil in a time  $t$ , g;  $M$  – mass of oil sump before testing, g.

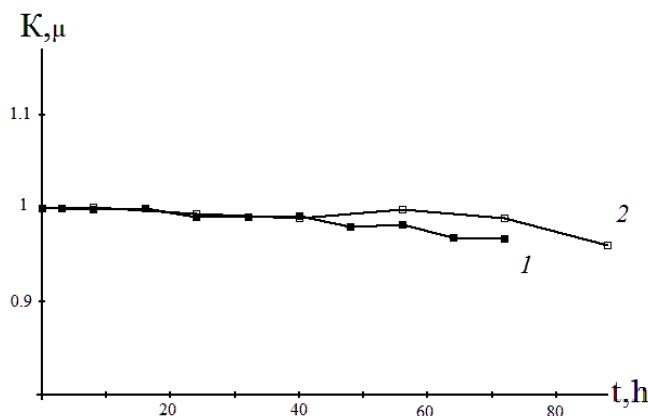
The thermo-oxidative stability coefficient represents the amount of heat energy absorbed by the oxidation products and evaporation during oil research.

Evaporation of M-8G2 oil is more intense and uneven at 180 °C than one of M-10G2k since the manufacturer makes this oil for summer. It is essential to pay attention to the oil level in the operating equipment when the M-8G2 oil in use.



**Figure 3.** Dependence thermal-oxidative stability coefficient on the light flux extinction coefficient and the testing temperature equaling 180 °C for mineral motor oil 1 - M-10G2k и 2 - M-8G2.

Dependence of the thermo-oxidative stability coefficient on the time and testing temperature figure 3 shows that these two oils behave alike at test temperatures of 180 °C. Arcs of these oils have differences at the initial phase of the test and the end of the research.



**Figure 4.** Stepping of the extinction coefficient of relative viscosity  $K_{\mu}$  on the test time at a temperature of 180 °C of mineral motor oil 1 - M-10G2k and 2 – M-8G2

The relative viscosity coefficient determined by the ratio of oxidized oil viscosity to the market grade oil one figure 4 estimates the kinematic viscosity. Concerning this parameter of these two oils, the viscosity of the M-10G2k decreases after 40 hours of oxidation, and one of the M-8G2 remains at a sufficient level.

### 3. Conclusion

The use of one or another mineral motor oil is not particularly affecting the operability of heavy equipment because of their similar features. Making a seasonal choice and taking into account climate, it estimates to consider the recommendations of the equipment manufacturer and quality of the produced oil. Several companies produce this oil in Russia. Each manufacturer setting down its composition or quantity of additives, the oil quality has a slight difference in the oxidation processes as a result of the research. This type of oil is most suitable for use in a moderate climate or more southern part of Russia, where excludes low abnormal temperatures [8].

The indexes of mineral oil M-10G2k will be more stable than the ones of oil M-8G2, when operating in a high-temperature range. The claimed winter oil viscosity is more persistent than that of M-10G2k at the long-term operating time. But the evaporation processes of this oil occur more intensively at high temperatures than that of M-10G2k.

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