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DEVELOPING LUBRICATING COMPOSITIONS FOR LOKOMOTIVE AND INDUSTRIAL DIESELENGINES ON THE BASIS OF REGENERATED PRODUCTS

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Abstract. Multifunctional additive package SAN-2022A, viscosity additive Viscoplex-2-670, detergent-dispersant C-150 additives with M-14Q_2 type motor oil lubricating composition were formed by using used Mysella-40 motor oil as base oil of regenerated products. Lubricating composition of M-14Q_2 oil is the detergent-dispersant additive with the use of M-8 and MC-20 Eastern oil compound obtained from the mixture of Azerbaijan oil types as base oil –and condensation of methylene-bis-alkylphenols with formaldehyde and monoethanolamine working with boric acid and obtained product with calcium salt (AKİ-115B) was used. Both oil compositions fully meet demands set for physicochemical properties of M-14Q_2 motor oil.

Keywords: *composition, base oil, regeneration, additive package, oxidation, corrosion.*

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1. Introduction

One of the scientific-research works implemented in the Institute of Chemistry of Additives is working out the regeneration technology of the lubricating oils used in different types of technique.

Regeneration technology of used motor oil has been developed and scientific investigations on creation of different lubricating compositions on the basis of the regenerated oil are conducted.

Production of motor oils is related to their development history. According to the information gathered in this field, more than 40 various types of motor oils are known. This fact puts forward the solution to complex problems in creating ecologically and economically effective analogues of them. One of such problems is to achieve the reuse of tones of usedmotor oils consumed in a large amount as base oil for productsobtained by different regeneration methods.

2. Materials and method

Regeneration technology of Mysella-40 oil after 6000 operating hours used in the spark-ignited generators of Modular power plants that produce electricity was used (Javadova *et al.*, 2011).

Kinematic viscosity is 12,26 mm^2/s, viscosity index is -96, flash point is - 267°C, freezing point is minus 18°C and density of regenerated product of Musella-40 motor oil is -884kg/m^3. Resistanceto oxidation at 200°C within 30 hours (GOST 982) was

satisfactory. Corrosion was –124.6g/m^3 in experiments conducted with copper naphthenate catalyst at 140°C and within 25 hours (Table 1).

Table 1. Fundamental physicochemical properties of Mysella-40 used oil and its regenerated product

Indicators	Mysella-40 industrial oil	Baseoil	
		Mysella-40 oil after 6000 operating hours	Regenerated product
Kinematic viscosity, mm^2/s 40°C 100°C	 139,0 14,0	 154,47 15,06	 115,19 12,26
Viscosity index	97	97	96
Freezing point, °C	Minus 18	Minus 15	Minus 18
Flash point, °C	274	250	267
Alkalinity, mg KOH/g	1,1	0,86	0,14
Mass of mechanical mixture, %	0,01	0,04	N/A
Corrosion on C-1 and C-2 type lead plates under GOST 3778-77, g/m^3, not more than	118,0	141,2	124,6
Density, 15°C (kg/m^3)	882	897	884

Positive results of fundamental physicochemical properties of regenerated products enabled to use them as base oil while developing motor oils.

M-14Q$_2$ type API CC SAE-40 new lubricating oil composition was created for locomotive and industrial diesel engines with SAN-2022A multifunctional foreign additive package of regenerated products, viscosity Viscoplex-2-670, detergent-dispersant C-150 additives (Javadova, 2000; Javadova *et al.*, 2017) (Table 2).

M-14Q$_2$ lubricating composition also consists of oil base that is a compound of M-8 and MC-20 Eastern distillation oils obtained from the mixture of Azerbaijani oil and 5% AKI-115“B” – multifunctional additive, 0.4% Lubrizol-6446, (C-400) – detergent-dispersant additive, 0.8% DF-11–anti-oxidation, anti-corrosion and anti-wear, 0.003% ПМС-200А – polymethylsiloxaneanti-foaming additive (Ramazanova, 2018)

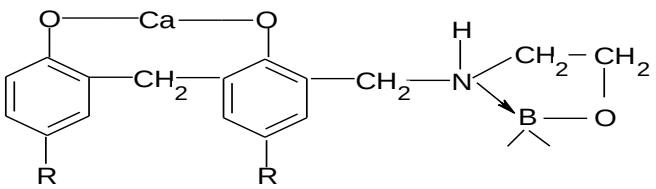
It should be noted that thecondensation of AKI-115“B” - methylene-bis-alkylphenolswith formaldehyde and monoethanolamineworking with boric acid product and obtained product with calcium salt was used as a detergent-dispersant used in this composition.

