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Contents

Experımental study of resıdual oıl compressıon from hydated sludge usıng a surface-actıve substance (sas) mıxture whıch ıs a non-sedıment solutıon ın the formatıon fluıd

Gasimli A.M., Aliyev E.N., Bayramova N.S., Yusubova N.A., Huseynova S.S.
Scientific Research Institute of Geotechnological Problems of Oil, Gas and Chemistry, ASOIU, 227 Dilara Aliyeva Ave., Baku, AZ-1010 Azerbaijan

Abstract

The irrigation method, which was once highly valued by oil workers and could increase oil recovery from fields, is currently unable to ensure full oil production from the reservoir. Especially when pumping into heterogeneous formations and fields with high-viscosity oil, this manifests itself in a small set of sweep coefficients. Upon completion of field development, it turns out that 40-70% of oil reserves remain unrecoverable. At this time, the remaining oil reserves are in such a state that they cannot be extracted by known processing methods.

Keywords:.

Corresponding author. Tel.: +994 50 6201516
E-mail address: elsan67@mail.ru

1. Introduction

It is known that the stage of development of the oil industry is characterized by the complexity of the operating conditions of the fields. The reason is that due to changes in the structure of oil and the characteristics of reservoirs, the reserves of the fields have become difficult to recover. As a result, there is a decrease in the volume of oil produced, a sharp increase in dilution, and a large number of highly productive fields are entering the final period of development. At present, in the development of oil fields, the most pressing problems are considered to be the involvement in active development of areas remaining outside of development - stagnant zones - and the exploitation of recoverable residual oil reserves. It is shown that this reserve is 160 million tons in onshore fields and 135 million tons in offshore fields.

The reason why most methods used to improve oil recovery from oil fields that have been in production for a long time cannot give the expected effect is that oil is retained in the pore channels due to capillary forces, the coefficients of movement of the compressive agents and the compressive agents are unfavorable, and reservoir reservoirs are heterogeneous.

2. Methodological part.

Methods of influencing the oil layer are either methods that affect the compression of the oil (various gases, alkalis, surfactants, etc.), or methods that provide an increase in the coverage coefficient of the layer with the working agent (polymer solutions, water-gas mixture, precipitant, etc.).

To increase the degree of oil compression, physicochemical methods are mainly used. Recently, some advantages have been observed in this area, and it has been possible to increase the oil compression ratio from 0.25-0.45 to 0.50-0.60. However, the application coverage ratio remains small, which does not allow achieving the desired level of oil production during field development.

Many years of experience in developing oil fields shows that water injected into the reservoir in most cases does not end up in low-permeability formations, but in formations with high filtration properties. The volume of oil collected as a result of a decrease in the effectiveness of the impact method, which increases the dilution of the resulting product to 70-90%, is 35-40% of the balance reserve. On the other hand, severe dilution of the product indicates the ineffectiveness of physicochemical methods used to increase oil yield.

The results of the conducted theoretical studies showed that during the compression of oil by water in the well system, the pressure gradient changes several times, causing the current lines to be directed in a complex way, especially in fields with non-Newtonian oil, and the formation of stagnant zones [1,2]. Therefore, there is a great need to create a working agent that ensures the displacement of high-viscosity oil from the porous medium.

Recently, one of the most urgent problems facing the justification of the effective development system in fields is the problem of increasing the oil yield of fields with oil reserves that are difficult to extract. These deposits are mainly oil objects with small permeability of oil reservoirs (less than 0.05 mkm^2) and high oil viscosity (more than 10 mPa·s). When exploiting fields with hard-to-extract reserves, the use of known technology (various options of the irrigation method) does not ensure the elimination of the reasons preventing the increase of the oil yield of the formation. If the ratio of the viscosity of the oil in the formation to the viscosity of the injected water exceeds 15, the formation of the water-oil boundary becomes difficult. In such a situation, the movement of water-oil contact in the formation is disturbed, the coverage of oil with water decreases, the injected water finds its way and begins to move towards the production wells, and the formation of stagnant zones occurs in the formation.

