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LUBRICATING COMPOSITIONS FOR SUPERCHARGED AND UNSUPERCHARGED HIGH-PERFORMANCE DIESEL ENGINES

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***Abstract**:Permanent improvement of metal structures of up-to-date diesel engines actualizes creation of new, higher quality analogues of motor oils. For some time past the goal-oriented studies into application of multifunctional alkylphenolate additives AKİ (C_8-C_{12}) series as calcium salts of formaldehyde condensation with various amines ended in the creation of new lubricants of M-10$Г_2$k u M-14$Г_2$ (API CC, SAE 15W-30; API CC, SAE 15W--40) grades. Experimental samples of lubricant compositions based on compound of basic oils M-8 and M-12 obtained from Baku oils, alkylphenol additives synthesized at the Institute of Chemistry of Additives and viscous additives of Viscoplex (V) series of «Evonik» firm have been appraised by the results of qualification tests on Д-240 engine.*

***Keywords:** motor oil, additive, lubricating compositions, engine tests, corrosion, wear*
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Introduction

Continuous improvement of metal constructions in modern diesel engines makes it necessary to prodice new, more qualitative analogues of motor oils used in these engines.

The solution of economic and ecological problems accounts for carrying out research work into substitution of some long-term used additives with new generation additives.

Depending on the type of technology, an import task is to select various motor oils. A number of new multifunctional alkylphenolate aditives - AKI-130; 150; 115B; 210; 219 were synthesized as a result of long-term studies carried out at the Institute of Chemistry of Additives. Accelerated, high-energy supercharged and unsupercharged API CC motor oils were developed using these additives and additives of some foreign companies, specifically for automobiles, auto tractors, ships, industrial and stationary diesels: multifunctional AKI-115B (calcium salt of condensation product of alkylphenol with formaldehyde, monoethanolamine and boric acid), AKI-150 (carbonated calcium salt of condensation product of alkylphenol with formaldehyde and aminoacetic acid), viscosity additives Viscoplex-8-450; 4-550 (relevantly), as well as various additives, M-8 and M-12 compound from Baku oils as base oils were used to develop motor oils for SAE-30-accelerated auto tractor diesels, SAE-40 diesel locomotive and industrial diesel engines [1-4].

Experimental part

Newly developed motor oils are prepared by means of mixing the components of motor oils. Viscoplex viscosity additives V-8-450, V-4-550 (correspondingly) are added into previously heated (70-80^0) base oils and mixed at this temperature, then the remaining additives are added in a calculated quantity and mixed again.

The content of prepared new lubricating compositions is as follows:

М-10$Г_{2к}$: М-8+ 0.5%Viscoplex-8-450 +5.0% AKI -115B + 0.8% DF-11+ 0,5% C-400+ 0,4%Viscoplex-5-309+0,003% PMS-200A

М-14$Г_2$: М-8+М-12(50:50) 2,4% Viscoplex -4-550 + 4,0% AKI-150+1,5% C-150 + 0,8% A-22+ 0,5% Viscoplex-5-309 + 0,003% PMS-200A

Quality parameters of base oils are cited below:

Quality parameters	M-8	M-12
Kinematic viscosity, mm^2/s		
40 ^{0}C	70.22	147.98
100 ^{0}C	7.76	12.46
Viscosity index	72.0	75.0
Combustion temperature,^{0}C	210.0	230.0
Density, kg/ m^3 , 20 ^{0}C	895.0	900.0
Freezing point,^{0}C	6.0	15.0
Coke, %	0.12	0.26

Standard limit of viscosity index of modern oils produced by various technological schemes is provided through the use of polymethacrylate viscosity additives.

It should be noted that growing viscosity properties and viscosity index of additives are different.

Thus, the following is required to increase the kinematic viscosity of:

Viscoplex-3-950 > Viscoplex-1-810 > PMA«D» > Viscoplex-8-450 > Viscoplex-4-550 > Shellvis-50 >Eridan B- 1751.

To increase the viscosity index of:

Viscoplex-3-950 >Viscoplex-1-810 > Viscoplex-8-450 > Eridan B-1751 > PMA«D» > Viscoplex-4-550> Shellvis-50.

