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The Development and Implementation of Nanodemulsifiers is one of the Priority Directions of the Oilfield Nanotechnology

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ABSTRACT: The article presents the results of laboratory tests "IKHLAS"-1 in comparison with the basic demulsifier T-2015-1815. Are presented also appropriate comments, interpretations and conclusions based on the results of the research, on the basis of which the "IKHLAS"-1 nanodemulsifier have been recommended for carrying out experimental-industrial tests at the oilfields of LLP "Tasbulat Oil Corporation".

KEYWORDS: nanodemulsifier “IKHLAS”-1, oilfield nanotechnology, LLP "Tasbulat Oil Corporation"

I.INTRODUCTION

In oil production conditions, especially in the late stages of oilfield operation, water-oil emulsions (reverse water-in-oil), oil-water emulsions (direct oil in water) and multiple emulsions (water-oil-water) are formed in the wells. [1]. It is known that the stability of emulsions plays a large role in the primary preparation of oil (PPO). The main reasons for the formation of stable emulsions include the following factors [2]:

- The presence of some natural emulsifiers in the composition of the oil itself: naphthenic acids; asphaltenes; resins, etc.;
- The salt composition of the aqueous phase;
- Negative temperature gradient in the oil wells when fluid moves from the bottomhole zone of formation to the wellhead;
- The share of nanoemulsions and multiple emulsions in the composition of water-oil emulsions;
- The presence of nanoscale (up to 100 nm) mechanical impurities (solid mineral particles, for example, clays, iron sulfide, etc.), which can be adsorbed spontaneously on the surface of the globules of the aqueous dispersed phase. In order to desorb nanoparticles, the demulsifier, in our opinion, should also have a nanostructure [3].

In literature there are reports of some nanodemulsifiers [4-6]. However, there were no information on the using of these nanodemulsifiers. The subject of the study was crude oil from the fields of LLP “Tasbulat Oil Corporation” of the Republic of Kazakhstan, which refers to resistant water-oil emulsions. Therefore, the development and implementation of nanodemulsifiers for the preparation of persistent water-oil emulsions in general is one of the priority directions of oilfield nanotechnology.

II.THE EXPERIMENTAL PART

The period of the tests in the Laboratory of OilField Nanotechnology of the LLP "International Oil Services Kazakhstan": 18.07.18-29.07.18.

The purpose of the work: selection of the most effective demulsifier of LLP "International Oil Services Kazakhstan" for carrying out EIT on the oil fields of LLP “Tasbulat Oil Corporation”. The stated goal is achieved by the Bottle tests, with pre-selected "IKHLAS" -1 nanodemulsifier, in comparison with the basic demulsifier T-2015-1815.

Brief information on primary oil preparation at the ShPPO of LLP “Tasbulat Oil Corporation”: Crude oil to the shop primary preparation of oil (ShPPO) comes from three oil fields (average): "Tasbolat", - 127 tons/day emulsion; "Aktas", - 158 t/day emulsion; Turkmeni, - 578 t/day emulsion, the total volume is 863 tons/day. Daily commercial oil volumes by fields (average): "Tasbolat", - 76 t/day; "Aktas", - 40 t/day; "Turkmeni", - 224 t/day, the total volume is

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340 t/day. Base demulsifier: T-2015-1815 (USA, company M-I SWACO, division "Schlumberger"). T-2015-1815 is an oil-soluble demulsifier. The daily consumption of the base demulsifier (depending on the volume of oil production), on average, is 120 liters. Specific flow rate (Sfr) T-2015-1815 on the average is S_{fr} = 127 g/t. Temperature at the output of the furnaces: 58-61°C. Daily consumption of the Volga water: ~ 100 m^3/day. Time of the oil dreg in RVS-2500 averages 3 days. The test demulsifier: nano-emulsifier "IKHLAS" -1 (Kazakhstan, "International Oil Services Kazakhstan" company); Nanodemulsifier "IKHLAS" -1 is also an oil-soluble demulsifier [7]. Sampling of water-oil emulsion without the content of a basic demulsifier was carried out on each deposit separately. The mass ratio of oils from the fields "Tasbolat", "Aktas" and "Turkmenoyi" in accordance with the production volumes was: 127:158:578 = 1:1.24:4.55. Bottl tests were carried out in accordance with the generally accepted methodology [8]. Conditions of execution Bottle tests: T=60°C, 58°C; S_{fr} =127 g/t, 100 g/t. The dynamics of the change in the demulsification process with respect to the residual water content was determined after 5 minutes; 15 minutes; 30 minutes; 40 minutes; 1 hour; 2 hours; 3 hours; 6 hours; 9 hours; 12 hours; 15 hours; 16 hours; 20 hours. Bottl tests were executed, accordance to the above conditions, in the following 4 variants.

