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Development and Implementation of Nanodemulsifiers for the Treatment of Formation Water in the Conditions of Primary Oil Preparation is One of the Priorities Directions of Oil Field Nanotechnology

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ABSTRACT. The article presents the results of experimental-industrial tests of the nanodemulsifier "IKHLAS-1" at the shop of primary preparation of oil "Karsak" and JV "Botakhan" field OGPD "Dossormunaygas" of "Embamunaigas" JSC Republic of Kazakhstan. It has been established that with one reagent such as nanodemulsifier "IKHLAS-1" it is possible to simultaneously clean oil from water and salts, and formation water from oil within the existing standards. Therefore, development and implementation of nanodemulsifiers for the treatment of formation water in the conditions of primary oil preparation indeed is one of the priorities directions of oilfield nanotechnology.

KEYWORDS: nanodemulsifier "IKHLAS"-1, oilfield nanotechnology, the criteria for the evaluation of demulsifiers, primary oil preparation, treatment of formation water.

I. INTRODUCTION

During period 02.02.2019-12.02.2019 in the shop of primary preparation of oil (ShPPO) "Karsak" and in the period 03.02.2019-12.02.2019 at the JV "Botakhan" field oil and gas production department (OGPD) "Dossormunaygas" of JSC "Embamunaigas" Republic of Kazakhstan were carried joint experimental-industrial tests (EIT) of the nanodemulsifier "IKHLAS-1", which manufactured by "International Oil Services Kazakhstan" LLP. Nanodemulsifier "IKHLAS-1" was developed and patented jointly by specialists and scientists LLP «International Oil Services Kazakhstan», JSC "Mangistaumunaigas" of the Republic of Kazakhstan and Azerbaijan State University of Oil and Industry [pat]. Oil emulsions come to the ShPPO "Karsak" from the "Botakhan", "Karsak" and "Baychunas" oil fields. The average daily production volumes for these fields during the period of the EIT were, respectively, ~ 326 tons; ~ 80 tons, ~ 10 tons, and the average monthly volume of delivery of commercial oil to LLP "KazTransOil" amounted to ~ 400 tons. In contrast to the two other fields, at the "Botakhan" field an oil emulsion with a water content of ~ 85% is pretreated with. The "Dissolvan-V4795" is used as a demulsifier at the ShPPO "Karsak" and JV "Botakhan" with an average specific consumption and preparation temperature 193.2 g/t; 60-65°C; and 51.6 g/t; 40 °C respectively. In cases of no treatment with a demulsifier at "Botakhan" JV, due to the viscoelastic properties of the mixture of water-oil and oil-water emulsions, a sharp increase in pressure can occur on the pipeline lines (normal pressure of 2-3 atm) and can increase emergency risks during oil transportation. Therefore, daily monitoring is carried out on the specific consumption of the demulsifier, on the temperature of the preliminary preparation of oil, as well as on the pressure on the pipe lines. If necessary, is carried out on increase the specific consumption of the demulsifier, as well as the temperature of oil preparation at the JV "Botakhan". Daily analytical monitoring of oil

International Journal of Innovative Research in Science, Engineering and Technology

