Reduction the viscosity of oil-slime emulsions of heavy oils using gas condensate

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Abstract. For breakdown of each type of stable oil-water and oil-slime emulsions, individual approaches for selection of effective emulsion breakers or their compositions with the determination of optimal conditions for their use are required. Solution to such a complex problem is achieved using integrated approach that includes a number of colloidal-chemical, technological and other research methods. In this case, we offer technology of dehydration and desalting of stable water-oil and oil-slime emulsions using the created compositions of emulsion breakers and viscosity-lowering agent, i.e. gas condensate.

1. Introduction
In the world, with the growth of production and processing of heavy oils, the share of water-oil emulsions (WOE) and oil-slime emulsions (OSE) are significantly increasing, the main part of which are highly stable. Their transportation and processing with a significant content of brine water, mechanical and mineral impurities is considered irrational. In this direction, the development of compositions of emulsion breakers for dehydration and desalination of highly stable WOE and OSE of heavy oils is of great importance. For this, nonionic surface-active substances (SAS), i.e. detergents and wetting agents for mechanical impurities obtained from local raw materials are used [1].

In the world scale [2], special attention is paid to the development of new compositions of emulsion breakers with polyfunctional properties, reduction of their consumption during dehydration and desalting of heavy oils, as well as the use of new detergents and wetting agents for mechanical impurities that accelerate the breakdown of highly resistant WOE and OSE. Great attention is paid to scientific research devoted to reducing the viscosity of WOE and OSE of heavy oils, which determine the intensity of their breakdown and separation. Therefore, the development of effective compositions of emulsion breakers used in breakdown of highly resistant WOE and OSE of heavy oils is considered an urgent problem and requires a solution [3].

At present, Uzbekistan has achieved certain theoretical and practical results on development of new highly effective emulsion breakers and their compositions based on local raw materials, as well as technologies for dehydration and desalting WOE and OSE with their application.

2. Methods
As we know, oil fields located in the foothills of Uzbekistan mainly contain heavy hydrocarbons and accompanying substances (resins, asphaltenes, paraffin, etc.) [4]. Most of the above-mentioned
compounds have surface active properties i.e. performs the role of emulsifiers, which is confirmed by formation of stable oil-water emulsions.

Analysis of stable oil-water emulsions of heavy oils shows that they are difficult to break down, because contains emulsifiers, associates, etc. in the form of complex compositions.

The specific feature of oil-slime containing finely dispersed clays and iron sulfide shows that they worsen the effect of emulsion breakers on the surface of armor shells of water.

Mechanical impurities, accumulating on the surface, lead not only to the stabilization of large water droplets, but also to increase in the proportion of the highly dispersed part of water globules, which are the most difficult to extract from trapped water-oil emulsions. It was established that the mechanism for removing mechanical impurities and water from the trap emulsion is interrelated: more complete removal of mechanical impurities from the interface into the aqueous phase leads, in turn, to facilitating the coalescence of water droplets, reducing the aggregate stability of the emulsion and more complete separation of water droplets.

3. Results
At present, heavy oils are produced in the Bukhara, Andijan, Fergana and Surkhandarya regions of Republic, where most of the fields contain a significant amount of brine water, mechanical impurities, mineral salts, etc. Difficulties in separating stable oil-water emulsions produced from such wells dictate the need to develop and use effective emulsion breaker compositions taking into account their complex composition.

Considering this, we have studied the effect of asphaltenes and resins on indicators of oil-water emulsions using the standard “bottle” method. The results are given in figure 1.

As can be seen from figure 1, with an increase in the content of resins and asphaltenes in heavy oil, its degree of stability increases exponentially. Moreover, asphaltenes are the main stabilizers of oil emulsions and, concentrating on the interface, form a protective film. Resins found in crude oil are considered weak organic in molecular weight, and therefore also stabilize the oil-water emulsion, but are less active in comparison with asphaltenes [5].

There is the Haudag field in Surkhandarya region, which contains heavy oil, with the following indicators: density at 20 °C is 979.5 kg/m³, viscosity (kinematic) at 80 °C is 405.3 mm²/s, viscosity (conditional VC-80) is 53 mm²/s, pour point is 23 °C, coking is 12.1% mass, content of asphaltenes is 9.5% mass, of resins is 50.5% mass, paraffin is 3.85% mass, water is 3.1% mass, mechanical impurities 0.01% mass, flash point 165 °C. Fractional composition of Haudag oil is presented on Fig. 2.
As can be seen from figure 2, the Haudag oil is mainly heavy and can be used to obtain bitumen of various grades. From an economic point of view, the processing of such oils into simple hydrocarbons is considered expensive. The same applies to breakdown of stable oil-slime emulsions.

However, on the other hand, the processing of such oils with the addition of gas condensate is possible, which promises certain economic benefits.

Considering this, we attempted to breakdown stable oil-water emulsion obtained from a mixture of heavy Haudag oil with gas condensate. This method was used proceeding from the raw materials available in the oil and gas industry for organizing the technology of heavy oil refining [6].

The main physical and chemical indicators of demulsification process for mixtures of oil and gas condensate are shown in table 1.

