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The influence of ethylene/α-olefin copolymers used as additives on the viscosity and low-temperature properties of mineral oils

RAPID COMMUNICATION

Summary — Ethylene/α-olefin copolymers ($M \leq 20\ 000$) (PEAOP) were studied as depressants and viscosity improvers, at concentrations of 0.5 and 1% by wt., in (a) industrial oil I—20A and (b) motor oil M-11. The pour points of the oils fell (a) by 15°C and 25°C, and (b) by 6°C and 10°C, respectively. Slovenian Viskocryl-100 was found to be equivalent and superior to the copolymer additive as depressant for the I-20A and the M-11, respectively (Table 2). Russian PMA-D was inferior as depressant. Kinematic viscosity and viscosity index of the oils were studied in relation to additive content (Table 3).

Key words: ethylene/α-olefin copolymer as oil additive, pour point, viscosity, viscosity index

Mineral oils endowed with properties required by customers are well known to be prepared by admixing various types of additives (depressants, viscosity improvers, dispersants, detergents, antioxidans, etc.) to the base oil [1—3].

The viscosity of a mineral oil usually increases abruptly when temperature drops below a certain value. This behavior is connected with structural changes of various hydrocarbons present in the oils. A significant increase in oil viscosity makes the start-up and operation of an engine substantially more difficult in the wintertime, when ambient temperature is low. To facilitate smooth operation of mechanisms over a wide range of temperatures, oil viscosity should change progressively, *i.e.* a sharp increase in viscosity when the temperature is lowered, must be eliminated. For this purpose, viscosity improvers and depressants are added to base oils. Depressants preclude the formation of new structure elements in oils whereby the pour point of the oil is decreased. Viscosity improvers make changes in kinematic viscosity with temperature smooth.

Various polymers, *e.g.* homo- and copolymers of high esters of acrylic and methacrylic acids, polyisobutylene, ethylene-propylene copolymers and/or butadiene-styrene copolymers, can be used as additives for mineral oils [3, 4]. Methacrylates dominate on the Russian market as the base stock for viscosity improvers (PMA-V1, PMA-V2) and depressants (PMA-D). Some reports on copolymers of ethylene with vinyl acetate, propylene or alkyl methacrylate suggest that, compared with high alkyl methacrylates, these compounds are less efficient as additives. For example, poly(ethylene-*co*-propylene) copolymer with a molecular weight of *ca* 80 000 and fraction of polypropylene units equal to 35%, used at a concentration of 0.3% w/w, decreases the pour point of the M-11 base oil by as little as 5—6°C [4].

The aim of this work is to investigate the applicability of copolymers of ethylene and α-olefins (PEAOP) with an average molecular weight of up to 20 000 as depressant and viscosity improvers for lubricating oils. To assess the efficiency of these additives, an industrial oil I-20A (GOST 20799-88) and a motor oil M-11 (TU 38.101523-80) were chosen as the base oils. Results are collected in Table 1.

The influence of PEAOP content onto the pour point of the oils is illustrated in Table 2. PEAOP was found to be a better depressant for I-20A oil (pour point decreased to 15 and 25°C at PEAOP concentrations equal to 0.5% w/w and 1% w/w, respectively) than for the base oil M-11 for which at the same PEAOP concentrations the pour point decreased only by 6 and 10°C, respectively.

In order to compare the effectiveness of PEAOP with that of other additives, domestic PMA-D and Slovenian "VISKOCRYL-100" (V-100) were used; some data for these additives are given in Table 2. PEAOP is seen to be as good as V-100 as depressant for I-20A, but for the M-11 base oil V-100 is better. The kinematic viscosity and viscosity index (*VI*) of M-11 and I-20A oils (at 40

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Table 1. Typical specification for base oils I-20A and M-11

No.	Physical property	I-20A	M-11
1	Density at 20°C, kg/m^3	800	800
2	Kinematic viscosity, cSt		
	40°C	31.67	94.75
	100°C	5.21	10.45
3	Viscosity index	91	91
4	Acid number, mg KOH/g	0.02	—
5	Flash point, °C	202	222
6	Pour point, °C	-15	-15
7	Color (ZNT scale)	2.0	2.0
8	Water	—	—
9	Mechanical pollution	—	—

Table 2. Pour point of base oils I-20A and M-11 in relation to additive content

No.	Additive concentration, % by wt.	Pour point of I-20A, °C	Difference, °C	Pour point of M-11, °C	Difference, °C
1	0	-15	—	-15	—
2	PEAOP, 0.1%	-15	0	-19	-4
3	PEAOP, 0.5%	-30	-15	-21	-6
4	PEAOP, 1.0%	-40	-25	-25	-10
5	V-100, 0.1%	-15	0	-15	0
6	V-100, 0.5%	-30	-15	-35	-20
7	V-100, 1.0%	-40	-25	-38	-23
8	PMA-D, 0.1%	-25	-10	—	—
9	PMA-D, 0.5%	-30	-15	—	—
10	PMA-D, 1.0%	-35	-20	—	—

Table 3. Kinematic viscosity (V) and viscosity index (VI) of I-20A and M-11 oils as a function of the content of additives

PEAOP, % by wt.	PMA-D, % by wt.	V-100, % by wt.	V_{40}/V_{100} for I-20A	Dif. V_{40}/Dif. V_{100} for I-20A	V_{40}/V_{100} for M-11	Dif. V_{40}/Dif.V_{100} for M-11	VI-20A/VI M-11	Dif. VI I-20A/ /Dif. VI M-11
0	0	0	31.67/5.21	—	94.75/10.45	—	91/91	--
0.1	0	0	31.67/5.33	0/0.12	95.29/10.60	0.54/0.15	98/93	7/2
0.5	0	0	33.46/5.64	1.79/0.43	99.11/10.89	4.36/0.44	100/93.4	9/2.4
1.0	0	0	35.99/5.89	4.32/0.68	100.07/11.0	5.32/0.57	106/93.7	15/2.7
0	0.1	0	32.31/5.19	0.64/-0.02	—	—	86/	-5/
0	0.5	0	34.43/5.59	2.76/0.38	—	—	94/	3/
0	1.0	0	34.74/5.7	3.07/0.49	—	—	102/	11/
0	0	0.1	32.55/5.34	0.88/0.13	—	—	91.8/	0.8/
0	0	0.5	34.07/5.54	2.40/0.33	98.1/11.05	3.35/0.6	95.36/96.0	4.64/5.0
0	0	0	35.89/6.01	4.22/0.8	102.25/11.45	7.5/1.0	111.6/114.0	20.6/23.0

and 100°C) are shown in Table 3 in relation to the concentrations of additives. The thickening effect PEAOP was found to be similar to that of V-100 at each temperature. The effectiveness of PMA-D was found to be substantially lower.

On the basis of our experiments we conclude that PEAOP, a depressant for diesel fuel [5], could serve also as an additive for lubricating oils to improve their viscosity and low temperature properties.

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