Another reason is that the capillary forces formed as a result of surface exchange between the formation fluid and the porous medium keep the oil immobile in stagnant zones.

It is known that there are two types of residual oil. The first is the oil that is not covered by the entrapping agent in the stagnant zones and leeches. The reason for the formation of this type of oil is, first of all, that reservoirs of the formation have non-homogeneous permeability and are poorly covered by the impact. Mining experience has proven that if the permeability of two layers separated by a clay layer differs by several times, water does not enter the layer with low permeability. Such oil differs from compressed oil because it does not come into contact with the compressing agent.

The second residual oil is the oil remaining in the wetted areas of the reservoir. For such oil, the relationships of the rock-oil and injected fluid system play a major role, for example, the wetting nature of the rock surface.

Oil displacement from hydrophilic porous media is close to the "piston shapes" regime, and 90% of oil is recovered in the anhydrous period. Aqueous period is short in hydrophilic rocks, so when 0.5-1.5 pore volume of water enters, it is known that the obtained oil is fully hydrated. The oil in the formation completely covers the rock surface in a thin layer, and the residual oil accumulates in high pores. Water percolation occurs primarily in small and medium capillaries, from which oil is transferred to large capillaries in the form of droplets. In this case, saturation with residual oil is capillary-buried.

The adsorption of surface-active substance (SAS) on a solid surface depends on two main factors: the affinity of the SAS with the surface and the hydrophobicity of the SAS, which creates a hydrophobic effect. This effect is highly dependent on the structure of the SAS molecule – the solubility of SAS in water.

It has been confirmed that these effects play the main driving role of SAS adsorption if these surfaces are hydrophobic (because SAS molecules are adsorbed as a result of molecular contact on a hydrophobic surface).

At a highly polar surface and a small concentration of SAS, its molecules are oriented with polar groups on the surface.

Ametov I.M., Khavkin AY, Buchenkov LN note [3] that, regardless of the thickness of the oil layer absorbed on the rock, at the zero value of wetting, it becomes very strong. At any other values of cooling, the oil layer can change its thickness depending on the following expression (1):

$$\sigma_{S\text{-}W} - \sigma_{S\text{-}O} = \sigma_{W/O} \cos\theta \qquad (1)$$

where $\sigma_{S\text{-}W}$, $\sigma_{S\text{-}O}$, $\sigma_{W\text{-}O}$ surface tension at the solid-water, solid-oil and water-oil boundaries, respectively, θ - is the wetting angle.

The occurrence of the change is due to the fact that the differentiation of the oil layer into droplets occurs quickly, depending on surface tension on the one hand and viscosity on the other, the shape of the droplets is determined by formula (1), and the adhesion force is determined by formula (2):

$$A = \sigma_{W/O} (1+\cos\theta) \qquad (2)$$

This process is observed regardless of whether one of the compressing or compressing fluids wets the rock surface.

Currently, there are a large number of surfactants. According to their chemical structure, they are divided into two classes: ionogenic surface-active substances (ISAS) and nonionic surface-active substances (NSAS). The solubility of SAS in fresh, formation (alkaline or hard) and sea water is of great importance for its application in various technological processes of oil production. In particular, the fact that SAS dissolves in formation water without precipitation is of more interest. If the SAS solution forms a precipitate in contact with the oil while injecting the formation, then not only the active components of the SAS will decrease or completely disappear, but at the same time, pores may be blocked by the formed precipitates. This will lead to a decrease in the compactness of layer collectors.

Almayev RX shows that [4], despite the positive effect of non-ionogenic SAS solution on formation oil yield compared to water, its application to terrigenous rocks saturated with oil lowers the permeability of the porous medium.

It is known that we can reduce the effect of capillary forces by lowering the value of the surface tension coefficient formed at the water-oil boundary. For this purpose, recently various types of surfactants are added to the water injected into the formations, so that the surface tension value at the boundary between the formation oil and the injected water will decrease due to their influence, and as a result, it will be possible to remove most of the residual oil.

