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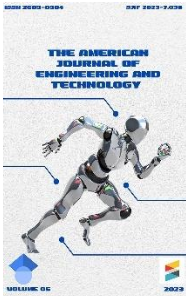

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Research Article

STUDY OF THE EXPLOITATIVE PROPERTIES OF THE DEVELOPED ADDITIVES AND THEIR APPLICATION

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ABSTRACT

Naphthalene additives, as indicated in the literature review, are classified as detergent additives. Additives of this type are primarily used in engine oils. It is known that the composition of the "D" group oil should include an effective package of additives to achieve the level of performance properties, which ensures long-term performance of the most forced engines especially in severe operating conditions. To date, there is no universal method for assessing the behavior of oil at high temperatures, therefore oil is usually tested via several (laboratory and stand) methods. For example, in domestic practice, a four-stage system for determining the quality of newly created (experimental) oil products is provided.

KEYWORDS

Naphthalene, additives, sulfur, phenate, viscosity, sulfonate, engine, density, oxidation, dithiophosphate additives, synthetic sulfonate additive, alkaline, engine oils.

INTRODUCTION

Purpose of the study. Considering that the additives PDj-2 and PDj-3 do not contain sulfur, they can be promisingly used in Mid- and Low SAPS motor oils, as well as in those oil compositions where sulfur-containing phenates are currently used. In this regard, this study is aimed to test the additives PJ-2 and PJ-3 in the composition of engine oil for diesel engines of a high group (D), and to compare the test results with the commercial oil M-10DM, which includes a sulfur-containing phenate additive K-36.

Objects and methods of research. To assess the properties of the studying additives, samples of oil of the "D" - M-10DM group were prepared in which the studied additives replaced the commercial sulfur-containing phenate additive. In addition, samples of M-

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10DM oil were studied using various commercial sulfonate additives to find the most successful compositions. Taking into account that the other components of the oil were unchanged, the main attention was paid to assess the effectiveness of the investigated detergents, which was expressed in determining the high-temperature properties of the tested oil samples with new additives. Evaluation of the high temperature properties of an oil is one of the most important characteristics of engine oils. When the oil is operating in the engine, the oil is oxidized both in volume and on the surface of heated parts resulting the formation of varnish and carbon deposits on the surface of the parts.

At the first stage, the fundamental possibility of using fuels and lubricants in the technical sphere is determined taking into account the general design features of the latter; on the second – the influence of fuels and lubricants on the reliability of equipment itself; on the third – the influence of fuels and lubricants on the running characteristics of machines and mechanisms, and on the fourth – the frequency of maintenance of equipment during its operation on the given fuels and lubricants [3].

Taking into account the duration and high cost of tests at II-IV stages, modern standards imply the limitation the scope of testing mainly to I stage without reducing the objectivity of the final results, if possible [4]. Therefore, in this study, the oils with the tested additives were considered within the limits of the I-II stage of tests.

Further, in accordance with the approved Plan of the Scientific and Production Enterprise (SPE) "Qualitet" LLC according to the technology for the production of additives PDj-2, PDj-3 and assessment of the functional and performance characteristics of the additives, the anti-corrosion and antioxidant properties of oils determined with the involvement of the tested additives at the DK-NAMI unit.

Results of the study and discussion. Samples of oil M-10DM (sulfur-containing additives K-33, K-36 and OLOA-219 from Chevron were used as phenates) with the use of a sulfonate oil additive KND and with the use of a synthetic sulfonate additive manufactured by SPE "Qualitet" were oxidized in accordance with GOST 11063 for 60 hours (normal for oils of group "D") after which the results of oxidation were compared. Data are shown in Tables 1 and 2.