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Visit: www.ijirset.com

Vol. 8, Issue 2, February 2019

"Botakhan" is carried out in the laboratory of the ShPPO "Karsak" by analyzing samples from VST (vertical steel tank) No 2, 7. The duration of the "Botakhan" oil preparation is about 4 hours and for the preparation of a mixture of oil from the "Karsak" and "Baychunas" fields, the oil preparation time is about 6-8 hours. Therefore, the daily preparation of oil is a two-step discontinuous process. At ShPPO "Karsak", in general, is carried out full periodic analytical monitoring at all stages of demulsification, resulting in commercial oil in VST No 10, 12 with minimum values of water (0-0.03%) and chloride salts (up to 36-65 mg/l). Then commercial oil is delivered daily to "KazTransOil" JSC. "Dissolvan-V4795" and "IKHLAS-1" have a density of 930 kg/m³ and 905 kg/m³, respectively. Both reagents are oil-soluble demulsifiers. At the beginning of the EIT (02.02.2019) at exemption of capacity from base demulsifier "Dissolvan-V4795", we found in a mass quantity of curd-like sediments from the specified reagent. Similar negatives were also found by us during the EIT (January 2018) of the nanodemulsifier "IKHLAS-1" at the ShPPO of the OGPD "Zhaikmunaygaz" of "EMBAMUNAGAZ" JSC, where "Dissolvan-V4795" was also the basic demulsifier [6]. These curd-like deposits are potential sources of prolonged disruptions in the operation of the metering pumps in the ShPPO. * Indeed, for the first day of the EIT, in the dosing pump of the reagent, partial clogging of the systems with the indicated precipitations occurred, as a result of which the dosing pump could not realize the planned dosing. For this reason, the dosage together of 190 g/t was 86 g/t, i.e. 2.2 times less. Phase separation is one of the reasons for the decrease in the effectiveness of demulsifiers during oil preparation. The main cause of phase separation in the demulsifiers, in our opinion, is the thermodynamic incompatibility of the individual components of the compositions. This often happens with other brands of dissolvan. Thus, the thermodynamic and aggregative resistance of demulsifiers under various technical, thermal, technological and climatic conditions of oil preparation is one of the important requirements for demulsifiers. As international experience of the use of demulsifiers shows, this requirement is a generally accepted criterion for all industrial designs of demulsifiers. Therefore, if the demulsifiers do not meet the specified requirement, consumers often refuse to purchase the following portions of reagents with similar negatives. No phase separation problems were found for "IKHLAS-1" at the time of the EIT. This was the very first advantage of "IKHLAS-1" in comparison with the base demulsifier "Dissolvan-V4795". For carrying out EIT, "International Oil Services Kazakhstan" LLP delivered a test batch of nanodemulsifier "IKHLAS-1" to ShPPO "Karsak" and JV "Botakhan" for free.

II. LITERATURE SURVEY

As a result of years of world experience in the field oil production, were formulated some basic requirements for demulsifiers in the condition primary preparation of oil: [1]:

1. Demulsifiers should be effective, i.e. must ensure high quality of the prepared oil at the minimum specific consumption, minimum sludge time at the minimum temperature;
2. The demulsifier must have a large surface activity from the phase in which it is introduced;
3. The demulsifier should be well dispersed in the dispersion medium;
4. Demulsifier molecules should have good peptizing (grinding) properties in order to adsorb on reserving shells to cause their loosening;
5. The demulsifier molecules should have a high wetting effect on the elements of armor, without which it is impossible to transfer solid particles into a dispersion medium;
6. The molecules of demulsifiers should not form strong films, i.e. should not be stabilizers of the emulsion of the opposite type, and should also be cheap, transportable, universal, should not affect the commodity properties of oil and significantly change their properties when change the of externals conditions.
7. The demulsifier reagents should be low-viscosity liquids that do not exfoliate during long-term storage and do not solidify at low temperatures;
8. The demulsifiers should provide high quality separated water in the conditions of primary oil preparation, allowing it to be used in the reservoir pressure maintenance system without additional preparation;
9. The demulsifiers should not cause corrosion of pipes and equipment and reduce the effectiveness of all other reagents;
10. The demulsifier should not coagulate in the formation waters;

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 2, February 2019

11. The demulsifier must have certain anti-foam properties;
12. It is desirable that the demulsifier is oil soluble and non-ionic;
13. The demulsifier must have a high speed action;
14. Demulsifiers should exhibit thermodynamic and aggregative resistance under various technical, thermal, technological, and climatic conditions for oil preparation;
15. With the aim of maximum efficiency of destruction of all types of oil emulsions (reverse emulsions of type W/O; direct emulsions of type O/W; medium emulsions of type W/O/W), taking into account their natural nanostructures, and all types of technological residues (hard to destroy water-oil emulsions (HDWOE), hard to destroy water-oil suspensions (HDWOS), trap oil, granary oil, bottom sediments of process and commercial tanks, trap oil sludge, etc.) primary oil preparation, demulsifiers should have a nanostructure, i.e. must be nanodemulsifiers.
16. The surface pressure for nanodemulsifiers should be at least 40 mJ/m^2 [2];
17. Nanodemulsifiers should have liquid-crystalline properties [3] and their liquid-crystalline state can be visually observed [2];
18. The components of the active phase of nanodemulsifiers should show a synergistic effect in the destruction of reverse, direct and medium emulsions [4];
19. Highly effective nanodemulsifiers as a wetting agent should contain a synergistic component from homologous series of low molecular weight nonionic surfactants such as ethoxylated ethers of n-aliphatic alcohols, acids and other compounds that cause the maximum wetting (or $\cos\theta=0$, or $\cos\theta\rightarrow 0$) of components of the molecular adsorption layer ("reservation shell") [4];
20. The most suitable solvents for nanodemulsifiers are critical nano-emulsions [5], which with the active phase can produce a synergistic effect;
21. The demulsifier with the solvent should not give a visco-elastic systems;
22. Molecules of the active phases of nanodemulsifiers should easily overcome of nanostructured barriers in the dispersion medium and in the dispersed phase of oil emulsions;
23. Demulsifiers, including nanodemulsifiers should not contain nanopowder components, which can further increase the resistance of oil emulsions;

