INVESTIGATION OF ANTIOXIDANTS AND CARBON DEPOSITION SUPPRESSANTS IN CARBURETOR AND DIESEL ENGINES

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Improvement of the carbon deposition properties of present-day motor oils is being accomplished mainly through the use of detergent and dispersant additives of the sulfonate, alkylsalicylate, succinimide, and other types [1]. Improvement of the antioxidant and antiwear properties of these oils is achieved through the use of additives of the zinc dialkyldithiophosphate type.

In the process of developing lube oils, due consideration must be given to the efficiency of various types of additives when the oils are tested in both carburetor and diesel engines. Results from tests on oils containing complex additive packages often fail to give any valid information on the individual efficiency of each of the additives.

In the present study, we have attempted to obtain comparative ratings of the efficiencies of certain additives with respect to the antioxidant and carbon deposition properties in carburetor and diesel engines. The additives used in these tests were the overbased calcium alkylsalicylate MASK (concentrations 3%, 6%, and 9%), medium-alkalinity calcium sulfonate PMSya (concentrations 3% and 6%), succinimide additives S-5A and SVbor (concentration 3%), and zinc dialkyldithiophosphate DF-11 (concentration 1.2%). Also tested were various combinations of these additives. The concentrations chosen for test were based on the concentrations actually used in various motor oils. The additives were blended in a DS-11 lube base stock (TU 38-101-523–72) produced from medium-sulfur crudes. The tests were performed in single-cylinder units with carburetor and diesel engines.

The method used to determine the antioxidant properties was one developed in application to an IKM unit with a UD-1 carburetor engine. This method consists essentially of testing the oil for 40 h in the IKM unit, rating the antioxidant properties on the basis of the change in oil viscosity. Along with the antioxidant properties, the carbon deposition suppressant properties of the additives were rated in the IKM unit on the basis of the "index of deposits" (deposit demerit rating), as characterized by the mobility of the piston rings and the quantity and color of deposits on the piston. The test procedure and operating conditions for oil tests in the IKM unit are described in the standard GOST 20457–75.

The carbon deposition suppressant properties of the additives were also determined by a procedure developed for an IDM unit with a diesel engine. By means of 60-h tests in this unit, carbon deposition characteristics can be rated not only for commercial lube oils, but also for individual additives present in the oils, on the basis of the ring mobility and the quantity and color of deposits on the piston. The test procedure and operating conditions for oil tests in the IDM unit are described in [2].

Oils are subjected to greater thermal stresses in the IDM unit than in the IKM. With a coolant temperature of 160°C, the temperature in the No. 1 ring groove in the IDM unit will vary within the range 280-290°C, whereas in the IKM unit it is 240-250°C. The tests in the IKM unit were conducted with a cylinder temperature of 200°C. This temperature was attained by throttling the cooling air.

The higher piston temperature in the IDM unit in comparison with the IKM unit is explained by the better conduction of heat from the ring zone by the aluminum piston used in the IKM unit. In both the IKM and IDM tests, the conditions were made more severe by eliminating the oil makeup during the test period. The test results on the various additives in the IKM and IDM units are presented in Tables 1 and 2.

The data listed in Table 1 indicate that the most effective antioxidant is the MASK. When this material is added to the base oil in quantities of 3% and 6%, the viscosity increase is reduced from 110% to 72% and 33%, re-

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TABLE 1. Test Results on DS-11 Oil (TU 38-101-523-75) Containing Various Combinations of Additives in IKM Unit

Oil + additive	Ring mobility demerit rating	Color rating of piston deposits		Quantity of deposits on piston, g	Deposit demerit rating	Viscosity increase, %
		in ring zone	on piston skirt			
DS-11 oil (without additive)	5,0	10,0	7,5	3,2	15,0	110
Same + 3% MASK	2,0	4,5	0	0,4	5,5	72
Same + 6% MASK	0	4,0	0	0,3	4,5	33
Same + 9% MASK	0	4,0	0,5	0,7	4,5	28
Same + 3% PMSya	3,0	6,5	0,5	2,5	9,5	200
Same + 6% PMSya	2,0	4,5	0,	1,1	6,0	210
Same + 3% S-5A	2,5	8,9	2,6	0,9	10,8	119
Same + 3% SVbor	2,5	8,0	2,9	0,7	9,4	111
Same + 1,2% DF-11	2,8	9,2	4,3	1,2	11,8	92
Same + 3% SVbor + 1.2% DF-11	2,0	7,0	1,4	0,8	8,4	95
Same + 3% MASK + 1.2% DF-11	0	3,8	0	0,7	4,4	27
Same + 3% PMSya + 1.2% DF-11	0	4,5	0	0,5	5,0	90
Same + 3% PMSya + 3% MASK	0	3,4	0	0,8	4,0	99
Same + 3% SVbor + 3% MASK	0	3,6	0	0,3	4,1	60

TABLE 2. Test Results on DS-11 Oil Containing Various Combinations of Additives, in IDM Unit

