ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 12, Issue 4, April 2025

The degree of stability of water-in-oil emulsions and factors affecting it

Uzakbaev K.A

PhD student, Bukhara State Technical University.

ABSTRACT: Water-oil emulsions are unstable systems, which cause the formation of small phase boundaries, and their phase separation processes also occur due to the difference in density. However, in most cases, emulsions with high stability are formed during the operation of oil production equipment. This complicates the choice of technological mechanisms and modes for the preparation of water-oil emulsions, as well as the separation of the water phase from oil. The time required for the separation of highly stable water-oil emulsions into separate phases is characterized by a long period of time. Depending on the type of emulsions, the stability of the emulsions can occur for a period of several seconds to a year or more. In oil production wells, the flow velocity of the water-oil emulsion during its movement from the wellhead to the collection and preparation points varies from 2-3 m/s to several tens of m/s.

KEYWORDS: water-oil emulsions, demulsifiers, oil preparation equipments (OPE), kinematic viscosity, dynamic shear stresses, indicator Δρ.

I. INTRODUCTION

Large changes in the speed of fluid movement lead to the dispersion of water droplets in oil and the formation of an emulsion. Similarly, in separation devices, measuring devices, pump or compressor units, the movement of the flow through sections of pipes with a changed diameter, bends, and twists causes the formation of emulsions and their stabilization. In the above technological units, the flow velocity and turbulence can significantly increase, which, based on physicochemical laws and procedures, leads to a decrease in the size of water droplets and an increase in their dispersion by several tens or even hundreds of times [1; p. 87-88].

II. SIGNIFICANCE OF THE SYSTEM

This article examines the factors affecting the stability of water-oil emulsions formed in the fields of the foreign enterprise "Sanoat Energetikal Group". It also examines the extent to which the results of the research work studied differ from certain standard requirements. The Methodology and Discussion is presented in section III, section IV covers the experimental results of the study, and section V discusses the future study and conclusion.

III. METHODOLOGY AND DISCUSSION

The evaluation of the activity of selected surfactant compositions with demulsifying properties in the separation of water-oil emulsions into phases is carried out in laboratory conditions, modeling the processes of dewatering water-oil emulsions in special devices equipped with a mixing device for demulsifiers in water-oil emulsions and a thermostatic shell.
This method allows for a high degree of reliability in determining the specific consumption of the surfactant recommended for pilot tests conducted mainly in oil fields and determining the activity levels of the tested demulsifying surfactants. This method is used to compare the activity of surfactants or their compositions with demulsifying properties in order to separate natural water-oil emulsions and artificial water-oil emulsions formed during the operation of oil production wells.

This special method is not intended to determine the technological consumption of demulsifiers for the purpose of using them in specific technological processes. The specific standards set are determined based on the results of experimental tests with demulsifying surfactants at each specific technological facility. The emulsion samples used in laboratory tests must be close to natural emulsion samples, that is, their properties must be characteristic of at least 50% of all raw

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 12, Issue 4, April 2025

materials extracted from the mine. The procedure for taking emulsion samples from pipelines is carried out in accordance with GOST 2517-2012 [2; 8-12 p.].
In order for the results of laboratory studies to be reliable, the emulsion sample must be taken and the experiments must be carried out within a short period of time, that is, the samples must be taken or prepared within a period of no more than 2 hours from the start of the experiment. It is necessary to ensure that the selected sample has not undergone the "aging" process and is compatible with natural emulsions transported from production wells. If water and oil are separated into separate phases, they must be mixed in a mixer at a speed of 1500 rpm for 3-5 minutes. After that, it is left to settle for 20 minutes, and if phase separation is not observed, this process is repeated, then poured into separate sediments, taking into account the exact volume of water [3; p. 75-77].

The composition of locally produced high-viscosity heavy oils contains a large amount of natural stabilizers (asphaltene, tar, naphthene, paraffin, etc.) and emulsifiers.
In addition, the smallest solid particles (clay, quartz, salts, etc.) present in SNEs also contribute to their increased stability [4; 174-176 p.].