Side requirements for nanodemulsifiers in the condition primary preparation of oil:

24. Nanodemulsifiers may also possess depressant, anticorrosive and bactericidal properties;
25. Nanodemulsifiers can also perform the function of a nanodesuspensifier for treating bottom sediments consisting of a mixture of HDWOE and HDWOS;
26. Nanodemulsifiers can also perform the function as an inhibitor and solvent of visco-elastic systems in the condition primary preparation of oil;
27. Nanodemulsifiers can also perform the function as an inhibitor and solvent of gas hydrates in the condition primary preparation of oil [6];
28. Nanodemulsifiers can also perform function as a neutralizer of hydrogen sulfide and highly dispersed iron sulfide in oil in the condition primary preparation of oil;
29. Demulsifiers can also contribute to the prevention of salt deposits and mechanical impurities in the technological equipments;

Requirements number 14-28 formulated by us. Thus, the development and implementation of nanoemulsifiers (as much as possible meet the above requirements) for the treatment of formation water from oil in the conditions of primary oil preparation is one of the priorities directions of oilfield nanotechnology.

III. GROUNDS FOR CARRYING OUT THE OPI OF NANO DEMULSIFIER "IKHLAS-1":

- Technical Report of LLP NII Caspimunaigas JSC "Kazmunaygas" in the city of Atyrau. The results of the selection of samples of demulsifiers for the preparation of oil at the ShPPO "Karsak" "Embamunaigas" JSC;
- An agreement on conducting an EIT nanodemulsifier "IKHLAS-1" at the ShPPO "Karsak" and at the JV "Botakhan" OGPD "Dossormunaygas" of "Embamunaigas" JSC;

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 2, February 2019

- An approved schedule of works on OPI of demulsifiers at the ShPPO "Karsak" OGPD "Dossormunaygas".

IV. PURPOSES OF CARRYING OUT EXPERIMENTALLY-INDUSTRIAL TESTS

The objectives of the EIT were:

- determination of the effectiveness of the use of nanodemulsifier "IKHLAS-1" in the conditions of the ShPPO "Karsak" and at the JV "Botakhan" OGPD "Dossormunaygas" of "Embamunaigas" JSC;
- evaluation of the effectiveness of the use of nano demulsifier "IKHLAS-1" in comparison with the basic demulsifier "Dissolvan-V4795", used for the primary preparation of oil in the ShPPO "Karsak" and at the JV "Botakhan" OGPD "Dossormunaygas" of "Embamunaigas" JSC;
- data acquisition for the feasibility study of the industrial implementation of the nanodemulsifier "IKHLAS-1".

V. EXPERIMENTAL PART

V. I. ShPPO "Karsak"

During the period of the EIT of nanodemulsifier "IKHLAS-1", at the ShPPO "Karsak" were controlled the following most stable parameters of oil preparation:

- the residual water cut of the oil (in %) and the residual content of chloride salts in the oil (in mg/l) technological VST No.1;
- the residual water cut of the oil (in %) and the residual content of chloride salts in the oil (in mg/l) technological VST No.10, 12;
- demulsifier consumption (in kg) for the process of oil preparation (demulsification);
- specific consumption (S_c , in g/t) of demulsifier;
- the residual oil in water (in mg/l)

02.02.2019 the dosage of the nanodemulsifier "IKHLAS-1" was started. The demulsifier tank was freed from residues of the basic reagent "Dissolvan-V4795" and charged with the tested demulsifier "IKHLAS-1" and was launched at 20.10.