Variant 1

The conditions of variant 1: T=60°C, S_{fr}=100 g/t; the dynamics of the change in the demulsification process with respect to the residual water content are determined after 5 minutes; 15 minutes; 30 minutes; 40 minutes; 1 hour; 2 hours; 3 hours; 6 hours; 9 hours; 12 hours; 15 hours. The results of the studies are presented in Table 1.

Variant 2

The conditions of variant 1: T=60°C, S_{fr}=127 g/t; the dynamics of the change in the demulsification process with respect to the residual water content are determined after 5 minutes; 15 minutes; 30 minutes; 40 minutes; 1 hour; 2 hours; 3 hours; 6 hours; 9 hours; 12 hours. The results of the studies are presented in Table 2.

Variant 3

The conditions of variant 1: T=58°C, S_{fr}=100 g/t; the dynamics of the change in the demulsification process with respect to the residual water content are determined after 5 minutes; 15 minutes; 30 minutes; 40 minutes; 1 hour; 2 hours; 3 hours; 6 hours; 9 hours; 12 hours; 15 hours; 20 hours; The results of the studies are presented in Table 3.

Variant 4

The conditions of variant 1: T=58°C, S_{fr}=127 g/t; the dynamics of the change in the demulsification process with respect to the residual water content are determined after 5 minutes; 15 minutes; 30 minutes; 40 minutes; 1 hour; 2 hours; 3 hours; 6 hours; 9 hours; 12 hours; 16 hours. The results of the studies are presented in Table 4.

Based on the experimental data on C_{rw} using the method of least squares, are obtained the correlation analytical expressions $C_{rw} = f(\tau)$ for each variant of application of demulsifiers T-2015-1815 and "IKHLAS" -1. With the help of the obtained empirical expressions, were calculated the theoretical values of C_{rw}. As follows from the data of Tables 1-4, the existing deviations of the theoretical data, relative to the experimental data, do not exceed ±7.3%, which are within the error of the experiment. In Fig. show comparative photographs of all variants of the performed bottle tests with demulsifiers "IKHLAS" -1 and T-2015-1815 on samples of a mixture of water-oil emulsions from oil fields of LLP "Tasbulat Oil Corporation".

III.RESULTS AND DISCUSSION

By data of table 1: The concentration of residual water (C_{rw}) for "IKHLAS"-1 is reduced to zero, and for the basic demulsifier to C_{rw} = 4%. The efficiency of "IKHLAS"-1 on value C_{rw} is 2.9-6.4 times higher than the efficiency of the basic demulsifier T-2015-1815. In addition, the efficiency of "IKHLAS" -1 on value degree of demulsification (d) in the first five minutes is 79.5%, i.e. the bulk of the bound water is separated at the beginning of the demulsification process, and at the end, d = 100%. For T-2015-1815 at τ = 5 min, C_{rw} = 39.1%, i.e. 2 times less than for "IKHLAS" -1, and at the end d = 80.9%, i.e. by 19.1% less than the "IKHLAS" -1.