Oil + additive	Ring mobility demerit rating	Color rating of piston deposits	Quantity of deposits on piston, g	Deposit demerit rating
DS-11 oil (without additive)	10.0	6.0	7.0	22.7
Same + 3% MASK	2.5	3.5	1.5	7.6
Same + 6% MASK	1.0	3.5	1.0	5.8
Same + 9% MASK	0	3.0	0.8	4.4
Same + 3% PMSya	3.5	4.0	3.5	13.3
Same + 6% PMSya	2.5	3.0	1.7	7.3
Same + 3% S-5A	10.0	4.0	6.6	23.7
Same + 3% SVbor	8.0	4.0	6.0	19.4
Same + 1.2% DF-11	5.0	5.5	5.5	16.1
Same + 3% SVbor + 1.2% DF-11	3.5	3.5	4.3	15.4
Same + 3% MASK + 1.2% DF-11	2.5	3.0	1.5	6.1
Same + 3% PMSya + 1.2% DF-11	3.0	3.5	2.3	9.6
Same + 3% PMSya + 3% MASK	2.5	3.5	1.7	6.6
Same + 3% SVbor + 3% MASK	2.5	3.0	0.8	5.0

spectively; with the DF-11 additive, the viscosity increase is reduced to 92%. The use of the additives S-5A, SVbor, and PMSya in the base oil leads to greater viscosity increases, indicating that these additives are not antioxidants, but rather prooxidants. The PMSya shows the greatest effect in this direction, with 3% of the additive giving a viscosity increase of 200% during the test, in comparison with 110% for the base oil. The addition of 1.2% DF-11 or 3% MASK along with the sulfonate additive (PMSya) brings the viscosity increase down from 200% to 90-99%. The addition of 1.2% DF-11 to the oil containing 3% SVbor produces only a slight reduction of the viscosity increase (only down to 95%). When the MASK is used in place of the DF-11 [with the SVbor], the oil viscosity increase is reduced to 60%. These results indicate synergism for such a combination of additives.

From the results obtained on carbon deposition in the IKM unit, it was found that the smallest quantity of piston deposits is given by the combinations of additives MASK/PMSya and MASK/DF-11; for these combinations, the deposit demerit rating is 4-5, in comparison with ratings of 5.5-11.8 for these additives when tested singly.

Analogous results were obtained when the antideposition properties were rated in the IDM unit.

The data of Table 2 indicate that the additives with good antioxidant properties (as indicated by the IKM test results) also give less carbon deposition on the piston of the diesel engine.

When the concentration of the MASK is increased from 3% to 9%, the oil viscosity increase in the IKM unit is reduced from 72% to 28%, and the deposit demerit rating in the IDM unit likewise is reduced from 7.6 to 4.4.

When the prooxidant additive PMSya is introduced, the deposit demerit rating is almost twice as high as when the antioxidant additive MASK is used.

We should also take note of the synergism exhibited in antideposition properties when the MASK and SVbor additives are combined. For the oil with 3% SVbor and 1.2% DF-11, the deposit demerit rating is 15.4, in comparison with a rating of 5 for the combination of 3% SVbor and 3% MASK.

Further, each of these additives, when tested separately, gives results considerably inferior to those obtained on the additive combinations. Specifically, the SVbor additive alone gives a deposit demerit rating of 19.4, and the MASK additive alone a rating of 7.6.

Although the additive ratings in the carburetor and diesel engines are generally similar, there are certain differences, particularly in the ratings obtained on the succinimide additives. For example, when a combination of the succinimide additives S-5A and SVbor (3% each) is added to the oil, the deposit demerit rating in the IKM unit is reduced from 15 to 9.4-10.8.* In contrast, in the IDM test on the oil containing the S-5A additive alone (at 3% concentration), the rating is increased from 22.7 to 23.7; with 3% of the SVbor alone, the rating is reduced only to 19.4.

These differences in rating of the succinimide additives [in the two types of test unit] are apparently due to the inadequate thermal stability of the succinimide additives.

At the higher piston temperature in the ring zone in the IDM unit, the succinimide additive breaks down, so that the oil quality deteriorates. But the succinimide additive modified with boron (SVbor) is better in thermal stability than the [unmodified] S-5A additive.

LITERATURE CITED

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*As in Russian original; data in Table 1 refer to these additives used singly rather than in combination — Translator.

ELECTRICAL CONDUCTIVITY OF RT FUEL [HYDROTREATED JET FUEL] CONTAINING ANTISTATIC ADDITIVE, DURING PUMPING AND FILTRATION

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Antistatic additives have come into widespread use in recent years; these additives prevent the accumulation of static electricity in jet fuels and eliminate the fire and explosion hazard from this source in transfer, filtration, and servicing of fuels [1]. These additives increase the electrical conductivity of the fuel and thereby give almost instantaneous relaxation of the static charges formed in the fuel. The additive is usually injected into the fuel immediately at the refinery.

It has been noted that, from the time the fuel is produced at the refinery to the time it reaches the consumer, there is a partial depletion of additive and a consequent drop in fuel conductivity [2]. This drop in conductivity of fuel with antistatic additives in the various stages of its supply and travel to the consumer requires careful study and due consideration in selecting the minimum concentration of additive in the fuel, as well as in organizing production control with respect to the level of conductivity.

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