Section 4. Technical sciences in general

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ANALYSIS OF THE PROCESS OF BREAKING DOWN WATER-OIL EMULSIONS OF HEAVY OILS USING THE DEVELOPED LOCAL DEMULSIFIER

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Abstract

In this article, samples of water-oil emulsions of local deposits in oil production facilities are studied and their composition and properties are studied. The images of water and salts in the obtained high-viscosity water-oil emulsions were studied using an electron microscope. Also, demulsification of these emulsions was carried out using a demulsifier synthesized on the basis of local raw materials, and the obtained results were compared with export demulsifiers.

Keywords: *dewatering, desalting, deemulsifier, emulsion aging, water globule, armored layer*

Introduction

Currently, the development of oil fields is characterized by an increase in the production of heavy, high-viscosity oils. Such hydrocarbon systems contain heavy components, asphaltene-resin substances and mechanical impurities together with a large amount of water. Their presence significantly complicates oil production processes, especially dehydration processes. In addition, during the processing of high-viscosity oils, intermediate layers (salvat layer) are formed, which are characterized by a very high resistance to decomposition. These layers can accumulate in the settling equipment, which causes the complete oil purification process to be continuous.

Also, one of the main sources of environmental pollution as a result of man's man-made activities is oil extraction and oil processing industries. Due to emergency situations, as well as during the production activities of oil extraction and oil refining enterprises, a lot of oil waste accumulates.

Methods

During the operation of oil fields, the formation of permanent water-oil emulsions, their properties change over time and depend on many factors. With long-term storage in open embers and reservoirs, the stability of such systems increases significantly. This happens due to the «aging» of emulsions, the compression and hardening of armored shells in water droplets over time, the evaporation of light fractions, the decomposition of petroleum products, the increase of mechanical impurities due to atmospheric dust, etc.

The processing of oil waste is considered a complex technical and technological task, which is primarily caused by a stable oil emulsion with a large amount of mechanical impurities. Its main task is to separate into three parts: water, mechanical compounds and hydrocarbon parts.

Like any pollutant, refinery waste also has a negative impact on the environment. Oil waste belongs to the 3rd class, it disrupts the natural balance in ecosystems, another negative effect on the environment is the adaptation of solar radiation. In the process of this phenomenon, gas exchange and evaporation processes are disturbed. .

Traditional methods of heavy oil preparation (dewatering, desalination) in field conditions can be done using thermal, chemical and their combined methods, as well as electric field methods. However, their acceleration, which is necessary in such cases – increasing the temperature of oil processing, increasing the doses of flow-selective reagents-demulsifiers, increasing the strength of the electric field – leads to a significant increase in the cost of the oil preparation process.

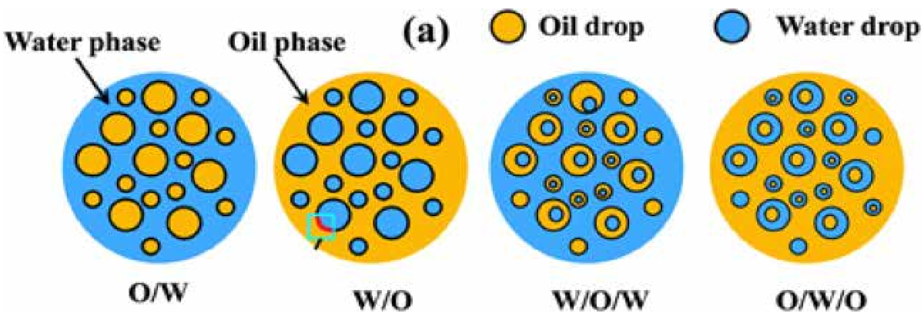
Various methods are used to break oil emulsions, each of which has its own advantages and disadvantages. These methods are characterized by high capital and operating costs and the unstable effects of breaking emulsions. Therefore, the improvement and development of existing effective methods for the separation of oil emulsions are urgent tasks.

Water-in-oil emulsions are one of the few problems directly related to the oil industry. The presence of a large amount of emulsified water increases the cost of transportation of crude oil, increases corrosion and causes other types of additional technical services. These emulsions are stabilized in the presence of asphaltenes. When the emulsion is stabilized, the water-oil emulsion is difficult to separate into phases. When a water-oil emulsion rises to the surface and is poured into production facilities, the formation of an emulsion increases the cost of oil production.

The stability of most oil emulsions increases with time. During the aging of the emulsion in water globules, the emulsifier layer increases and, accordingly, its mechanical strength increases. When such globules collide, they do not come together due to the presence of a strong hydrophobic film. To combine the water globules, it is necessary to destroy this film and replace it with a hydrophobic layer of any surfactant. Aging of emulsions continues intensively only in the initial period after their formation, and then slows down significantly.

Emulsions commonly used in crude oil production include oil-in-water (o/w), oil-in-water (w/o) emulsions, oil-in-water-in-oil (o/w/o) and water-in-oil-in-water (w/o/w) emulsions. A complex emulsion is also called a multi-emulsion. Four types of emulsion are shown in (Figure 1).