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Table 1. Results of the bottle tests by effectiveness of the nanodemulsifier ”IKHLAS”-1 in comparison with the basic demulsifier T-2015-1815 (variant 1)

Demulsifier	S_{fr}, g/t	T, °C	τ	Concentration of water in oil,%				Efficiency of “IKHLAS”-1 relative to T-2015-1815	
				initial	residual (C_{rw})			by C_{rw} for τ= const (times)	by the degree of demulsification (d), %
					exp.	theor.	error,%		
C_{rw}=12.6 - 0.57·τ									
T-2015-1815	100	60	5 min	21	12.78	12.55	-1.80	-	39.1
T-2015-1815	100	60	15 min	21	12.30	12.46	+1.30	-	41.4
T-2015-1815	100	60	30 min	21	11.83	12.31	+4.05	-	43.6
T-2015-1815	100	60	40 min	21	12.76	12.22	-4.23	-	39.2
T-2015-1815	100	60	1 h	21	12.03	12.03	0	-	42.7
T-2015-1815	100	60	2 h	21	11.00	11.46	+4.18	-	47.6
T-2015-1815	100	60	3 h	21	10.21	10.89	+6.66	-	51.4
T-2015-1815	100	60	6 h	21	9.69	9.18	-5.26	-	53.8
T-2015-1815	100	60	9 h	21	8.20	7.47	-8.90	-	60.9
T-2015-1815	100	60	12 h	21	5.93	5.76	-2.87	-	71.7
T-2015-1815	100	60	15 h	21	4.00	4.05	+1.25	-	80.9
C_{rw} =4.3 - 0.286·τ									
«IKHLAS»-1	100	60	5 min	21	4.30	4.27	-0.69	3	79.5
«IKHLAS»-1	100	60	15 min	21	4.23	4.23	0	2.9	79.8
«IKHLAS»-1	100	60	30 min	21	4.10	4.16	+3.90	2.9	80.5
«IKHLAS»-1	100	60	40 min	21	4.03	4.11	+1.98	3.2	80.8
«IKHLAS»-1	100	60	1 h	21	3.95	4.01	+1.52	3	81.2
«IKHLAS»-1	100	60	2 h	21	3.84	3.73	-2.86	2.9	81.7
«IKHLAS»-1	100	60	3 h	21	3.57	3.44	-3.64	2.9	83.0
«IKHLAS»-1	100	60	6 h	21	2.50	2.57	+2.80	3.9	88.1
«IKHLAS»-1	100	60	9 h	21	1.74	1.72	-1.15	4.7	91.7
«IKHLAS»-1	100	60	12 h	21	0.92	0.87	-5.43	6.4	95.6
«IKHLAS»-1	100	60	15 h	21	0	0.01	+1.00	∞	100

Note: S_{fr} is the specific flow rate; T is the temperature; τ is the time of settling

By data of table 2: The concentration of residual water (C_{rw}) for "IKHLAS"-1 is reduced to zero, and for the basic demulsifier to C_{rw} = 3.64%. The efficiency of "IKHLAS"-1 on value C_{rw} is 2.9-6 times higher than the efficiency of the basic demulsifier T-2015-1815. In addition, the efficiency of "IKHLAS" -1 on value d in the first five minutes is 81.9%, i.e. the bulk of the bound water is separated at the beginning of the demulsification process, and at the end, d = 100%. For T-2015-1815 at τ = 5 min, C_{rw} = 47%, i.e. 1.7 times less than for "IKHLAS" -1, and at the end d = 83.4%, i.e. by 16.6% less than the "IKHLAS" -1.

Table 2. Results of the bottle tests by effectiveness of the nanodemulsifier ”IKHLAS”-1 in comparison with the basic demulsifier T-2015-1815 (variant 2)

Demulsifier	S_{fr}, g/t	T, °C	τ	Concentration of water in oil,%				Efficiency of “IKHLAS”-1 relative to T-2015-1815	
				initial	residual (C_{rw})			by C_{rw} for τ= = const (times)	by the degree of demulsification (d), %
					exp.	theor.	error,%		
C_{rw} =11.18 - 0.641·τ									
T-2015-1815	127	60	5 min	21	11.56	11.13	-4	-	47
T-2015-1815	127	60	15 min	21	11.01	11.02	0	-	47.5
T-2015-1815	127	60	30 min	21	10.98	10.86	-1.1	-	48.3
T-2015-1815	127	60	40 min	21	10.73	10.76	+2.8	-	48.8
T-2015-1815	127	60	1 h	21	10.19	10.54	+.4	-	49.8
T-2015-1815	127	60	2 h	21	9.9	9.9	0	-	52.9
T-2015-1815	127	60	3 h	21	9.6	9.26	-3.5	-	55.9
T-2015-1815	127	60	6 h	21	7.05	7.33	+4	-	65.1
T-2015-1815	127	60	9 h	21	5.57	5.41	-2.9	-	74.2