It should be noted that the use of Viscoplex-8-450; -4-550; 2-670; 1-810 and additives from these series in creation of new compositions is preferable [5,6].

This advantage is also based on the test results of mechanical and thermal destruction of additives explored. The use of viscosity additives was accounted for by studying their mechanical and thermal destruction properties.

Results and discussion

Mechanical destruction of viscosity additives used in preparation of new compositions was determined at УЗДН-2Т ultrasonic dispersant 22kHs with vibration pressure for 60 min. by ГОСТ 6794-75, paragraph 3.6 (Table 1).

Table 1. Test results of mechanical destruction of polymethacrylate viscosity additives in M-12 oil (sound time, 60 min.)

Parameters	M-12 oil							
	Viscoplex					Eridan B-1751	Shelvis -50	ПМА «Д»
	2-670	1-810	8-450	4-550	3-950			
	Concentration of viscosity additives in oil, %							
	1.2	2.7	2.4	3.3	2.55	0.5	0.37	3.0
Kinematic viscosity, mm^2/s, 100^0 C Before testing	13.98	13.94	13.83	13.63	14.14	13.65	13.86	13.92

After testing	13.12	12.97	12.18	13,06	11.48	13.08	13.21	13.40
Viscosity change,%	6.1	6.95	11.98	4.1	18.8	4.17	4.68	3.63

According to Table above, the destruction degree of viscosity additives with various structures and compositions against mechanical impacts are different. Note that the destruction resistance of co-polymer and polymethacrylate additives of Eridan, Shell and the Russian Federation is weaker than Viscoplex additives of Evonik.

Research into the thermal destruction and proper selection makes it possible to reduce the engine oil consumption used in all seasons.

It should be added that the destruction of polymer compounds at high temperatures used for the improvement of viscosity-temperature properties of oils reduces viscosity, viscosity index, combustion temperature.

To study the thermal destruction of the additives, their samples of optimal thickness were examined by well-known methods [7]. The viscosity and viscosity changes were determined through heating for 1 to 12 hours at 200^0 C (table 2).

Table 2. Determination of viscosity changes of additives at optimum concentrations

Viscoplex additive samples in M-12 oil	Stability index of viscosity, %				Viscosity change, %			
	HOUR							
	1	4	8	12	1	4	8	12
1,2% V-2-670	96.49	93.77	93.56	93.70	3.57	6.22	6.43	6.29
2,7%V- 1-810	99.21	97.63	96.98	96.12	0.78	2.36	3.01	3.87
2,4% V-8-450	99.34	99.71	97.54	96.96	0.28	0.65	2.45	3.08
3,3% V-4-550	97.50	97.65	97.35	96.11	2.56	2.34	2.71	3.88
2,5% V-3-950	97.17	92.50	91.44	89.53	2.82	7.49	8.55	10.46

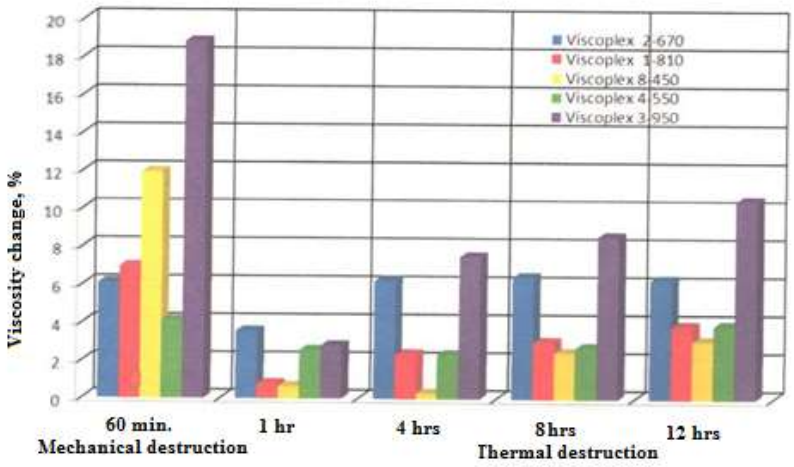

Figure 1. Comparative results of mechanical and thermal destructions of viscosity additives.

