DEPENDENCE OF CHANGES IN THE PROPERTIES OF MOTOR OILS ON THE OPERATING CONDITIONS OF THE ENGINE

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https://doi.org/10.5281/zenodo.7809889

Annotation
The purpose of this work is to study the performance characteristics of the
M-10V₂ engine oil used in diesel engines. During the operation of the controlled vehicles, tests of samples of fresh oil, working and spent with mileage recording were carried out. The main physical and chemical parameters of properties (viscosity, alkaline number, dispersing and stabilizing ability, moisture content, fuel, mechanical impurities, ash content, etc.) affecting the operational characteristics of the oil have been studied.
Keywords: engine oils, additives, oxidation, sedimentation, varnish deposits, carbonaceous particles.

Rational use of motor oils is one of the most difficult problems of using petroleum products. In recent years, the idea of lubricating oils as an engine design element has become increasingly widespread and recognized. The diesel-oil-oil system complex is in constant interaction, and the oil undergoes continuous quantitative and qualitative changes.

Quantitative oil changes are caused by carbon monoxide and depend on the engine design. A number of physical and chemical processes lead to qualitative changes called oil aging. The most important of them are the oxidation of oil with air oxygen, oil contamination with insoluble impurities, the operation of multifunctional additives.

Knowing the patterns of behavior and changes in the operational properties of engine oil, it is possible to use it more effectively in engines, to scientifically justify the timing of its change. Of particular importance in this case are the operating conditions.

Currently, the service life of the oil is set by the manufacturers regardless of the specific working conditions. It is known from the literature that determining the optimal timing of oil change in engines is an important and complex task of chemmotology, solved only on the basis of in-depth research in actual operating conditions.

The purpose of this work is to study the performance characteristics of the M-10V$_2$ engine oil used in diesel engines. During the operation of controlled vehicles, studies of samples of fresh oil, working and spent with mileage recording were carried out.

The main physical and chemical parameters of properties (viscosity, alkaline number, dispersing and stabilizing ability, moisture content, fuel, mechanical impurities, ash content, etc.) affecting the operational characteristics of the oil have been studied.

During operation, the viscosity of the oil changes both in the direction of increase and in the direction of decrease. This is due to changes in the structural and group composition, the ingress of fuel and mechanical impurities.

Group chemical composition: base, commercial and waste oil M-10V$_2$

IBAST | Volume 3, Issue 4, April

Oil name	Paraffin-naphthenic hydrocarbons, %	Light aromatic hydrocarbons, %	Medium aromatic hydrocarbons, %	Heavy aromatic hydrocarbons, %	Resins, %	Losses, %	Total, %
Base oil M-10V$_2$	59,2	21,0	18,3	-	1,3	0,2	100,0
Waste oil M-10V$_2$	54,0	21,0	18,3	-	4,5	2,0	100,0

In accordance with the recommendations for diesel engines, the main rejection indicators for oil change are the following:
- decrease in viscosity by one class, or increase in viscosity by 40% compared to fresh oil;
- increasing the content of pollutants to 2.0% by weight;
- reduction of the alkaline number to 4.5;
- increase of water content up to 0.3% by weight;

The oil change should be carried out when one of the rejection indicators reaches the limit value. The analysis of the obtained data on the operation of M-10V$_2$ oil in a diesel engine is presented in Table 1.

Table 1.

Car mileage, km	Kinematic viscosity at 100^{0}C, cSt	Flash point, ^{0}C	Ash content, %	Alkaline number, mg KOH/g	Hydrogen index	Fuel content,, %	Content of mechanical impurities ,%
0	10,87	236	1,408	8,70	9,45	-	-
1000	10,74	230	1,289	7,38	8,52	1,2	0,341
2000	10,81	225	1,307	6,77	7,61	1,3	0,889
3000	10,54	225	1,315	6,32	7,56	1,3	1,065
4000	10,67	210	1,333	6,10	7,40	1,6	1,502
5000	10,77	205	1,340	5,91	7,53	1,6	1,608
6000	10,64	194	1,372	5,74	7,60	0,80	1,687
7000	11,69	190	1,302	4,99	7,21	0,8	1,739
8000	13,85	180	1,202	3,85	6,45	0,65	2,022

By the ash content of the oil, it is possible to judge the content and composition of the metal-containing ash additives introduced into it. Due to the addition of fresh oil, the ash content remains at a fairly high level. Very important indicators of oil quality and its operability are alkalinity and hydrogen index – the main criteria for evaluating the effectiveness of the additive. The decrease in alkalinity is associated with its expenditure on the neutralization of acidic compounds, the deposition of additives on engine parts. It occurs most intensively in the initial period, and then somewhat stabilizes. The hydrogen index>5 indicates the absence of strong acids in the oil.