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T-2015-1815	127	60	12 h	21	3.64	3.49	-4.1	-	83.4
C_{rw} =3.83 - 0.325·τ									
«IKHLAS»-1	127	60	5 min	21	3.77	3.80	+0.8	2.9	81.9
«IKHLAS»-1	127	60	15 min	21	3.7	3.75	+1.3	2.9	82.1
«IKHLAS»-1	127	60	30 min	21	3.69	3.66	-0.8	3	82.6
«IKHLAS»-1	127	60	40 min	21	3.59	3.61	+0.5	3	82.8
«IKHLAS»-1	127	60	1 h	21	3.5	3.50	0	3	83.3
«IKHLAS»-1	127	60	2 h	21	3.36	3.18	-5.4	3.1	84.9
«IKHLAS»-1	127	60	3 h	21	2.83	2.85	+0.7	3.2	86.4
«IKHLAS»-1	127	60	6 h	21	1.8	1.88	+4.4	3.9	91.0
«IKHLAS»-1	127	60	9 h	21	0.9	0.9	0	6	95.7
«IKHLAS»-1	127	60	12 h	21	0	0	0	∞	100

By data of table 3: The concentration of residual water (C_{rw}) for "IKHLAS"-1 is reduced to zero, and for the basic demulsifier to C_{rw} = 4.4%. The efficiency of "IKHLAS"-1 on value C_{rw} is 2.9-4.4 times higher than the efficiency of the basic demulsifier T-2015-1815. In addition, the efficiency of "IKHLAS" -1 on value d in the first five minutes is 77.2%, i.e. the bulk of the bound water is separated at the beginning of the demulsification process, and at the end, d = 100%. For T-2015-1815 at τ = 5 min, C_{rw} = 29.3%, i.e. 2.6 times less than for "IKHLAS" -1, and at the end d = 79%, i.e. by 21% less than the "IKHLAS" -1.

Table 3. Results of the bottle tests by effectiveness of the nanodemulsifier "IKHLAS"-1 in comparison with the basic demulsifier T-2015-1815 (variant 3)

Demulsifier	S_{fr}, g/t	T, °C	τ	Concentration of water in oil,%				Efficiency of "IKHLAS"-1 relative to T-2015-1815	
				initial	residual (C_{rw})			by C_{rw} for τ= const (times)	by the degree of demulsification (d), %
					exp.	theor.	error,%		
C_{rw} =14.4 - 0.5·τ									
«IKHLAS»-1	100	58	5 min	21	14.85	14.36	-3.3	-	29.3
«IKHLAS»-1	100	58	15 min	21	14.59	14.27	-2.2	-	30.5
«IKHLAS»-1	100	58	30 min	21	14.07	14.15	+0.6	-	33
«IKHLAS»-1	100	58	40 min	21	13.89	14.06	+1.2	-	33.9
«IKHLAS»-1	100	58	1 h	21	13.62	13.9	+2.1	-	35.1
«IKHLAS»-1	100	58	2 h	21	13.4	13.4	0	-	36.2
«IKHLAS»-1	100	58	3 h	21	12.9	12.9	0	-	38.6
«IKHLAS»-1	100	58	6 h	21	11.8	11.4	-3.4	-	43.8
«IKHLAS»-1	100	58	9 h	21	9.3	9.9	+6.4	-	55.7
«IKHLAS»-1	100	58	12 h	21	8.5	8.4	-1.2	-	59.5
«IKHLAS»-1	100	58	15 h	21	7.1	6.9	-2.8	-	66.2
«IKHLAS»-1	100	58	20 h	21	4.4	4.4	0	-	79
C_{rw} =4.9 - 0.251·τ									
«IKHLAS»-1	100	58	5 min	21	4.79	4.88	+1.9	3.1	77.2
«IKHLAS»-1	100	58	15 min	21	4.75	4.84	-1.9	3.1	77.4
«IKHLAS»-1	100	58	30 min	21	4.73	4.77	+0.8	3	77.3
«IKHLAS»-1	100	58	40 min	21	4.72	4.73	+0.2	2.9	77.5
«IKHLAS»-1	100	58	1 h	21	4.7	4.65	-1	2.9	77.6
«IKHLAS»-1	100	58	2 h	21	4.61	4.4	-4.5	2.9	78
«IKHLAS»-1	100	58	3 h	21	4.13	4.15	+0.5	3.1	80
«IKHLAS»-1	100	58	6 h	21	3.35	3.39	+1.2	3.5	84
«IKHLAS»-1	100	58	9 h	21	2.67	2.64	-1.1	3.5	87.3
«IKHLAS»-1	100	58	12 h	21	1.92	1.89	-1.6	4.4	90.9
«IKHLAS»-1	100	58	15 h	21	1.11	1.13	+1.8	4	94.7
«IKHLAS»-1	100	58	20 h	21	0	0.12	0	∞	100