Insignificant changes in viscosity index of additive oil samples after testing for 1-12 hours at high temperature (200^0C) indicate their high resistance against themal destruction.

As Table 2 shows viscosity change of Viscoplex-1-810; 8-450 and 4-550 additives is (3.08-3.88%). These indices make it possible to use Viscoplex additives in creating various high-viscosity oils based on Baku distilled oils. Figure 1 shows the comparative results of mechanical and thermal destruction of viscosity additives.

Qualification test results and physical-chemical indices characterizing new oil samples are given in the Table 3.

Table 3. Physical-chemical and operation properties of M-10Γ_2k and M-14Γ_2 oils

Parameters	M-10Γ_2k ГОСТ 8581-78	M-10Γ_{2K} Comp.I	M-14Γ_2 ГОСТ 12337-84	M-14Γ_2 Comp.II	Test method
Kinematic viscosity, mm^2/s, 100^0C	11.0±0.5	11.26	13.5-14.5	13.5	ASTM D445
Viscosity index, not less than	85	87	90	90	ASTM D2270
Alkali number, mg KOH/g oil, not less than	6.0	7.3	7.0	7.3	ASTM D4739
Sulfated ash content, % not more than	1.15	0.99	1.3	1.0	ASTM D874
Mass of mechanical mixture, %, not much	0.015	0.015	0.01	0.009	ASTM D2273
Water mass, %, not more than	trace	Trace	trace	trace	ASTM D95
Combusion temperature by open cup tester, ^{0}C, not lower than	220	231	220	225	ASTM D92
Freezing point, ^{0}C, not higher	Negative 15	Negative 22	Negative 12	Negative 16	ASTM D97
Corrosion on ГОСТ 3778-77 C-1 and C-2 lead plates q/m^2,	no	No	no	no	ГОСТ 20502
Detergent properties, ПЗВ, ball, not more than	0.5	0.5	0.5	0.5	ГОСТ 5726
Oxidative resistance during induction period of deposit, 50 hrs.	resistant	Resistant	resistant	resistant	ГОСТ 11063
Density, 200^0C, kq/m^3, not more than	905	903	905	902	ASTM D4052

Qualification tests, detergent, antiwear, anticorrosion properties of M-10Γ_{2K} and M-14Γ_2 engine oils were determined at Д-240 motor. Before testing 6.3 kg of oil was injected into the engine and tested for 5 hrs in an estimated mode (Table 4).

Table 4. Operating mode of testings in idling Д-240 engine

Operation mode	Engine power ktv.(at.g.)	Rotation frequency of crankshaft r/min	Test time (min.)

Running idle	-	800	20
Running idle	-	1000	20
Running idle	-	1800	20
Load	11.95(16.25)	1800	30
Load	19.12(26.0)	1800	60
Load	23.9(32.5)	1800	60
Load	38.25(52.0)	1800	60
Full loading	41.8(56.0)	1800	20
Running idle	-	1000	10

Where the control operation mode of testings on Д-240 engine is running idle, the loading of the engine power begins from 11.95 (16.25) kvt(at.g.) to 38.25 (52.0) kvt(at.g.), at full loading it is 41.8 (56.0) kvt(at.g.). Rotation frequency of crankshaft in the course of running idle is 800-1800, if full loading it is 1800 r/min (Table 4).

In the course of control process, temperature of oil and cooling water is 90 ± 5^0C, pressure of oil in the basic oil line is 0.25±0.05mPa; in 5 hours the engine was emptied from oil and testing began after adding 12.6 kg of new oil, the testing was carried out without oil for 120 hours, the testing of each repeated cycle was carried for 7.5 hrs.

In the course of 20 min.,30, 60, 90 hrs, 200 sm^3 of oil sample was taken and in 120 hrs of operation 400 sm^3 of oil sample was taken and analyzed.

Amount of the oil taken was restorated through adding oil. Depending on testing period, the deposit content is 0,25% (20 min) on coke ГОСТ 19932-99 having been formed in oil during the testing, i.e. at the end of the test in 120 hrs it is 1,2 %.

With due regard for quality indices of newly prepared М-10$Г_2$к (API CC, SAE 15W-30) (I) and М-14$Г_2$ (API CC, SAE 15W -40) (II), oil samples are presented in Table 5.