The content of mechanical impurities is of considerable interest. Oil pollution intensifies when air and oil purification systems malfunction, which makes it possible for dust to enter, which increases the abrasive wear of engine parts. The content of mechanical impurities increases with the mileage of the engine, but there is no pattern for individual spent samples, which is apparently due to the different operation of filters after maintenance and oil change.

The oxidation of the oil at the first stages of its operation occurs under the influence of high-temperature gas flows bursting out of the combustion chamber. Compounds with the greatest affinity for oxygen appear in the oil, as well as those that have already reacted and are not involved in further oxidation. As a result, the oxidation process begins to slow down, and stabilization occurs.

For the purpose of a deeper study of changes in the structure of oil, it is advisable to determine separately their combustible and non-combustible part, that is, the content of organic and inorganic components. The non-combustible part of mechanical impurities consists of wear products of various compositions and road dust penetrating into the crankcase oil. The combustible components are mainly products of secondary origin formed as a result of oil oxidation.

In the oil, those molecules remain unchanged, which, due to the peculiarities of their structure, are characterized by high antioxidant stability. Since the process takes place both in the volume of the oil system and on the surface of the engine parts, the metal catalyzes both oxidation and polycondensation reactions, and the content of oxyacids and asphaltenes reaches 40-60% by weight from all oxidation products.

The dispersing and stabilizing ability (DSA) of the oil is determined by the drip test method - paper chromatography. A drop of the working oil is applied to the filter paper. After 2-4 hours, a chromatogram is used to evaluate the results.

The DSA is influenced by the temperature of the analysis, at room temperature (20^{0}C DSA allows us to judge the ability of the oil to form precipitation on the filters and in the crankcase of the engine. DSA at 200^{0}C characterizes the ability of the oil to cause carbon deposits on the hot surfaces of the engine.

Dispersing and stabilizing ability (DSA)oils

Car mileage, km	Dispersing and stabilizing ability at temperature			
	20^{0}C	100^{0}C	150^{0}C	200^{0}C
0	1,000	1,000	1,000	1,000
1000	0,788	0,687	0,649	0,609
3000	0,678	0,668	0,645	0,602
5000	0,651	0,640	0,636	0,590
8000	0,563	0,559	0,551	0,540

With an increase in the mileage of the car, the DSA drops. However, like the change in other indicators, after 5000-8000 km of mileage, it practically stabilizes and remains at the same level. Analyzing the oil test data in diesel engines of cars, the following conclusions can be drawn:

-oil in the initial period of operation dramatically changes almost all physical and chemical parameters, but then their stabilization and preservation of operational properties occur within the limits allowed by the norms;
-the consumption of the additive (alkalinity, DSA) ensures the maintenance of the working condition of the oil in the engine;
-refusal to change the oil at a predetermined time, the transition to a change according to its actual condition should lead to significant oil savings and improved engine operation.
To reduce the intensity of contamination of engine parts by oxidation products, effective dispersing additives are introduced into the oil. We conducted a study of samples of industrial oils M-10V_2 with a sulfonate additive SK-3. The advantage of this additive compared to other additives, it is quite effective and stable at relatively high temperatures. To conduct experiments, the M-10V_2 engine oil with the added sulfonate additive SK-3 was analyzed according to physico-chemical parameters for compliance with the requirements and the physico-chemical parameters of the engine oil for different concentrations of additives were determined.

According to the results of laboratory tests, when introducing the SK-3 additive 9% into the M-10V_2 engine oil, the physico-chemical indicators gave a positive result compared to the M-10V_2 base oils. When using such an additive, the service life of the engine oil will increase and which can also lead to a decrease in the wear of the piston rings by 3-4%.

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