The results of EIT of nanodemulsifier "IKHLAS-1" in comparison with the base demulsifier "Dissolvan-V4795" are presented in tables 1-4. Comparisons of data of the Tables 1 and 2 allow the following conclusions:

- Nanodemulsifier "IKHLAS-1" can be used with $S_c = 115-120$ g/t;
- The efficiency of "IKHLAS-1" nano demulsifier with respect to "Dissolvan-V4795" ($S_c = 193-198$ g/t) is up to 67.4% or on 78 g/t;
- The effectiveness of "IKHLAS-1" for PBC number 10, 12 on residual water is three times higher than the efficiency of "Dissolvan-V4795", and on chloride salts by 8 mg/l; the dominant water concentration for "IKHLAS-1" is 0%, and for "Dissolvan-V4795" 0.03%;
- On PBC-1, the residual water averages 0.03%, and chloride salts 41 mg/l.

Tables 3 and 4 show the results of physical (density) and analytical monitoring (water and chloride salts) for each oil field at the ShPPO "Karsak" during the period of the basic technology and during the period of the EIT, respectively. Preliminary treatment with a demulsifier is carried out only at the Botakhan field. Relevant comments on "Botakhan" field are presented in section III. II. As follows from Tables 3 and 4, the density of oils entering the ShPPO "Karsak" for each field before the EIT and at EIT is almost the same.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 2, February 2019

Table 1: Results of analyzes and the necessary indicators for the primary oil preparation before EIT ("Dissolvan-V4795")

| Date | Production, t | Technological VST No.1 | | Commercial VST No.10, 12 | | Demulsifier consumption | | Oil in water, mg/l |
|--------------------|---------------|------------------------|----------------------|--------------------------|----------------------|-------------------------|--------------|--------------------|
| | | water, % | chloride salts, mg/l | water, % | chloride salts, mg/l | kg | g/t | |
| 02.01.2019 | | - | - | 0.02 | 47.6 | - | - | - |
| 03.01.2019 | 410 | - | - | 0.03 | 65.1 | 74.4 | 181 | - |
| 04.01.2019 | 415 | - | - | 0.04 | 44.3 | 83.7 | 202 | - |
| 05.01.2019 | 415 | - | - | 0.07 | 51.2 | 74.4 | 179 | - |
| 06.01.2019 | 404 | - | - | 0 | 39.8 | 93.0 | 230 | - |
| 07.01.2019 | 402 | - | - | 0 | 40.7 | 93.0 | 231 | - |
| 08.01.2019 | 399 | - | - | 0.03 | 53.8 | 65.1 | 163 | - |
| 09.01.2019 | 392 | - | - | 0.03 | 36.8 | 93.0 | 237 | - |
| 10.01.2019 | 399 | - | - | 0.06 | 64.5 | 65.1 | 163 | - |
| 11.01.2019 | 389 | - | - | 0.03 | 37.4 | 65.1 | 167 | - |
| 12.01.2019 | 416 | - | - | 0.03 | 36.8 | 74.4 | 179 | - |
| the average | 404 | 0.03* | 43.7* | 0.03 | 47.1 | 78.1 | 193.2 | 72.9** |

* data are average values for the period October-December 2018; ** value was determined before the start of the EIT

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 2, February 2019

Table 2: Results of analyzes and the necessary indicators for the primary oil preparation at EIT (“IKHLAS-1”)