Physicochemical properties of AKI-115“B” additive are as follows: kinematic viscosity at 100°C – 67.1-89.1 mm^2/s, sulphated ash 11.01%, alkalinity – 125.7-130.0 mgKOH/g. Active components: B -0.56%, N – 1.1%, Ca – 2.9%.

Table 2. Comparative indicators of fundamental physicochemical and exploitation properties of lubricating compositions and M-14Q_2 industrial oil

Indicators	**Base oils**			**Test method**
	M-14oil	**Regenerated product**	**M-8+MC-20**	
		I sample	**II sample**	
	M-14Q_2 GOST 12337-84	**SAN 2022A V-2-670 C-150 V-5-309 IIMC-200A**	**AKI-115B DF-11 Lubrizol-6446 Viscoplex-5-309 IIMC-200A**	
Kinematicviscosity, mm^2/s, 100°C	13,5-14,5	14,5	14,0	GOST 33 ASTM D 445
Viscosity index, not more than	90	110	100	GOST 25371 ASTM D 2270
Alkalinity, mg KOH/g, not less than	7,0	8,66	8,02	GOST 11362 ASTM D 4739
Sulphated ash, %, not more than	1,3	1,20	1,19	GOST 417 ASTM D 95
Flash point, in an open pot, °C, not lower than	220	240	230	GOST 4333 ASTM D 92
Freezing point, °C, not higher than	Minus 12	Minus 16	Minus 16	GOST 20287 ASTM D 97
Tribological properties at (20±5) °C - attritionindex, I_s,kgf, not less than - - critical load, P_b,N, not less than - wear scar diameter, D_y, mm196N,1 hour, not more than	 34 823 0,45	 35 881 0,30	 37 881 0,30	GOST 9490 ASTM D 2596 ASTM D 2266
Corrosion on C-1 and C-2 type lead plates under GOST 3778-77, g/m^2, not more than	N/A	N/A	N/A	GOST 20502; variant 2
Stability on induction period for sediment formation (IPO), 50 hours	Resistant	Resistant	Resistant	GOST 11063
Colour, ÇHT unit in ÇHT colorimeter (diluted 15:85), not more than	4,0	3,5	3,5	GOST 20284 ASTM D 1500

AKI-115“B” formula



,

where

$$R = C_9 \cdot C_{12}$$

Lubricating composition developed with multifunctional SAN-2022A additive package is preferred to the known oil for its physicochemical indicators – viscosity index (100 industrial oilagainst 90), freezing point – minus 16°C against to minus 12°C,

flash point 240°C against 220°C, ash index 1.2% against 1.3% and meet demands for exploitation properties, as well as fully meet normative standards of M-14Q_2 motor oil used in locomotives and ЧН 26/26, ЧН 30/38 industrial diesels (Javadova *et al.*, 2018; Leitar *et al.*, 1999; Dzhavadova *et al.*, 2017; Patent of Azerbaijan Republic, 2016; Farzaliyev *et al.*, 2014; Nağıyeva *et al.*, 2019).

Qualification experiments and definition of resistance properties to detergent, wear and corrosion of M-14Q_2 motor oil was conducted in the D-240 engine. Before testing 6.3 kg oil to be tested was poured in the engine and it was tested for 5 hours in the specified mode. The operating mode of experiments conducted in D-240 engine at idle is provided in the Table 3.

The engine's power in loading time and idling mode of experiments conducted in D-240 engine during the experiment starts from 11.95 (16.25) kW (hp) to 38.25 (52.0) kW (hp) and full loading is 41.8 (56.0) kW (hp).

Table 3. Operating mode of the experiment conducted in D-240 device of M-14Q_2 motor oil

Operating mode	Engine power kW (hp)	Crankshaft rotation speed revolutions/minute	Experiment duration (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
Fullloading	41,8(56,0)	1800	20
Running idle	-	1000	10

Crankshaft rotation speed is 800-1800 rotations/minute at idle, but 1800 rotations/minute in full loading.