Table 1. Indicators of resistant WEE derived from mixtures of heavy oil and gas condensate

| Composition of the mixture % | Density at 20 °C, kg/m³ | Viscosity at 80 °C, mm²/sec | Consumption, g/ton | Water residual content, % |
|------------------------------|-------------------------|----------------------------|-------------------|-------------------------|
| Oil                          | Gas condensate          |                            |                   |                          |
| 100                          | 0                       | 1085                       | 202               | 60                      | 2.1                       |
| 95                           | 5                       | 1015                       | 191               | 60                      | 1.9                       |
| 90                           | 10                      | 992                        | 182               | 55                      | 1.6                       |
| 85                           | 15                      | 925                        | 173               | 55                      | 1.2                       |
| 80                           | 20                      | 889                        | 161               | 50                      | 0.9                       |
| 75                           | 25                      | 865                        | 153               | 50                      | 0.6                       |
| 70                           | 30                      | 852                        | 141               | 40                      | 0.2                       |

From table 1 it can be seen that with the introduction of gas condensate into the composition of heavy oil from 5 to 30%, the density and viscosity of stable WOE are significantly reduced. This is especially evident in the kinematic viscosity measured at 80 °C. Due to this, the consumption of the emulsion breaker is reduced from 60 g/ton to 40 g/ton.

It is known that the intensity of breakdown of stable WOE formed from mixture of heavy oils with gas condensate can be characterized by the difference between the densities of brine water and oil (Δρ), as well as the ratio of the total content of asphaltenes (a) and resins (r) to the content of paraffin (p) in oil (a+r) / p.

Here, the last indicators predetermine the method of demulsification of processed emulsion, and Δρ corresponds to the driving force of gravitational sedimentation [7].

Heavy oil of Haudag field has Δρ equal to 0.175-0.185 g/cm³, and index (a+r) / p = 7.795 - 7.852. This suggests that the WOE formed from this oil is difficult to delaminate due to its high content of asphaltenes, resins and paraffin. Here, lowering the viscosity and density of heavy oil using gas condensate allows the resistant WEE to be broken down by emulsion breaker.

Advantage of this method is that lowering the WOE viscosity allows intensifying the process of separating mechanical impurities from this emulsion. The change in content of dispersed mechanical impurities depending on the amount of introduced gas condensate is shown in figure 3.

Form figure 3 it can be seen that with the introduction of gas condensate into the composition of heavy oil of Houdag field, the amount of mechanical impurities in the WEE decreases exponentially, which is due to a decrease in the density and viscosity of the latter.

The change in residual content of mineral salts in the heavy oil of Haudag field, depending on the amount of gas condensate introduced is of certain scientific and practical interest.

The results of research are shown in figure 4. From figure 4 it can be seen that the introduction of gas condensate up to 30% of the total mass of the mixture allows increasing the removal of salts from heavy oil due to a significant decrease in the viscosity of its WOE.
Therefore, the results of this research show the promise of using gas condensate in the destruction of stable WEE formed from heavy oils from Haudag field. At the same time, along with a decrease in the density and viscosity of WOE, the process of coagulation of dispersed water, salts, etc. is accelerated. Moreover, the coarsening of particles of the dispersed phase accelerates the rate of its sedimentation, which can also be confirmed by effect of synergy of some variable factors of the process under consideration.

4. Discussions

When the emulsions formed in oil-slime are broken down, it is necessary to consider the pour point of oil, which affects the stability of the system. We have studied the effect of the introduced gas condensate on the pour point of local oils at room temperature (+ 25 °C). The measurement results are given in table 2.

| The amount of gas condensate introduced, % | Djarkurgan oil | Shurchi oil | Mullakhol oil |
|------------------------------------------|----------------|------------|--------------|
| ρ, kg/m³                                  | T<sub>pour</sub> °C | ρ, kg/m³   | T<sub>pour</sub> °C | ρ, kg/m³ | T<sub>pour</sub> °C |
| 0                                       | 998            | 25         | 905          | 16       | 901          | 18            |
| 10.0                                     | 985            | 23         | 880          | 12       | 875          | 13            |
| 20.0                                     | 977            | 20         | 861          | 8        | 860          | 10            |
| 30.0                                     | 970            | 18         | 842          | 5        | 840          | 6             |

Table 2 shows that with an increase in the amount of gas condensate from 10 to 30% of the total mass of the mixture, the pour point of Djarkurgan oil in the oil slime decreases by about 1.3 times, Shurchi oil by 3.2 times, and Mullakhol oil by 3.0 times. This ratio is associated with the content of components that affect the pour point of local oils. Taking into account that resins and asphaltenes contain a number of heterocyclic compounds, their emulsifying properties can be predicted [8].

Consequently, the introduction of gas condensate into the composition of highly resinous oils obtained from oil slime can significantly reduce the dynamic viscosity and shear stress, which is very necessary for intensifying the process of destruction of stable oil-water emulsions. At the same time, the “aging” of emulsions on water globules increases the emulsifier layer and, accordingly, increases its mechanical strength. This is accelerated due to the high salinity of the brine water, which contributes to
the “aging” of the emulsions formed in the oil slime. In addition, hydrophobic films must be replaced with hydrophilic surface-active substances [9].

5. Conclusions
In order to reduce the viscosity of oil-water and oil-slime emulsions, it is proposed to use a cheap local hydrocarbon, i.e. gas condensate.

The method to intensify the process of breakdown of stable oil-water and oil-slime emulsions using the created compositions of emulsion breakers and their viscosity reducer, i.e. gas condensate has been developed.

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