| Date | Production, t | Technological VST No.1 | | Commercial VST No.10, 12 | | Demulsifier consumption | | Solution and result | Oil in water, mg/l |
|--------------------------|---------------|------------------------|----------------------|--------------------------|----------------------|-------------------------|--------------|---|--------------------|
| | | water, % | chloride salts, mg/l | water, % | chloride salts, mg/l | kg | g/t | | |
| 02.02.2019 | - | - | - | - | - | - | - | set the specific dosage: Sc = 190 g/t | - |
| 03.02.2019 | 417 | - | - | - | - | 36.2 | 86.8 | aim not achieved * control of dose pump for Sc → 190 g/t | 46.9 |
| 04.02.2019 | 430 | 0.03 | 43.1 | 0 | 30.8 | 81.7 | 190.2 | control of dose pump for Sc =140-190 g/t | 26.5 |
| 05.02.2019 | 425 | 0.03 | 38.5 | 0 | 25.7 | 82.9 | 195.1 | control of dose pump for Sc =120-140 g/t | 23.0 |
| 06.02.2019 | 420 | 0.03 | 43.7 | 0 | 37.2 | 50.6 | 120.6 | the aim achieved | 27.1 |
| 07.02.2019 | 420 | 0.03 | 42.4 | 0 | 36.0 | 50.6 | 120.6 | the aim achieved | 27.0 |
| 08.02.2019 | 400 | 0.03 | 25.7 | 0 | 30.8 | 54.3 | 135.7 | the aim achieved | 24.9 |
| 09.02.2019 | 413 | 0.03 | 45.0 | 0.03 | 51.4 | 50.6 | 122.7 | control of dose pump for Sc =110-120 g/t | 28.4 |
| 10.02.2019 | 400 | 0.03 | 31.2 | 0 | 47.5 | 46.1 | 115.4 | the aim achieved control of dose pump for Sc =95-100 g/t | 30.0 |
| 11.02.2019 | 397 | 0.03 | 51.4 | 0 | 37.2 | 48.8 | 123.1 | the aim not achieved **control of dose pump for Sc =95-100 g/t | 28.9 |
| 12.02.2019 13.02.2019 | 413 | 0.03 | 38.5 | 0.03 0 | 48.8 26.0 | 48.8 | 118.3 | the aim not achieved ** | 29.2 |
| the average | 413,5 | 0.03 | 39.9 | ≈0 | 38.3 | 55.1 | 132.8 | - | 29.2 |

* The reason is set out in the “Introduction” section; ** The reason is set out in section VI. I.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

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Vol. 8, Issue 2, February 2019

Table 3: The results of the analysis of liquids supplied to the ShPPO "Karsak" for the primary preparation of oil (demulsification) during the period of application of the base demulsifier "Dissolvan-V4795" (02.01.19-12.01.19)

| Date | Oil field "Botakhan" | | | Oil field "Karsak" | | | Oil field "Baychunas" | | |
|--------------------|----------------------------------|-------------|----------------------|----------------------------------|------------|----------------------|----------------------------------|-----------|----------------------|
| | density oil, kg / m ³ | water, % | chloride salts, mg/l | density oil, kg / m ³ | water, % | chloride salts, mg/l | density oil, kg / m ³ | water, % | chloride salts, mg/l |
| 02.01.2019 | 841.4 | 0.55 | 6025.0 | 869.8 | 7.3 | 39765 | 868.7 | 20 | 44585 |
| 03.01.2019 | 841.5 | 0.50 | 5724.0 | 868.1 | 6.9 | 41573 | 871.3 | 27 | - |
| 04.01.2019 | 841.8 | 0.45 | 4820.5 | 870.0 | 6.5 | 41573 | 870.7 | 25 | - |
| 05.01.2019 | 842.0 | 0.50 | 5724.0 | 872.3 | 7.0 | 39163 | - | - | - |
| 06.01.2019 | 842.0 | 0.50 | 4519.0 | 868.7 | 6.7 | 42175 | - | - | - |
| 07.01.2019 | 841.7 | 0.55 | 6025.5 | 872.3 | 6.4 | 44585 | - | - | - |
| 08.01.2019 | 841.4 | 0.55 | 6326.5 | 871.0 | 6.0 | 41573 | - | - | - |
| 09.01.2019 | 841.3 | 0.50 | 6326.5 | 875.1 | 6.3 | 41573 | 868.7 | 22 | - |
| 10.01.2019 | 841.9 | 0.45 | 6025.5 | 873.0 | 7.0 | 41573 | - | - | - |
| 11.01.2019 | 841.7 | 0.45 | 4820.0 | 873.1 | 7.3 | 45790 | 871.3 | 23 | 42175 |
| 12.01.2019 | 842.1 | 0.55 | 5121.5 | 873.0 | 8.0 | 45188 | - | - | - |
| the average | 841.7 | 0.50 | 5587.1 | 871.5 | 6.9 | 42230 | 870.2 | 20 | 44585 |