From the analytical data of local water-oil emulsions, it became clear that the size of water globules in the dispersion aqueous phases varies from 0.1 to 250 µm. Also, during the "living" processes of emulsions, the emulsifier layer on the water globules increases, which leads to an increase in their mechanical strength. In addition, the extracted mineralized layer waters lead to the formation of oil emulsions that are relatively stable and age quickly compared to fresh waters. When the globules of these layer waters collide with each other, their coalescence process is not observed, since they have strong hydrophobic protective layers. Therefore, in order to ensure the coalescence of water globules, it is necessary to eliminate these protective layers and replace them with hydrophilic layers of some surfactants [4; p. 54-58].
Water-oil emulsions can be characterized by the degree of their demulsification or the intensity of oil emulsification over a certain period of time.
The acceleration of the process of separation of stable water-oil emulsions into separate phases is characterized by the difference between the densities of water and oil ($\Delta\rho$), the components in the composition of the oil (a + r)/p, as well as the ratio of the amounts of asphaltenes (a) and resins (r) to the total amount of paraffins (p). The values of these indicators allow us to determine the methods of separation of the processed water-oil emulsions into separate phases [165; 57-59 p.].

In this case, the density difference $\Delta\rho$ is determined based on the difference in densities of water and oil in the samples under study, corresponding to gravitational sedimentation under the influence of gravity. After the separation of water-oil emulsions into separate water and oil phases, their densities are measured separately and the difference between them is determined [5; p. 57-59].
Based on the above, local oils can be divided into the following according to the (a+r)/p indicator [5; p. 57-59]:
- mixed [(a+r)/p] = 0.951÷1.400;
- resinous [(a+r)/p] = 2.759÷3.888;
- highly resinous [(a+r)/p] = 4.774÷7.789.

We have studied the classification of the breakdown of local water-in-oil emulsions based on $\Delta\rho$ [6; pp. 4-10]:
- difficult to decompose ($\Delta\rho$=0.2-0.25 g/cm^3);
- decomposed ($\Delta\rho$=0.25-0.30 g/cm^3);
- easily decomposed ($\Delta\rho$=0.3-0.35 g/cm^3).

In oil production wells, the well product is obtained in the form of an emulsion, which simultaneously contains water, various salts, mechanical impurities and other components. Therefore, in the initial stages of water-oil emulsions, these substances are separated from the oil using various methods.
As noted above, unfortunately, this process does not allow easy separation of water and associated components in all oil emulsions. Today, highly stable water-oil emulsions of heavy oils extracted from the corresponding fields are being prepared at the oil preparation equipments (OPE) of the "Northern Ortabulok", "Shurtepa" and "Shirkent" owned by the "Sanoat Energetikal Group" PE [7; pp. 127-131].
The separation of such stable water-oil emulsions is complicated by the presence of highly dispersed mixtures, asphaltene-resinous substances, etc., which act as emulsifiers [8; pp. 268-273].

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 12, Issue 4, April 2025

IV. EXPERIMENTAL RESULTS

We studied the factors affecting the stability of the water-oil emulsion formed in the fields belonging to the “Sanoat Energetikal Group” JSC. In this case, sampling of the water-oil emulsion is carried out in the OPE themselves, before and after treatment with a demulsifier (up to 50 ÷ 110 g/t).

We studied the content of asphaltenes, resins, paraffins and other emulsifiers in the oils of the Northern Ortabulaq, Shirkent, Okkul, Shu‘rtepa, Kruk, Sarikum, New Koratepa OPE and the Kokdumalaq (under-reef) collection point using various methods and techniques, and the results obtained are presented in Table 1. And the extent to which the results of the studied research work differ from certain standard requirements was studied [8; 268-273 p.].

Table 1.
Chemical composition of prepared oils in local OPE

Oil preparation equipments	Composition (by weight), %				
	Asphaltene	Resin	Paraffin	Sulfur	Coke
Northern Ortabulaq	0,89	4,52	6,2	1,23	6,32
Shirkent	5,36	11,798	6,34	4,553	9,58
Okkul	2,85	2,92	9,61	0,42	7,35
Shu‘rtepa	0,43	7,83	6,39	1,59	2,88
Kruk	1,45	3,16	2,03	2,18	3,38
Sarikum	0,404	6,65	2,99	0,12	2,63
New Koratepa	4,504	3,26	4,608	0,1	5,28
Kokdumalaq (under-reef) collection point	1,28	9,74	7,45	1,79	3,91

As can be seen from Table 3.1 above, the water-oil emulsions from the local Shirkent and New Koratepa OPE contain approximately two to three times more asphaltenes than the oils from the Okkul, Kruk OPE and the Kokdumaloq (under-reef) collection point, and up to ten times more asphaltenes than the oils from the Shurtepa and Sarikum OPE. The oils from the Shirkent, Shurtepa and Kokdumaloq (under-reef) collection points contain a higher amount of resins than the oils from the remaining OPE. The same indicators can be said about the sulfur content, which can be seen to be 2.5-4.0 times higher than the Kokdumaloq oils [8; pp. 268-273].