Figure 1. *Types of emulsions*



A water-in-oil emulsion is a type of emulsion in which the continuous phase is usually hydrophobic materials such as oil, and the dispersed phase is water. More than 95% of water-in-oil emulsions are inverted emulsions. The "aging" characteristics of the inverse emulsion depend on the composition and properties of oil, water sources, conditions of emulsion formation (temperature, intensity of phase mixing).

The main properties of oil emulsions include the degree of disintegration over a certain period of time, the effective (in some cases structural) viscosity, the average diameter of the emulsified droplets of the aqueous phase. Together, these parameters reflect the intensity of the oil emulsion, its physical and chemical properties, and the adsorption of the emulsifier.

Emulsion decomposition intensity can be estimated by the difference between water and oil densities ρ_d as well as the ratio of the total content of asphaltene (a) and resins (s) to the content of paraffin (n) in oil (a+s)/n. The last indicator determines the method of emulsification of oil emulsions. The indicator ρ_d orresponds to the driving force of gravity sedimentation. Both indicators are quality characteristics of emulsions, which allow them to be divided into groups.

Depending on the density ratio of water and oil, emulsions are classified as difficult to decompose $\rho_d = (0.200 - 0.250\ g/sm^3)$, decomposable $\rho_d = (0.250 - 0.300\ g/sm^3)$ and easily decomposed $\rho_d = (0.300 - 0.350\ g/sm^3)$. According to the (a+s)/n indicator, oils are divided into types: mixed ((a + s)/n = 0.951–1.400); resin ((a+s)/n = 2.759–3.888); and high pitch ((a + s)/n = 4.774–7.789).

Results and discussion

In our research, we took 6 water-oil emulsion samples from local heavy high-viscosity oil fields and studied their composition based on existing methods and standards, and the results are presented in (Table 1) below.

Table 1. *Composition and description of samples of water-oil emulsions*

Sample	Density kg/m ^{3}	Viscosity (20 °C) Pa*s	Paraffin quantity,%	Sulfur quantity,%	Asphalten, %	Salt, mg/l	Watering%
Sample 1	990	35.3	5.97	4.9	14.5	11330	84.7
Sample 2	947	30.1	3.85	3.5	8.8	470.5	77.7
Sample 3	973	32.3	4.52	2.33	7.9	7000.5	83.9
Sample 4	953	29.7	4.69	3.6	7.4	762	80.6
Sample 5	946	33.2	5.94	3.81	7.3	888.96	82.1
Sample 6	963	30.1	3.78	4.55	8.9	762.02	80.9

As can be seen from (Table 1), the studied samples are heavy oils that require deep purification in terms of hydration, viscosity, sulfur and salt quantity. Also, as a result of extraction of these oils from the well with the help of pumps, a complex water-oil emulsion is formed.

Viscosity oils are emulsions the main task of the cracking process is to separate water and oil into separate phases. In the process of breaking down emulsions, it consists in destroying the outer shell of the contained water globules. To prepare oils for industrial processing, the speed and efficiency of the stage of breaking up of emulsions is of great importance. Nowadays, it is important to choose the appropriate equipment, effective demulsifiers and technological regimes to optimize the processes of dewatering and desalination of oils.

A chemical cracking method was used to break up water-in-oil emulsions of high-viscosity heavy oils. For this, the demulsification process was carried out in laboratory conditions at a temperature of 60 °C with the TKM-1 demulsifier synthesized on the basis of local raw materials at a consumption of 90 g/t.

The role of demulsifiers acting on emulsions of high-viscosity oils is that they break up the emulsifiers surrounding the water globules and precipitate them. We used an electron microscope to study the mechanical compounds, salts, etc. that cause the stability of various types of stable emulsions of local oils.

In order to determine the efficiency of demulsification, the images of water-oil emulsions of samples 1 and 3 before demulsification and after demulsification were obtained using an electron microscope with optical indicators of brand NLCD-307B (made in Czechia). Conducting electron microscope studies of emulsions of high viscosity oils provides an opportunity to obtain more information about them.

Of course, with a small error, particles of water globules are visible, that is, evenly distributed. The obtained results are presented in Figure 2 below, where it is possible to see the localization of high viscosity oil emulsions and water globules.

Figure 2. *Electron microscope view of highly viscous water-oil emulsions before the demulsification process*
A) sample 1; B) sample 3

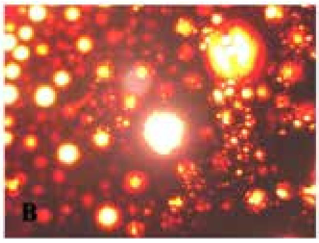


Figure 2 shows water and salts in water – oil emulsions imaged under an electron microscope the most complex of the obtained samples (a) sample 1 at 20 °C (a) sample 3 at 20 °C you can see the temperature state (b). It is observed that the additives in the oil act as an emulsifier and surround the dispersed phase of the emulsion from the outside.