Table 5. Change of quality indices of oil samples during testing in Д-240 engine

Test period	Kinematic viscosity, $mm^2/s,100^0$C		Alkali number, mqKOH/q		Acid number, mqKOH/q		Sulfated ash, %		Combustion temperature, ^{0}C	
	I	II	I	II	I	II	I	II	I	II
20 min	11.34	13.28	6.95	7.01	-	-	0.93	1.04	230	225
30 hrs	11.85	13.90	8.87	6.54	0.68	0.05	1.17	1.10	215	220
60 hrs	12.14	14.20	5.48	5.10	0.99	0.62	1.25	1.18	200	228
90 hrs	13.20	14.98	4.03	4.01	1.22	0.91	1.31	1.21	205	210
120 hrs	14.65	15.46	3.11	2.98	1.31	1.1	1.48	1.28	210	212

The changes during testings are presented for both oils in the figures 2 and 3.

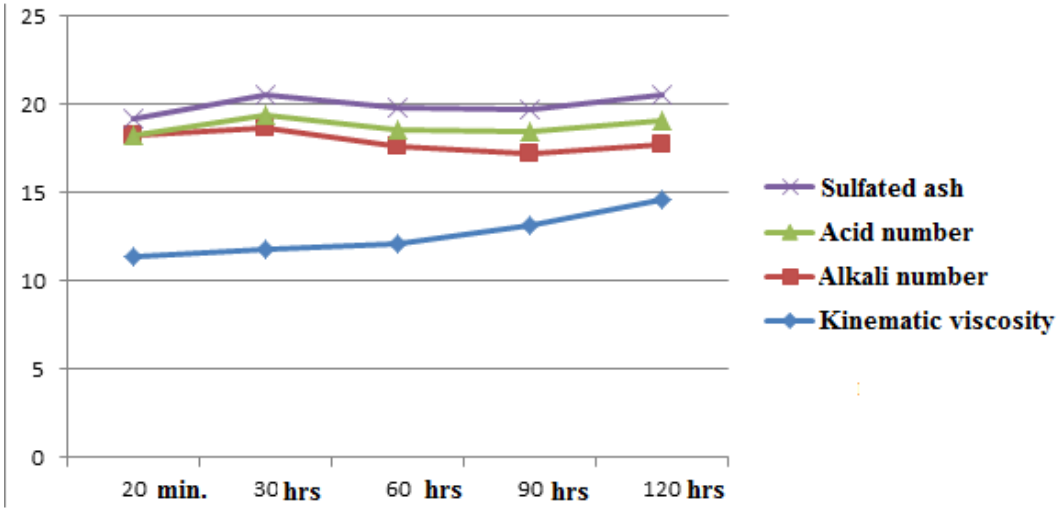

Figure 2. Testing results of M-10Г$_2$к oil in engine Д-240

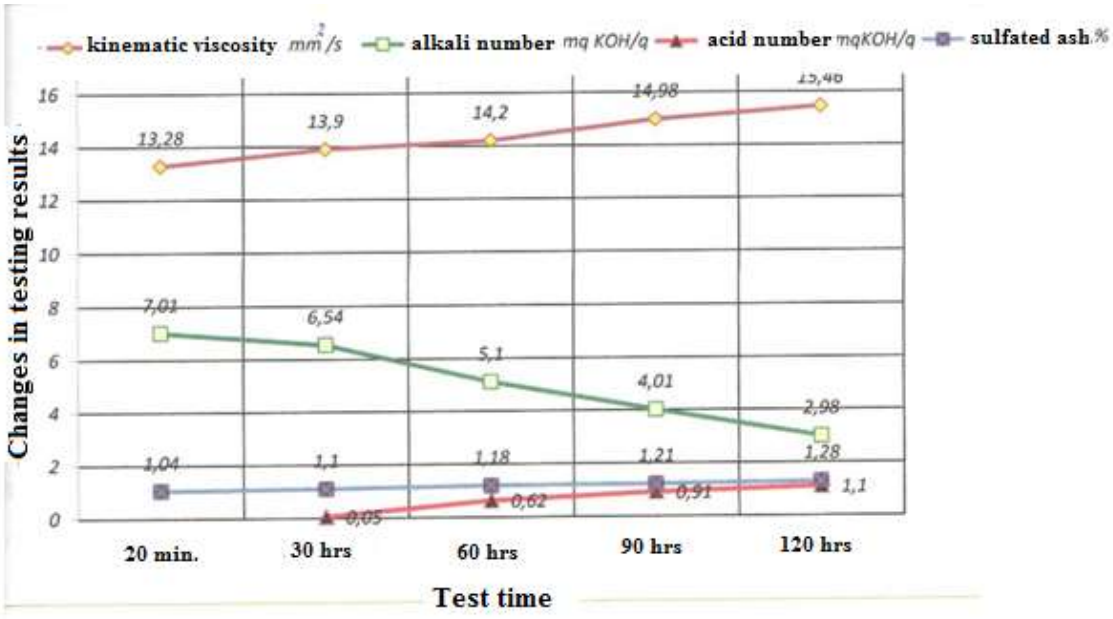

Figure 3.Testing results of M-14Г$_2$ oil in engine Д-240

After the test period came to an end, engine crankcase was emptied from oil and weighted, the amount of loss calculated (q/s) and engine dismantled and analyzed: detergent, anticorrosion and antiwear properties were determined.

Test results of experimental samples of new analogues of motor oils are given in Table 6.

Table 6. Test results of experimental samples of М-10$Г_2$к and М-14$Г_2$ motor oils in engine Д-240.

PARAMETERS	RESULTS			
	М-10$Г_2$k ГОСТ 8581-78 standard	М-10$Г_2$k Sample. (I)	М-14$Г_2$ TSh Az 3536814-008-2004 standard	М-14$Г_2$ Sample. (II)
1.Determination of detergent property 1.1.Mobility of piston ring, ball	-	0	0	0
1.2.Lacquer, soot in ditches	-	3.17	-	3.9
1.3.Pollution of screens, lacquer, soot, ball	-	0.95	-	1.2
1.4.Pollution of side surface of a piston, ball	-	0	-	0
1.5.Pollution of internal part of a piston, ball	-	0.5	-	0.1
Pollution of a piston, ball	6.5	4.22	10	6.2
2.Determination of wear property 2.1. Wear of piston rings, mg,	90	95.3	-	69.9