By data of table 4: The concentration of residual water (C_{rw}) for "IKHLAS"-1 is reduced to zero, and for the basic demulsifier to C_{rw} = 3.43%. The efficiency of "IKHLAS"-1 on value C_{rw} is 2.8-5.4 times higher than the efficiency of the basic demulsifier T-2015-1815. In addition, the efficiency of "IKHLAS" -1 on value d in the first five minutes is 79.4%, i.e. the bulk of the bound water is separated at the beginning of the demulsification process, and at the end, d =

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100%. For T-2015-1815 at τ = 5 min, C_{rw} = 38.8%, i.e. 2 times less than for "IKHLAS"-1, and at the end d = 83.6%, i.e. by 16.4% less than the "IKHLAS" -1.

By figure: Photographs of the executed bot-tests also demonstrate the advantages of "IKHLAS"-1 in comparison with the basic demulsifier T-2015-1815.

IV.THE EXPECTED ECONOMIC EFFECT

The expected economic effect from the introduction of the "IKHLAS"-1 nanodemulsifier at the fields of the LLP "Tasbulat Oil Corporation" in comparison with the basic demulsifier T-2015-1815 is expressed in the following arguments:

1. On the basis of specific flow rate **(S_{fr}).** S_{fr} for T-2015-1815 is an average of 127 g/t. As the results of the Bottl Test (BT) show, the optimum value of Vp for "IKHLAS"-1 is 100 g/t, i.e. saving only from a reduction in specific flow rate is 27 g/t or 21.3%;

2. By the dominant concentrations of water (in%) and salts (in mg / l) in commercial oil. The oil of the fields LLP "Tasbulat Oil Corporation" in terms of its physical and chemical properties is analogous to the oil of the Zhetybay Group deposits of JSC "Manigistaunaigas". As our experience in the introduction of the "IKHLAS"-1. S_{fr} is the specific flow rate

Table 4. Results of the bottle tests by effectiveness of the nanodemulsifier IKHLAS-1 in comparison with the basic demulsifier T-2015-1815 (variant 4)