We can see the results of the analysis of the local water-oil emulsion $\Delta\rho$ indicator from Table 2.

Table 2.
$\Delta\rho$ indicators of water-oil emulsions

Oil preparation equipments	Indicator $\Delta\rho$, g/sm^3
Northern Ortabulaq	0,272÷0,276
Shirkent	0,112÷0,131
Okkul	0,230÷0,236
Shu‘rtepa	0,274÷0,280
Kruk	0,132÷0,145
Sarikum	0,195÷0,199
New Koratepa	0,204-0,216

From the data in Table 3.2, it is clear that the water-oil emulsion under consideration does not contain easily decomposed emulsions. The emulsions prepared at the OPE “Shimoliy Ortabulok” ($\Delta\rho$=0.272÷0.276 g/cm^3) and “Shurtepa” ($\Delta\rho$=0.274÷0.280 g/cm^3) are classified as decomposed according to the $\Delta\rho$ indicator, while the rest are classified as difficult to decompose. In addition, the water-oil emulsions of the OPE “Shirkent” ($\Delta\rho$=0.112÷0.131 g/cm^3), “Sarikum” ($\Delta\rho$=0.195÷0.201 g/cm^3) and “Kruk” ($\Delta\rho$=0.132÷0.145 g/cm^3) are difficult to separate even with the presence of highly efficient demulsifiers.

Based on previous analyses, the (a+r)/p indices of oils from local OPE were calculated and the results obtained are presented in Table 3 [9; pp. 190-192].

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 12, Issue 4, April 2025

As can be seen from the data presented in Table 3.3, according to the (a+r)/p indicator, the “Northern Ortabulaq” OPE [(a+r)/p=4.406÷4.842] belong to local high-resin oils, the oils from the “Shirkent”, “Shurtepa”, “Kruk” and “Sarikum” OPE belong to the category of resinous oils, while the oils from the “Oqqul” (0.347÷0.770) and “Yangi Koratepa” (0.977÷1.465) OPE belong to the type of mixed oils.

Table 3.
(a+r)/p indicators for local oils

Oil preparation equipments	The value of (a+r)/p
Northern Ortabulaq	4,406÷4,842
Shirkent	2,706÷3,261
Okkul	0,347÷0,770
Shu‘rtepa	2,692÷3,239
Kruk	2,382÷2,961
Sarikum	3,479÷3,771
New Koratepa	0,977÷1,465

Based on the requirements established by a specific GOST, in addition to the above, the studied oils also differ in significant quantities based on their physicochemical characteristics.
Today, in the process of primary preparation of raw materials, mainly oils extracted from various fields are transferred to the preparation, which leads to large irretrievable losses of valuable raw materials.
The presence of water in the extracted oil formations causes changes in their physicochemical properties.
The results of the study of the kinematic viscosity of a water-oil emulsion at 20 ^{0}C are shown in Figure 1 as an example. As can be seen from Figure 3.1, as the water content in the oil increases, its kinematic viscosity increases sharply. Moreover, the greatest increase in the kinematic viscosity of the water-oil emulsion is observed in the oils of the Northern Ortabulak and Sariqum OPE.
In particular, due to the high viscosity of such water-oil emulsions and the presence of substances with emulsifying properties, the separation of these emulsions into separate phases is carried out with great difficulty and requires high capital costs and a long period of separation.
Since the viscosity of the water-oil emulsions at the Shurtepa and Kruk OPE (Figure 3.1) is low compared to the above-mentioned oils, dehydration, desalination, and fragmentation are easily carried out [10; pp. 559-564].