A solution of a concentrated alkaline reagent in water occupies a special place among the physico-chemical methods. The advantage of the alkaline solution is that it has a good oil-squeezing ability when the formation is injected, and it also increases the coverage of the formation as a result of lowering the surface tension in contact with the oil. In contact with the active components of the oil, a highly dispersed emulsion is formed at the compression front.

If we take into account that the active components of oil become soapy when using an alkaline solution, then the criterion for applying an alkaline solution to deposits is that the surface tension of the solution in contact with oil is sharply reduced.

The results of laboratory work conducted by various researchers [5,6] show that the main factors influencing the oil yield coefficient during the application of alkaline solution are the characteristics of water, rock and oil.

The water of the deposit, which makes it difficult to compress with an alkaline solution, has a high hardness (especially the presence of Ca and Mg ions). The hardness of the water reduces the surface activity of the alkaline solution.

It was confirmed that lowering of the surface tension by the alkaline solution depends on the presence of naphthenic acid in the oil.

Currently, SAS are used as a composition rather than as a separate product. This is considered more favorable both economically and physico-chemically. It has been proved that it is possible to replace SAS, which is often difficult to find and expensive, by means of a cheap composition [6].

If we talk about the mechanism of action of SAS, we should note that SAS added to water first of all reduces the surface tension at the oil-solution boundary. With a decrease in surface tension, the oil droplet undergoes easy deformation, less force is spent to pass through the narrowed pores of the reservoir, and the movement of the oil droplet in the reservoir increases.

SAS is a chemical compound that concentrates at the phase boundary and causes a decrease in surface tension. The main property of SAS is surface activity – its ability to reduce surface tension at the interface.

A solution of SAS in water increases the wetting of the rock surface. The wetting of the rock surface and the decrease in surface tension reduce the energy of contact of oil with the rock by 6-10 times. The solution of most SAS in water has a high oil-washing ability, and they have the ability to wash away the oil drop stuck to the rock surface in a thin layer.

Recently, the increase in the price of known SAS and the fact that most of them precipitate when dissolved in seawater and reservoir water have made it difficult to use them to increase reservoir oil yield. Therefore, alkaline waste (AW), which is the output product of the oil refinery, was used to increase the oil yield in Azerbaijan's fields [7]. However, in the AW, it gives sediment in formation and sea water. Currently, there are surfactants that are soluble in various waters without sedimentation. Therefore, it was decided to use a mixture of the substance with AW. First, the effects of the solutions of these substances in formation water separately on the surface tension at the boundary with oil were studied. For this purpose, samples of oil and reservoir water were brought from well No. 697 of "Absheronneft" Oil and Gas Production Department (OGPD). The viscosity of oil at room temperature is equal to 100 mPa·s. First, the surface tension at the boundary between oil and formation water was determined (13.5 mN/m). Then, 5% solution of AW [8] was mixed with the 1% solution of SAS in formation water, and the surface tension was determined to be 0.7 mN/m. It should be noted that the addition of 5% AW to a 1% solution of our selected SAS solution in formation water did not cause precipitation. This gave impetus to the use of the received composition to increase the oil yield of the formation. In the linear formation model, oil compression was carried out through reservoir water, and the oil compression coefficient was 0.18 in the dry period and 0.48 in the last period (Figure 1).