Demulsifier	S_{fr}, g/t	T, °C	τ	Concentration of water in oil,%				Efficiency of "IKHLAS"-1 relative to T-2015-1815	
				initial	residual (C_{rw})			by C_{rw} for τ= = const (times)	by the degree of demulsification (d), %
					exp.	theor.	error,%		
C_{rw} =12.9 - 0.59·τ									
T-2015-1815	127	58	5 min	21	12.86	12.85	-0.08	-	38.8
T-2015-1815	127	58	15 min	21	12.71	12.75	+0,3	-	39.5
T-2015-1815	127	58	30 min	21	12.67	12.61	-0.5	-	39.7
T-2015-1815	127	58	40 min	21	12.5	12.5	0	-	40.5
T-2015-1815	127	58	1 h	21	12	12.31	+2.6	-	42.8
T-2015-1815	127	58	2 h	21	11.44	11.72	+2.4	-	45.5
T-2015-1815	127	58	3 h	21	11.39	11.13	-2.3	-	45.8
T-2015-1815	127	58	6 h	21	10.1	9.36	-7.3	-	51.9
T-2015-1815	127	58	9 h	21	7.59	7.59	0	-	63.9
T-2015-1815	127	58	12 h	21	5.8	5.82	+0.3	-	72.4
T-2015-1815	127	58	16 h	21	3.43	3.46	+0.9	-	83.6
C_{rw} =4.45 - 0.28·τ									
«IKHLAS»-1	127	58	5 min	21	4.32	4.42	+2.3	3	79.4
«IKHLAS»-1	127	58	15 min	21	4.3	4.38	+1,9	2.9	79.5
«IKHLAS»-1	127	58	30 min	21	**4.28**	4.31	+0.7	3	79.6
«IKHLAS»-1	127	58	40 min	21	4.26	4.26	0	2.9	79.7
«IKHLAS»-1	127	58	1 h	21	4.22	4.17	-1.2	2.8	79.9
«IKHLAS»-1	127	58	2 h	21	4.09	3.89	-4.9	2.8	80.5
«IKHLAS»-1	127	58	3 h	21	3.60	3.61	+0.28	3.2	82.9
«IKHLAS»-1	127	58	6 h	21	2.76	2.77	+0.4	3.7	86.9
«IKHLAS»-1	127	58	9 h	21	1.97	1.93	-2	3.8	90.6
«IKHLAS»-1	127	58	12 h	21	1.08	1.09	+0.9	5.4	94.9
«IKHLAS»-1	127	58	16 h	21	0	0	0	∞	100

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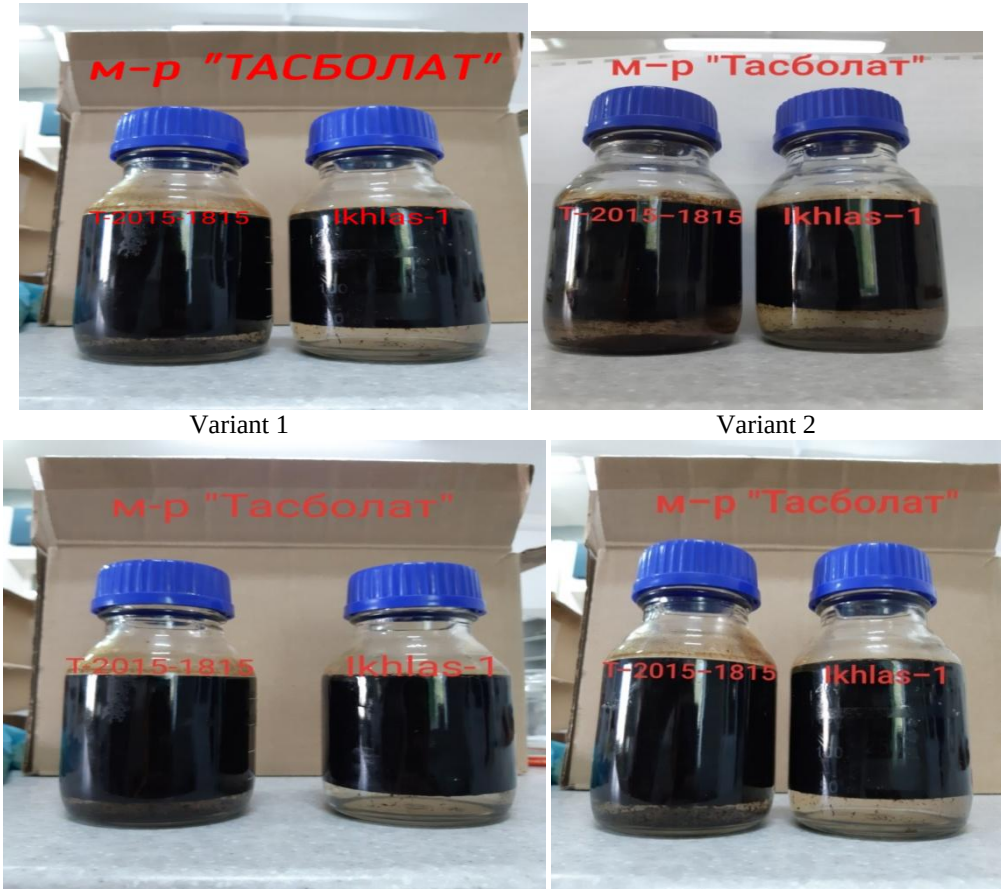