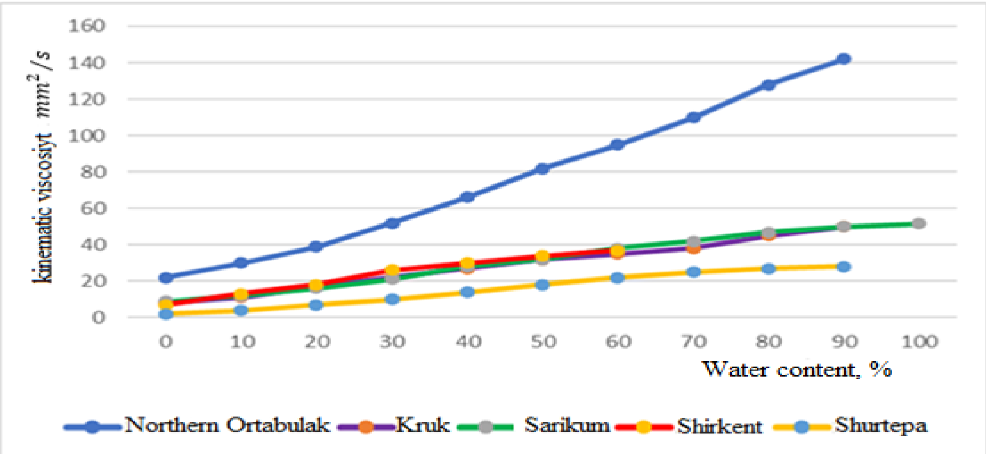

Figure 1. Variation of the kinematic viscosity (ν) of a water-oil emulsion depending on the amount of formation water (Q_s) in its composition: 1 - emulsion formed at the Northern Ortatubalok OPE; 2 - emulsion formed at the Shirkent OPE; 3 - emulsion formed at the Shurtepa OPE; 4 - emulsion formed at the Kruk OPE; 5 - emulsion formed at the Sarikum OPE;
A similar situation is observed when studying the dynamic shear stresses of local water-oil emulsions formed at the Northern Ortabulaq, Shirkent, Aqqul, Shurtepa, Kruk, and Sariqum OPE. The results of the study of the dynamic shear stresses of highly stable water-oil emulsions of local heavy oils are presented in Figure 2.

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 12, Issue 4, April 2025

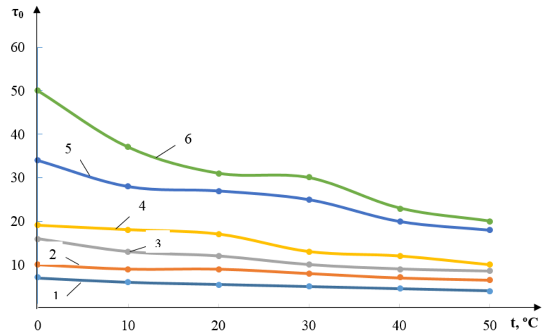

Figure 2. Variation of dynamic shear stresses (τ_0) of local oils as a function of temperature (τ).

Figure 2 shows that the rheological properties of the oils from the Northern Ortabulaq (curve 1), Shirkent (curve 2), Akkul (curve 3) and Shorchi (curve 4) fields are close to each other. On the contrary, the rheological properties of the oils from the Sarikum (curve 6) and Kruk (curve 5) fields differ sharply from the previous ones. This is explained by the presence of a large amount of resinous substances and paraffins in them [10; p. 559-564].

V. CONCLUSION AND FUTURE WORK

In particular, as a result of the analysis of the composition and physicochemical properties of emulsions formed during the extraction, well exploitation, and collection and preparation of local high-viscosity heavy oils, we conclude that it is advisable to prepare chemical reagents (demulsifiers) close to their properties for industrial preparation and mix them with oils and their emulsions. Also, based on the specific characteristics of the composition of the studied emulsions, it is advisable to prepare water-oil emulsions at the Northern Ortabulak and Sariqum OPE for processing separately, without mixing them with others. Also, as the amount of water in the emulsions increases, their viscosity also increases. It was found that when this indicator reaches the maximum value of hydration (B=98%), it increases from 3.6 to 6.7 times, depending on the place and environment of the emulsion extraction. As a result, the stability of the emulsion also increases several times. To break such highly stable emulsions, there is a need for an increased amount of demulsifiers or new complex demulsifiers.