a) including, I ring, mg	35.4	32.5	-	21
3. Determination of corrosion property 3.1.Wear of connecting rod inserts, mg	54	58	-	31
a) up	45	46	-	26
b)down	9	12	-	5
4.Amount of soot in piston, g/cylinder	-	1.05	-	1.54
a) in ditches	-	0.22	-	0.20
b) in piston	-	0.83	-	1.52
5.Oil loss consumption, g/hour	70	50.8	70	52

Parameters of detergent properties are indicative that experimental oil provides full mobility of piston rings and makes it possible to assess the contamination with lacquer, soot in separate parts of a piston is within permitted maximum limit. Tests show that the set of piston rings and connecting rod inserts are exposed to less mass loss antiwear, and anticorrosion properties of experimental oil are very high. When the installation works depending on the quality of oil, its anti cinder or soot property, including piston rings and ditches, oil washing rings, side of a piston and combustion camera are viewed.

Detergent property of oil is determined through evaluating the pollution of piston ring mobility, screens and piston bottom with soot and lacquer formed in ditches. Tests show that newly prepared oils in Д-240 engine are notable for total value of mobility of piston rings and lacquer, soot and formed in different parts of piston and pollution by ГОСТ to make up 4.22 against 6.5 for М-10$Г_2$к; however, for М-14$Г_2$ oil it is 6.2 against 10.0. These parameters are positive results for newly prepared М-10$Г_2$к and М-14$Г_2$ oils.

Conclusion

New M-10$Г_{2k}$ and M-14$Г_2$ (API CC, SAE 15W-30 and API CC, SAE 15W -40) lubricating compositions based on M-8 and M-12 Baku oils were prepared through the use of multifunctional alkylphenol additives AKI-115B and AKI-150. Qualification tests show that new lubricating compositions can effectively substitute its analogues.