Table 1

Results Of Oxidation Of M-10DM Oil Prepared With The Use Of KND And Various Phenate Additives According To GOST 11063

Sample number % additive input	№1 K-36	№2 PDj-3	№3 OLOA-219	№4 PDj-2	№5 K-33
phenate	1,0	1,0	1,0	1,0	1,0
Sulfonate oil additive	3,8	3,8	4,15	4,43	4,43
Sediment after inductive period of sedimentation (IPS) testing (%)	0,063	0,068	0,067	0,078	0,073
Norm of IPS, GOST 11063	0,5	0,5	0,5	0,5	0,5

As can be seen from Table 1, all M-10DM samples withstand oxidation on the DK-NAMI installation (according to GOST 11063) and the amount of sediment after oxidation for all samples lies in a fairly narrow interval.

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Table 2

Results of oxidation according to GOST 11063 of M-10DM oil prepared using alkaline sulfonate additives and phenate additives

Sample number/ % additive input	№1 PDj-2	№2 PDj-3	№3 K-36	№4 PDj-3
Phenate	1,1	1,0	1,0	1,0
Alkaline sulfonate 1	1,33	1,1	1,2	-
Alkaline sulfonate 2	-	-	-	1,35
Sediment after testing IPS (%)	0,023	0,015	0,016	0,018
Norm of IPS, GOST 11063	0,5	0,5	0,5	0,5

The data given in Table 2 also indicate that the studied samples withstand 60 hours of oxidation according to GOST 11063. However, if we compare the % sediment content, then the sediment in the sulfonate oil additive samples is greater than in the samples with alkaline sulfonate additives. In this regard, for further tests, 4 samples of M-10DM oil were prepared using alkaline sulfonate additives.

In accordance with GOST 8581, rev. 1-11, the physicochemical parameters of these samples were determined (see table 3).

Table 3.

The quality of motor oil for auto-tractor engines M-10DM in accordance with GOST 8581 rev. 1-11

№	Name of quality indicators	Sample №1	Sample №2	Sample №3	Sample №4	Norm of GOST 8581	Test method
1	Kinematic viscosity at 100 °C, mm^2/s	11,92	11,90	11,89	12,08	Not less than11,4	GOST 33
2	Viscosity index	90	90	90	94	Not less than 90	GOST 25371
3	Mass fraction of mechanical impurities, %	0,0081	0,0083	0,0085	0,008	Not more than 0,025	GOST 6370 and GOST 8581/4.2
4	Mass fraction of water, %	absent	absent	absent	absent	absent	GOST 2477
5	Flash point in open crucible, °C	246	242	245	247	Not less than 220	GOST 4333
6	Solidification temperature, °C, minus	18	18	18	18	No higher than minus 18	GOST 20287

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№	Name of quality indicators	Sample №1	Sample №2	Sample №3	Sample №4	Norm of GOST 8581	Test method
7	Corrosion resistance on plumbum plates, g/m^2	absent	absent	absent	absent	absent	GOST 20502 method A, type 2
8	Alkaline number, mg KOH per 1 g of oil	9,05	9,43	9,36	9,50	Not less than 8,2	GOST 11362
9	sulphated ash, %	1,13	1,29	1,25	1,29	Not more than 1,5	GOST 12417
10	Stability over the IPS within 60 hours at 200 ^{o}C	Satisfy (0,027)	Satisfy (0,016)	Satisfy (0,016)	Satisfy (0,019)	Satisfy (0,5)	GOST 11063
11	Color on the CNT colorimeter diluted in the ratio 15:85, CNT units	2,0	2,0	2,0	2,0	Not more than 3,5	GOST 20284
12	Density at 20 ^{o}C, g/sm^3	0,8905	0,8900	0,8915	0,8885	Not more than 0,905	GOST 3900
13	Mass fraction of active elements, % • calcium • zinc	0,30 0,096	0,33 0,096	0,33 0,099	0,33 0,096	Not less than 0,30 Not less than 0,09	GOST 13538

The data given in Table 3 indicate that all four experimental oil samples meet the requirements of GOST 8581 with rev. 1-11.

Table 4.