Table 4: The results of the analysis of liquids supplied to the ShPPO "Karsak" for the primary preparation of oil (demulsification) during the period EIT of nanodemulsifier "IKHLAS-1" (02.02.19-12.02.19)

| Date | Oil field "Botakhan" | | | Oil field "Karsak" | | | Oil field "Baychunas" | | |
|--------------------|----------------------------------|------------|----------------------|----------------------------------|------------|----------------------|----------------------------------|-------------|----------------------|
| | density oil, kg / m ³ | water, % | chloride salts, mg/l | density oil, kg / m ³ | water, % | chloride salts, mg/l | density oil, kg / m ³ | water, % | chloride salts, mg/l |
| 02.01.2019 | 841.2 | - | - | 873.0 | 7.2 | 44 762 | 871.2 | 23 | 45 384 |
| 03.01.2019 | 841.2 | - | - | 871.0 | 7.4 | 45 384 | - | - | - |
| 04.01.2019 | 842.0 | 0.4 | 4495 | 868.7 | 6.7 | 44 954 | 870.5 | 25 | 44 954 |
| 05.01.2019 | 841.8 | 0.3 | 3211 | 869.8 | 7.3 | 44 954 | - | - | - |
| 06.01.2019 | 842.0 | 0.4 | 3211 | 868.1 | 6.5 | 47 522 | 871.2 | 24 | 45 596 |
| 07.01.2019 | 842.7 | 0.4 | 3982 | 873.0 | 7.0 | 46 238 | - | - | - |
| 08.01.2019 | 842.7 | 0.4 | 3853 | 866.5 | 6.0 | 44 312 | 872.2 | 25 | 41743 |
| 09.01.2019 | 842.0 | 0.5 | 3211 | 865.0 | 6.7 | 45596 | - | - | - |
| 10.01.2019 | 842.3 | 0.4 | 3495 | 870.0 | 6.0 | 46238 | 873.0 | 36 | 33394 |
| 11.01.2019 | 842.5 | 0.5 | 3853 | 873.6 | 7.0 | 41743 | 870.5 | 25 | 44954 |
| 12.01.2019 | 842.3 | 0.4 | 3853 | 868.0 | 6.5 | 43670 | - | - | - |
| the average | 842.0 | 0.4 | 3684 | 869.7 | 6.7 | 45033 | 871.4 | 26.3 | 42670 |

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

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Vol. 8, Issue 2, February 2019

V. II. JV “Botakhan”

During the period of the EIT (03.02.19-11.02.19) of nanodemulsifier “IKHLAS-1”, at the JV “Botakhan” were controlled the following most stable parameters of oil preparation:

- the residual water cut of the oil (in %) and the residual content of chloride salts in the oil (in mg/l) technological VST No.2, 7 (in the ShPPO "Karsak") after preliminary preparation of oil at JV "Botakhan";
- demulsifier consumption (in kg) for the process of oil preparation (demulsification);
- specific consumption (S_c , in g/t) of demulsifier.

For the base comparison ETT of nanodemulsifier “IKHLAS-1”, were taken results of analysis of oil from the technological VST No.2, 7 (ShPPO "Karsak") and consumption indicators for the base demulsifier “Dissolvan-V4795” at the “Botakhan” field (05.01.19-15.01.19). The data are shown in table 5. 03.02.19 the dosage of the demulsifier “IKHLAS-1” was started. The tub was freed from the remnants of the basic demulsifier "Dissolvan-V4795" and filled with the tested nanodemulsifier "IKHLAS-1" and was launched at 16.00. The results of analyzes and indicators of the preliminary preparation of oil in the joint venture "Botakhan" with the use of the nanodemulsifier "IKHLAS-1" for the period of EIT (03.02.19-12.02.19) are given in table 6.

Table 5: Results of analysis of oil from the technological VST No.2, 7 (ShPPO “Karsak”) and consumption indicators for the base demulsifier “Dissolvan-V4795” at the “Botakhan” field