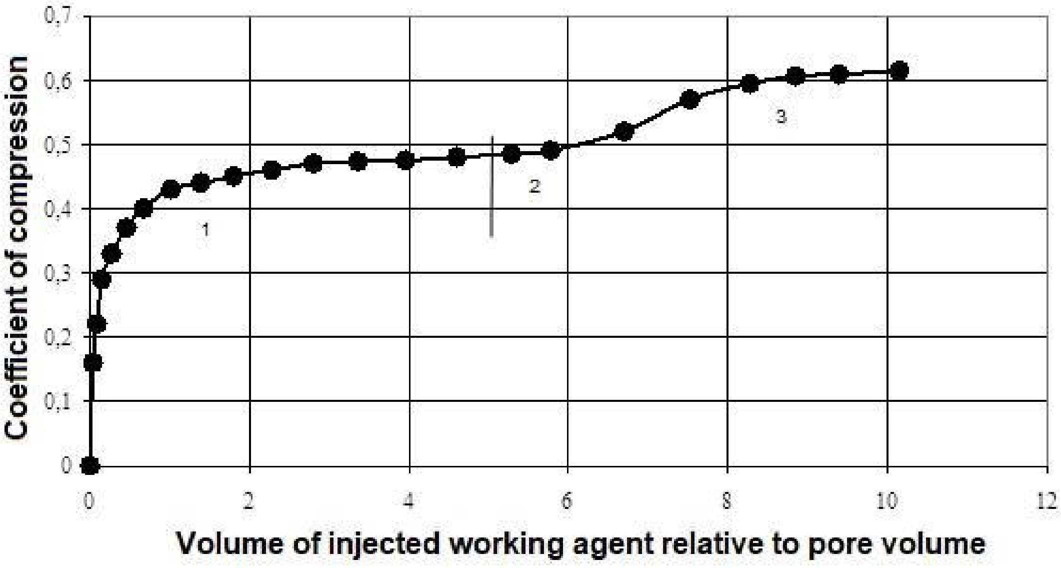

Figure 1. After forcing the oil through the formation water (1), the residual oil is again driven through the formation water (3) to form argate from the composition (2)

Using the developed composition for extracting residual oil from a wetted formation, 25% of the pore volume was injected into the reservoir model in the form of aragate (Figure 1 (2)), followed by continued injection of formation water. Injection of the pore volume of formation water after injection of aragat allowed to remove 14% of the remaining residual oil in the liquefied reservoir model (Figure 1 (3)).

3. Conclusion

As a result of the conducted experimental research, we can say that by using the composition obtained by adding 5% AW to a 1% solution of the selected SAS, which is a sediment-free solution in formation water, it was possible to remove a certain part of residual oil from the liquefied formation. This allows us to apply the results obtained in the real mining conditions.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research.

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Elimination of formation damage in the wellbore area and expansion of the well drainage area

[1]Y.Samedov, [2]J. Eyvazov

[1]ASOIU, 20 Azadlig Avenue. Baku, AZ1010
[2]Oil Gas Scientific Research Project Institute, SOCAR, 88a H.Zardabi str., Baku, AZ1012

Abstract
The exploration of unconventional oil and gas reservoirs is a prominent global trend today. Achieving cost-effective and efficient hydrocarbon production from these reservoirs necessitates advanced technologies. One such technology that has been employed in the oil and gas industry for many decades is hydraulic fracturing. It is used to create highly conductive channels within formations characterized by extremely low permeability values. The successful implementation of hydraulic fracturing hinges on the development of an effective fracturing design. This design is crucial to achieving the anticipated production outcomes from unconventional reservoirs, including tight gas, shale gas, coal bed methane, and reservoirs with very low permeability. Key parameters for the success of hydraulic fracturing operations include the determination of the optimal fracturing rate, fracture height, and the selection of propping agents. These factors collectively contribute to the efficiency and productivity of hydraulic fracturing activities in unconventional reservoirs.

Keywords: Formation damage, well stimulation, hydraulic fracturing, drainage area, tubing diameter, skin factor
[*]Corresponding author. Tel.: +994 559672223
E-mail address: jabrayil.eyvazov88@gmail.com (J.M.Eyvazov)

1. Introduction.

Formation damage refers to the phenomenon in which the permeability of the subsurface formation near the wellbore decreases. There are various factors that can lead to formation damage, which will be explored later. The decrease in permeability in the wellbore region has a direct impact on the overall productivity of the well. This reduction is often attributed to the blocking of pore throats in the vicinity of the wellbore, causing a decrease in the available flow area.
Turbulent flow in the well is another factor contributing to the reduction in the flow area. When turbulent flow occurs, it leads to a significant pressure drop in comparison to laminar or Darcy flow. The pressure drop associated with turbulent flow is notably higher, which results in a further