Change in optical density on blue (Ds) and red (Dk) light filters of M-10DM oil samples during their oxidation by the VKO method

Samples №	0 h		1 h		2 h		3 h	
	Ds	Dk	Ds	Dk	Ds	Dk	Ds	Dk
M-10DM sample №1	0	0	0,191	0,020	0,382	0,052	0,641	0,076
M-10DM sample №2	0	0	0,151	0,016	0,332	0,054	0,511	0,061

M-10DM sample №3	0	0	0,272	0,024	0,461	0,049	0,782	0,082
M-10DM sample №4	0	0	0,253	0,027	0,435	0,049	0,578	0,053
M-10DM commercial 1	0	0	0,062	0,021	0,238	0,039	0,565	0,064
M-10DM commercial 2	0	0	0,082	0,022	0,375	0,052	0,601	0,071
M-10DM (DF-11-2%)	0	0	0,221	0,053	0,525	0,092	0,815	0,138
M-10DM (CD-7 – 1%)	0	0	0,215	0,052	0,511	0,092	0,733	0,156

These samples of M-10DM oil were subjected to high-temperature catalytic oxidation according to the Shore method (VKO). This setup is believed to be able to predict oil behavior with high accuracy in a real engine. Installation picture is shown in Appendix 1. Tables 4 and 5 show the results of comparative tests by the Shore method (VKO) of prototypes and commercial oils M-10DM of different composition.

According to the data given in Table 4, it can be concluded that with an increase in the oxidation time, the optical density value of all tested samples increases. At the same time, according to this indicator, the values of the prototypes are close to the values of two commercial samples of M-10DM oils: the value of Ds of samples 1,2,4 lies in the range of 0.512-0.640, for commercial oils the range of Ds is 0.564-0.602; the Dc value of sample No. 3 is slightly higher and is 0.780 (reference sample prepared using a sulfur-containing phenate additive).In prototypes M-10DM with different dithiophosphate additives, the Dk values are higher - from 0.731 to 0.817. According to the Dk indicator, the same pattern can be traced as for the Dc indicator (samples 1, 2, 4 have values comparable to commercial oils, sample 3 has a higher value, and, finally, the Dk indicator for M-10DM on different dithiophosphates exceeds the values of all above oil samples).

Table 5.

Change in the base number of M-10DM oil samples during their oxidation by the VKO method

Sample number /alkaline number. mg KOH/g	Sample 1	Sample2	Sample3	Sample4	Commercial oil 1	Commercial oil 2
Before oxidation	9,03	9,42	9,33	9,52	9,38	9,30
After 3 hours oxidation	3,8	4,4	4,2	4,2	3,8	4,1
Kinematic viscosity at 40°C, mm^2/s, before oxidation	123,2	122,2	122,3	122,0	122,2	122,1
Kinematic viscosity at 40°C, mm^2/s, after oxidation.	140,0	138,9	140,2	140,6	140,2	143,2

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Viscosity increase, %	12,6	13,5	14,4	14,2	14,0	15,4

As can be seen from the data shown in Table 5, the base number level, the increase in viscosity before and after oxidation in all tested samples is very close, which indicates that the high-temperature properties of the prototypes determined on the Shore installation (VKO) and samples of commercial oils are on the same level.

CONCLUSIONS

When testing samples in an IKM-40 K setup in accordance with TU 38.401.405, samples 1, 2, 4 exceed sample 3 value in all specified indicators. Compared to M-10DM commercial oil (there is a K-36 additive) its composition), the M-10 DM prototype is an improved tribological one, with the addition of PJ-3 showed the characteristics;

The possibility of replacing phenate sulfur supplements containing group D oils, which have laboratory and bench-study methods, with ecologically clean sulfur-free supplements based on alkalines showed. Given that the created additives meet the requirements of Mid- (mid) and Low- (bottom) SAPS oils, they can be used prospectively in these oils.

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