References

1.MamedovaA.Kh., Kyazim-zade A.K., Nagiyev E.A. Detergent properties of some modifications of alkylphenolate additives. *Oil refining and petrochemistry.* 2007, no.10, pp. 32-35.

2. Kapustin V.M., Tonkonogov B.P., Fuchs I.G. /Oil refining technology. Part 3. Production of oil lubricants. Moscow: Himiya Publ., 2014, pp.325.

3. Shkolnikov V.M. Encyclopedic dictionary reference. Moscow, 2010, 756 p.

4. Farzaliev V.M., Javadova A.A., Azimov E.V. Lubricating compositions for highly accelerated diesel engines. / Prospects for the development of chemical processing of combustible minerals. St. Petersburg, 2006, p.159.

5. Patent № I 2008 0202 (2008). Azerbaijan.

6. Patent № I 2017 0014 (2017). Azerbaijan.

7. Folders KK, Semenido EG. / Motor and reactiveoils and liquids. Leningrad: HimiyaPubl., 1964, 704 p.

YÜKSƏKGÜCLƏNDİRİLMİŞ ÜFÜRMƏ VƏ ÜFÜRMƏSİZ İŞLƏYƏN DİZEL MÜHƏRRİKLƏRİ ÜÇÜN SÜRTKÜ KOMPOZİSİYALARI

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Müasir dizel mühərriklərində metal konstruksiyaların mütəmadi təkmilləşməsi bu mühərriklərdə istifadə edilən motor yağlarının yeni, daha keyfiyyətli analoqlarının yaradılmasını aktual edir. Son illər yeni modifikasiyalı çoxfunksiyalı AKİ seriyalı alkilfenolların (C_8–C_{12}) formaldehid və aminlərlə kondensləşmə məhsullarının kalsium duzlarının tətqiqi və tətbiqi sahəsində aparılan məqsədyönlü işlər M-10$Г_2$k və M-14$Г_2$ (API CC, SAE 15W-30; API CC, SAE 15W-40) markalı sürtkü kompozisiyalarının yaradılması ilə nəticələnmişdir. Bakı neftlərindən alınan M-8 və M-12 baza yağlarının kompaundu, Aşqarlar Kimyası İnstitutunda sintez edilmiş çoxfunksiyalı alkilfenol tipli aşqarlar və "Evonik" firmasının Viscoplex (V) seriyalı özlülük aşqarları ilə yaradılmış yeni M-10$Г_2$k və M-14$Г_2$ (API CC ,SAE 15W-30; API CC, SAE 15W-40) markalı sürtkü kompozisiyaları kvalifikasiya sınaqları ilə qiymətləndirilmiş, Д-240 markalı mühərrikdə sınaqdan keçirilmişdir.

Açar sözlər: *motoryağı, aşqar, sürtkü kompozisiyası, mühərrik sınağı,korroziya, yeyilmə.*

СМАЗОЧНЫЕ КОМПОЗИЦИИ ДЛЯ ВЫСОКОФОРСИРОВАННЫХ ДИЗЕЛЬНЫХ ДВИГАТЕЛЕЙ, РАБОТАЮЩИХС НАДДУВОМ И БЕЗ НАДДУВА

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Постоянное усовершенствование металлических конструкций современныхдизельных двигателей делает актуальным создание новых, более качественных аналогов моторных масел, применяемых в них. В последние годы целенаправленные работы, проводимые в области исследования и применения многофункциональных алкилфенольных присадок серии АКİ (C_8-C_{12}), являющихся кальциевыми солями продуктов конденсации формальдегида с различными аминами, завершились созданием новых смазочных композиций марок М-10$Г_2$k и М-14$Г_2$ (API CC, SAE 15W-30; API CC, SAE 15W--40).Опытные образцы смазочных композиций, созданные на основе компаунда базовых масел М-8 и М-12, полученных из Бакинских нефтей, алкилфенольных присадок, синтезированных в Институте Химии Присадок, и вязкостных присадок серии Viscoplex (V) фирмы «Эвоник», были оценены результатами квалификационных испытаний, проведенных на двигателе Д-240.

Ключевые слова: *моторное масло, присадка, смазочная композиция, испытание двигателя, коррозия, износ.*

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