Variant 1 Variant 2

Variant 3 Variant 4

Figure. Comparative photos based on the results of the boot tests of the demulsifiers "IKHLAS"-1 and T-2015-1815 on the samples of a mixture of water-oil emulsions from the fields of LLP "Tasbulat Oil Corporation".

nanodemulsifier at the ShPPO "Zhetybai" (2014) shows, the dominant water concentrations in commercial oil for "IKHLAS"-1 and "Randem" 2219 (base demulsifier) respectively were 0.09-0.12 and 0.18-0.27%, and the dominant concentrations of salts were 35-45 and 45-70 mg/l. Therefore, the nanodemulsifier "IKHLAS" -1 for dominating water concentrations (in%) and salts (in mg/l) in commercial oil also has an relevance for the fields of LLP "Tasbulat Oil Corporation";

3. By time of settling. The time of settling (τ) is also an important technological factor for dehydration and desalting processes at PPO for the timely delivery of commercial oil to JSC "KazTransOil". As are shown by the results of Bottl-Tests, the "IKHLAS" -1 nanodemulsifier is a more high-speed demulsifier than the basic demulsifier T-2015-1815. In all the experiments for the "IKHLAS" -1 nanodeemulsifier, in contrast to T-2015-1815, 100% demulsification is achieved (Table 1-4).

4. On cleaning of wastewater in conditions PPO. It is known that "IKHLAS"-1 is a demulsifier for the destruction of water-oil and oil-water emulsions, (Pat. 30960 RK.). Really on some deposits, a high degree of wastewater treatment was achieved (no more than 50 mg/l). Therefore, there is a potential chance to clean up the wastewaterr in conditions PPO at ShPPO of LLP "Tasbulat Oil Corporation"

5. Profitability of using the Volga water. Since "IKHLAS"-1 is a fast-acting demulsifier, one of the sources of the economic effect during the EIT is the saving of the daily consumption of Volga's water.

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6. By the factor of reliability of the results of the Bottl-Tests during the EIT. As the experience of "IOS KZ" in different oil fields of the RK shows, the factor of reliability of the results of the Bottl Test "IKHLAS" -1 during the EIT is about 100%.

A complex of unique properties of the nanodemulsifier IKHLAS-1 is protected by a patent [7] (PAT 30960 RK, Demulsifier for the destruction of water-oil and oil-water emulsions. Nugmanov A.K., Dashdieva T.K. and others 2016) and the IKHLAS-1 successfully is introduction on four oil fields and at two mini oil refineries of the RK.

V.CONCLUSIONS AND RECOMMENDATIONS

As follows from the data of Tables 1-4, the nanodemulsifier "IKHLAS"-1 is 1.7-6.4 times more effective than the basic demulsifier T-2015-1815, under all conditions of the conducted bottle-tests. With considering of above factors, it can be assumed that the expected total economic effect from the introduction of the nanodemulsifier IKHLAS-1 in comparison with the basic demulsifier T-2015-1815 at the fields of LLP "Tasbulat Oil Corporation" make up about 10- 50%. Judging by the materials of the article it can be concluded about, that the development and implementation of nanodemulsifiers for the primary preparation of resistant water-oil emulsions is one of the priority directions of the oilfield nanotechnology. Thus, the nanodemulsifier IKHLAS-1 can be recommended for to implement experimental-industrial testing, in the conditions of primary preparation of oil at the fields of LLP "Tasbulat Oil Corporation".

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