| Date | Oil pumping to ShPPO "Karsak" | Technological VST No.2, 7 | | consumption of demulsifier | |
|---------------------|-------------------------------|---------------------------|----------------------|----------------------------|-----------------------------|
| | | water, % | chloride salts, mg/l | daily consumption, kg | specific consumption, g / t |
| 05.01.2019 | 327 | 0.55 | 6025.0 | 16.9 | 51.5 |
| 06.01.2019 | 328 | 0.50 | 5724.0 | 16.9 | 51.4 |
| 07.01.2019 | 323 | 0.45 | 4820.5 | 16.9 | 52.2 |
| 08.01.2019 | 320 | 0.50 | 5724.0 | 16.9 | 52.7 |
| 09.01.2019 | 321 | 0.50 | 4519.0 | 16.9 | 52.5 |
| 10.01.2019 | 314 | 0.55 | 6025.5 | 16.9 | 53.7 |
| 11.01.2019 | 358 | 0.55 | 6326.5 | 16.9 | 47.1 |
| 12.01.2019 | 323 | 0.50 | 6326.5 | 16.9 | 52.2 |
| 13.01.2019 | 325 | 0.45 | 6025.5 | 16.9 | 51.9 |
| 14.01.2019 | 328 | 0.45 | 4820.0 | 16.9 | 51.4 |
| 15.01.2019 12.00 | 164 | 0.55 | 5121.5 | 7.0 | 42.8 |
| the average | 327 | 0.50 | 5587.1 | 16.9 | 51.6 |

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

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Vol. 8, Issue 2, February 2019

Table 6: Results of analysis of oil from the technological VST No.2, 7 (ShPPO “Karsak”) and consumption indicators for the nanodemulsifier “IKHLAS-1” at the “Botakhan” field

| Date | Oil pumping to ShPPO "Karsak" | Technological VST No.2, 7 | | consumption of demulsifier | |
|--------------------|-------------------------------|---------------------------|----------------------|----------------------------|-------------|
| | | water, % | chloride salts, mg/l | kg | g/t |
| 03.02.2019 | ≈326 | - | - | - | - |
| 04.02.2019 | ≈326 | 0.4 | 4495 | 15.611 | 47.8 |
| 05.02.2019 | ≈326 | 0.3 | 3211 | 15.611 | 47.8 |
| 06.02.2019 | ≈326 | 0.4 | 3211 | 13.575 | 41.6 |
| 07.02.2019 | ≈326 | 0.4 | 3982 | 13.575 | 41.6 |
| 08.02.2019 | ≈326 | 0.4 | 3853 | 13.575 | 41.6 |
| 09.02.2019 | ≈326 | 0.5 | 3211 | 13.575 | 41.6 |
| 10.02.2019 | ≈326 | 0.4 | 3495 | 13.575 | 41.6 |
| 11.01.2019 | ≈326 | 0.5 | 3853 | 13.575 | 41.6 |
| 12.01.2019 | ≈326 | 0.4 | 3853 | 13.575 | 41.6 |
| the average | 326 | 0.4 | 3684 | 14.0 | 42.9 |

VI. CONCLUSIONS

VI. I. ShPPO "Karsak"

During the period of EIT nanodemulsifier “IKHLAS-1”, produced by “International Oil Services Kazakhstan” LLP, the following results were achieved at ShPPO “Karsak” OGPD “Dossormunaygas” JSC “Embamunaigas”:

- The water content (in %) and the mass content of chloride salts in the oil (in mg/l) of the total oil sample from 3 levels of technological VST No. 1 averaged 0.03%; 41.7 mg/l, respectively, for the period of the EIT (02.02.19-12.02.19). Similar results when using the base demulsifier "Dissolvan-V4795" a month before the start of the EIT (02.01.19-12.01.19) were respectively 0.03%; 43.7 mg/l;
- During the period EIT of nanoemulgator “IKHLAS-1” (02.02.19-12.02.19) the average results of residual water cut of oil (in %) and of the mass content of chloride salts in oil (in mg/l) in commodity VST No. 10, 12 were respectively 0 % and 38.3 mg/l. Similar results when using the base demulsifier "Dissolvan-V4795" a month before the start of the EIT (02.01.19-12.01.19) were respectively 0.03%, 47.1 mg/l. Consequently, by chloride salts nanodemulsifier “IKHLAS-1” by 23% exceeds the efficiency of the base demulsifier “Dissolvan-V4795” in the conditions of reducing the demulsifier to 67.4% (or by 78 g/ton);
- The average consumption (in kg) of the nanodemulsifier “IKHLAS-1” for the process of preparation (demulsification) of oil during the period of the EIT amounted to an average of 55.1 kg. A similar result when using the base demulsifier "Dissolvan-V4795" a month before the start of the EIT (02.01.19-12.01.19) was 78.1 kg, i.e. in terms of average consumption, the “IKHLAS-1” nano demulsifier is 41.7% higher than the efficiency of the basic demulsifier “Dissolvan-V4795”.
- During the process of oil preparation (demulsification) the average specific consumption (dosage, in g/t) of the nanodemulsifier “IKHLAS-1” for the period of the EIT was 135.9 g / t. When using the base demulsifier

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Vol. 8, Issue 2, February 2019

"Dissolvan-V4795" a month before the start of the EIT (02.01.19-12.01.19) the analogous indicator was on average 193.2 g/t, i.e. according to the average specific consumption, the nanodemulsifier "IKHLAS-1" exceeds by 42.2% the efficiency of the base demulsifier "Dissolvan-V4795".