As can be seen from the above data, the mechanisms of formation of stable water-oil emulsions are very complex and their behavior has not been fully studied to date. Therefore, it is necessary to find effective methods for separating stable water-oil emulsions into phases and use unconventional methods of breaking mechanisms.

REFERENCES

[1]. Промысловая подготовка нефти и газа: Учебное пособие / Благовещенск: Амурский гос. ун-т, 2021. – 115 с.
[2]. ГОСТ 2517- 2012 Межгосударственный стандарт. Методы отбора проб нефть и нефтепродукты.-М.: Стандарт, 2014. 35 с.
[3]. Неклюдов А.Д., Иванкин А.Н., Федотов Г.Н., Олиференко Г.Л. Теоретические и экспериментальные методы исследования в химии. Учебное пособие. Изд. 2, доп. и перераб. – М.: МГУЛ, 2016. – 502 с.: ил. 124.
[4]. Эшметов Р.Ж. Ишлаб чикиилган сирт-фаол моддалардан фойдаланиб юқори қовушқоқ маҳаллий нефтларни ультратовушли деэмульгирлаш технологияси // т.ф.д. илмий даражасини олиш учун диссертация иши Тошкент. 2021. – 275 б.
[5]. Очилов А.А., Абдурахимов С.А., Адизов Б.З., Рахимов Б.Р. Разработка композиции деэмульгаторов, применямых в разрушении высокоустойчивых водонефтяных эмульсий тяжелых нефтей// Монография, - Бухара, Издательство "Умид", 2020. С. 120.
[6]. Abduraxim Ochilov, Bobirjon Adizov. Analysis of demulsifier production from sulfurized cottonseed oil and breakdown of water-oil emulsions // Austrian Journal of Technical and Natural Sciences 2024, № 3-4. P. 79-82.
[7]. Очилов А.А., Адизов Б.З. Разработка деэмульгатора для разрушения тяжелых высоковязких водо-нефтяных эмульсий // VIII Всероссийской научно-практической конференции «Информационые и инновационные технологии в науке и образовании»г.Таганрог. 26-27 октября 2023г. С. 127-131.
[8]. Xushnud Shukurulla uli Ismailov, Kamal Axmet uli Uzakbayev, Abduraxim Abdurasulovich Ochilov. Og'ir neftlarning suvneftli emulsiyalarini parchalash texnologiyalarini o'rganish bosqichlari // SCIENCE AND EDUCATION, Scientific journal. In volume 4. Issue 1, Yanuary 2023. 268-273 b.
[9]. Ochilov A.A., Uzakbayev K.A., Adizov B.Z. Mahalliy og'ir neftlar suv-neft emulsiyalarining dastlabki ko'rsatkichlari // "Neft va gaz sohasidagi zamonaviy innovasion texnologiyalar". Respublika miqyosidagi ilmiy-texnik anjuman materiallari 12-13 may, 2023 y, Toshkent 190-192 b.
[10]. Ochilov A.A., Ochilov X.G. Og'ir yuqori qovushqoqli neftlarda barqaror suv neft emulsiyalarining shakllanishi va barqarorlanishining sabablari SCIENCE AND EDUCATION, Scientific journal. In volume 3. Issue 4, April 2022., 559-564 b.

[11]. Ochilov A.A., Eshmetov I.D., Salikhanova D.S., Adizov B.Z. Decomposition of high-stable water-oil emulsions of heavy oils in an oil preparation device. *The journal "Processes of Petrochemistry and oil Refining" (PPOR).* **SSN: 1726-4685**
[12]. Uzakbaev K.A., Ochilov A.A., Abdikamalova A.B., Salixanova D.S. Analysis of the process of breaking down water-oil emulsions of heavy oils using the developed local demulsifier. The European Journal of Technical and Natural Sciences 2024, № 3 – 4, p 21-26.
[13]. Eshmetov I. D., Salixanova D. S., Adizov B. Z., Ochilov A.A., O'rinov X.X., Uzakbaev K.A. Yuqori turg'un suv - neftli emulsiyalarini parchalash uchun samarador deemulgator tarkibini tanlash. "Central Asian Food Engineering and Technology" elektron ilmiy jurnali, 2024. №8, 72-77 bet.