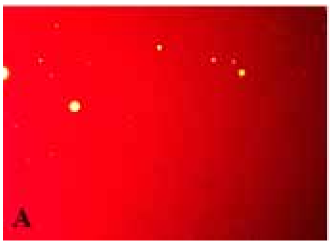
Taking them into account, based on the properties and stability of emulsions, emulsions the task of removing stabilizers separately is set. In the process of hydrodynamic action and in the presence of surfactants, mechanical mixtures with a hydrophilic surface are well wetted with water and transition to the aqueous phase (washed) due to the increase in the concentration of the mechanical mixture.

The result of removing mechanical impurities in the oil (highly dispersed mixture, asphaltene, tar, iron sulfide, etc.) is the formation of water globules in emulsions. there is an opportunity to reduce the surface tension force and the process of coalescence is observed in water droplets.

In recent years, various chemical reagents have been added to oil wells to facilitate oil extraction and processing processes, which affect the formation of stable emulsions.

The conducted studies show that it is effective to describe the external structure of water -oil emulsions of local high-viscosity oils using the electron microscope method. Currently, demulsifiers and non-traditional methods are used to break down the outer shells of water globules in emulsions and collect the water droplets in the emulsion. Also, the amount of water remaining after the demulsification process at high consumption of demulsifiers can be seen in (Figure 3).

Figure 3. *Electron microscope view of high viscosity water-oil emulsions after demulsification process*
A) sample 1; B) sample 3



As can be seen from Figure 3, a certain amount of water and salt remains after the process of demulsification of water-oil emulsions. In order to break down emulsions at the desired level, it is necessary to use a high demulsifier consumption or use other cleaning methods.

Deemul gator is one of the main technical and economic indicators of the processes of dewatering and desalination of WOE of especially heavy oils.

We analyzed the amount of residual water after the deemulsification process of water-oil emulsions at a temperature of 20 °C in laboratory conditions, and the obtained results are presented in (Table 2) below.

In practice, the selection of demulsifiers for breaking down water-oil emulsions of highly hydrated oils is carried out experimentally to determine the optimal technological regimes (temperature, mixing speed, demulsifier flow, etc.) for this process.

Table 2. *Experimental results of demulsification of WOEs of local oils with synthesized TKM –1 and existing demulsifiers DEKS-017 and SNPX-4410*

WOE fields	Emulsion hydration,%	Type of demulsifier	Demulsifier consumption, g\t	Separation time, min	Amount of residual water in oil,%
Sample 1	88	DEKS-017	90	30	11
Sample 1	88	SNPX-4410	90	30	9
Sample 1	88	TKM-1	90	30	6
Sample 3	81	DEKS-017	90	30	10
Sample 3	81	SNPX-4410	90	30	7
Sample 3	81	TKM-1	90	30	4

As can be seen from (Table 2), the proposed TKM-1 demulsifier is more efficient than the currently used demulsifiers. But these indicators are not at the level of the standards set for the preparation of oil.

In addition, the more complex the composition of stagnant water-oil and oil-slurry emulsions, the more difficult it is to break them up even with a large amount of demulsifier. Or it is necessary to carry out the demulsification process under temperature, that is, to carry out the chemical method by thermochemical method.

It is known that an increase in temperature usually has a positive effect on the demulsibility, so we studied the effect of this factor on the stagnation time. The experiments were carried out when TKM-1, SNPX-4410 demulsifiers were used in the amount of 0.01% of the total weight of the broken emulsions. From Table 3, the study was continued at the temperature of all emulsion samples from 20 °C to 80 ° C.

If we compare the previously known SNPX-40 deemulsifier, compared to TKM-1 deemulsifier, it is possible to reduce the residence time by 0.5 hours.

Heating of stable water emulsions under industrial conditions is associated with significant energy and material costs. Therefore, water-oil emulsion decomposition experiments are conducted at a temperature of 60 °C.

Table 3. *Time-dependent effect of temperature on the process of decomposition of water-oil emulsions*

The temperature is °C	WOE demulsification time, minutes	
	Sample 1 SNPX-4410 (control)	Sample 3
20	72.0	80.0
40	65.0	60.0
60	55.0	52.0
80	45.0	48.0

The temperature is °C	WOE demulsification time, minutes	
	Sample 1 SNPX-4410 (control)	Sample 3
	Demulsifier TKM-1	
20	45.0	48.0
40	30.0	35.0
60	25.0	30.0
80	15.0	17.0

Conclusion

Residue after cracking of water-oil emulsions in North Ortabulak oil production facilities with developed demulgators the amount of water serves as one of the important indicators of the success of the demulsification process. In demulsification process, it can be seen that the breaking time of emulsions decreases with increasing temperature. That is, if we heat the emulsions from 20 ° C to 80 ° C during the deemulsification process, the time for the 1st sample was shortened from 45 minutes to 15 minutes, for the 3rd sample from 48 minutes to 17 minutes. Also, after breaking down, the amount of residual water in the water-oil emulsion is reduced.

Therefore, in this case, import substitution based on domestic reagents allows to reduce the cost of products obtained in oil producing enterprises and improves their quality.

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