- ** Since the oil emulsions entering to ShPPO from the "Karsak" and "Baychunas" fields, unlike the oil from "Botakhan" field, have more density and are heavier, therefore the dosage of the demulsifier using a dosing pump presents certain difficulties at relatively low values of specific consumption (less than 140 g/t). For this reason, the lower limit (less than 115g/t) of specific consumption of "IKHLAS-1" nanodemulsifier during the EIT was not revealed, although according to the experiments at the fields of OGPD "Zhaikmunaygaz" JSC "Embamunaigas" and JSC "Phystech", "IKHLAS-1" had potential for a two-fold reduction of the demulsifier;
- For the first time with the test nanodemulsifier "IKHLAS-1" of the company "International Oil Services Kazakhstan" LLP it was achieved up to 67.4% (or on 78 g/t) reduction in specific consumption of the demulsifier;
- As follows from the data in Tables 1 and 2, the effectiveness of the "IKHLAS-1" nano demulsifier in terms of residual oil content in the composition of formation water is 2.5 times higher than effectiveness of the base demulsifier "Dissolvan-V4795" and complies with the existing standards (not more than 50 mg/l) for the system maintain reservoir pressure.

VI. II. JV "Botakhan"

During the period of EIT nanodemulsifier "IKHLAS-1", produced by "International Oil Services Kazakhstan" LLP, the following results were achieved at JV "Botakhan" OGPD "Dossormunaygas" JSC "Embamunaigas":

- The water content (in %) and the mass content of chloride salts in the oil (in mg/l) at the exit of the technological VST No. 2, 7 of the ShPPO "Karsak" during the period of the EIT (02.02.2019-11.02.2019) averaged 0.4% and 3685 mg/l, respectively. Similar results when using the base demulsifier "Dissolvan-V4795" one month before the start of the EIT (02.01.19-12.01.19) were respectively 0.5%, 5614.5 mg/. Consequently, the efficiency nano demulsifier "IKHLAS-1" on chloride salts of the are 52.3% higher than the efficiency of the base dissolver "Dissolvan-V4795". The dominant water concentration for "IKHLAS-1" is 0.4%, and for "Dissolvan-V4795" 0.50-0.55%, i.e. "IKHLAS-1" is 31.2% higher than the efficiency of "Dissolvan-V4795";
- The average consumption (in kg) of the nanodemulsifier "IKHLAS-1" for the process of preparation (demulsification) of oil during the period of the EIT amounted to an average of 14.0 kg. A similar figure when using the base demulsifier "Dissolvan-V4795" a month before the start of the EIT (02.01.19-12.01.19) was 16.9 kg. The effect of reducing the consumption of demulsifier is 20.7%;
- During the process of preparation (demulsification) of oil, the average specific consumption (dosage, in g/t) of the nanodemulsifier "IKHLAS-1" during the period of the EIT was 42.9 g/t. When using the base demulsifier "Dissolvan-V4795" a month before the start of the EIT (02.01.19-12.01.19) the similar indicator was on average 51.6 g/t. The effect for "IKHLAS-1" from reducing the specific consumption of the demulsifier is 20.3%.

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Visit: www.ijirset.com

Vol. 8, Issue 2, February 2019

VII. RECOMMENDATIONS

Based on the results of joint experimental-industrial tests, for the first time, were reached decline the specific consumption of the demulsifier to 67.4% (or on 78 g/t) and also the high quality of commercial oil and formation water, so nano demulsifier “IKHLAS-1” was recommended to industrial implementation at the ShPPO “Karsak” and at the JV “Botakhan” of the OGPD “Dossormunaygaz” JSC “Embamunaigas” Republic of Kazakhstan with specific consumptions of 115-120 g/t and 41-43 g/t, respectively.

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