Temperature of oil and cooling water during the experiment was 90±5°C, oil pressure in main oil passage was 0.25±0,05mПа, 5 hours later oil was drained from the engine and the experiment started after pouring 12.6 kg new oil, experiments were conducted for totally 120 hours, each of them for 7.5 hours on the basis of repeated rotations.

During the experiment, 200 cm^3 of oil sample was analysed for 20 minutes, 30, 60 and 90 hours while running and 400 cm^3 was analysed after 120 running hours.

The amount of oil taken is restored by adding oil.

The amount of sediment formed in the oil on coke GOST 19932-99 depending on the experiment duration is 0.25% (20 min.) after 120 hours, so that 1.2% at the end of the experiment.

Quality indicators of M-14Q_2 oil samples used within different periods are provided in the Table 4.

After the experiment oil is pulled and drained from the engine crankcase, the amount of loss is calculated (g/s) and the engine is disassembled and analysed. Indicators that evaluate the oil quality are its detergent, anti-corrosion and anti-wear properties.

Table 4. Quality indicators of M-14Q_2 oil samples

Samples, Duration	Kinematicviscosity, mm^2/s,100°C	Alkalinity, mgKOH/g	Acid number, mg KOH/g	Sulphated sh, %	Flash point, °C
20 minutes	13,28	7,01	-	1,04	225
30 hours	13,90	6,54	0,05	1,10	220
60 hours	14,20	5,10	0,62	1,18	228
90 hours	14,98	4,01	0,91	1,21	210
120 hours	15,46	2,98	1,1	1,28	212

The experiment results conducted to evaluate detergent, anti-oxidation, anti-wear and anti-corrosion properties of newly developed experimental oils in the D-240 engine areshown in the Table -5 (Ramazanova, 2019).

Table 5. Test results of experimental and industrial samples of M-14Q_2 motor oil in the D-240 engine

Indicators	**M-14Q_2 TŞ Az 3536814-008-2004 standard**	**Experimental and industrial sample of M-14Q_2 oil**
1. Definition of detergent property		
1.1.Mobility of piston rings, point	0	0
1.2.Lacquer, soot, etc. in ditches, point	-	3,90
1.3.Pollution of screens,lacquer, soot, etc., ball	-	1,20
1.4.Pollution of side surface of a piston, ball	-	0
1.5.Pollution of bottom part of a piston, ball	-	0,1
1.6.Pollution of a piston, ball	6,5	5,2
2. Definition of wear property		
2.1. Wear of piston rings, mg	-	69,9
a) including, I ring, mg	-	21
3. Definition of corrosion property		
3.1.Wear of connecting rod inserts, mg	-	25
a) up	-	18
b) down	-	7
4.Amount of soot in piston, g/hour	-	1,54
a) in ditches	-	0,019
b) in piston	-	1,52
5.Oil loss consumption, g/hour	70	52

3. Result and discussion

Parameters of detergent properties indicate that experimental oil provides full mobility of piston rings and enables to assess the contamination with lacquer and soot in separate parts of a piston is within permitted maximum limit.

A standard is determined to assess the resistance to wear and corrosion on the method. However tests show that the set of piston rings and connecting rod inserts is exposed to less mass loss anti-wear and anti-corrosion properties of experimental oil are very high.

Resistance properties of experimental and industrial sample of M-14Q_2 motor oil to oxidation, detergent, wear and corrosion are determined. When the equipment runsdepending on the quality of oil, its anti-cinder or soot property, including piston rings and ditches, oil washing rings, side surface of a piston and combustion chamber are viewed.

Detergent property of oil is determined through evaluating the pollution of piston ring mobility, screens and piston bottom with soot, lacquer, etc. formed in ditches. As shown in tables, total value of mobility of piston rings and lacquer, soot, etc. pollution is 6.2 against 10.0 point determined for M-14Q_2 oil. These parameters are positive results for Q_2 group oils (Ramazanova, 2020; Ramazanova, 2021a; Ramazanova, 2021b; Farzaliyev *et al.,* 2020; Mammadov *et al.,* 2019).

Study results of new analogues of M-14Q_2 motor oils developed with Baku base oils and additive package are recommended for application.

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