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STUDY OF THE IMPACT OF KEY TECHNOLOGİCAL PARAMETERS ON THE PRODUCTİVİTY OF PRODUCTİON WELLS

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ABSTRACT

Currently, worldwide, the main method influencing oil fields is water flooding, which is considered the most intensive and cost-effective method for developing oil fields with different geological structures and specific production conditions. The presence of various types and regimes of oil fields, complex geological structures (such as tectonic disturbances, multilayering, variations in thickness, porosity, and permeability of productive formations across fields and sections), complex physical and chemical properties of reservoir fluids, and production systems all affect the water flooding process to varying degrees. A significant volume of water is injected into the reservoir to maintain formation pressure and displace oil. The uneven production of reserves is facilitated by the fragmentation of oil-saturated formations and high heterogeneity. During reservoir development, accelerated production of oil reserves accumulated in zones with high permeability, a rapid increase in water cut, and a decline in oil recovery rate are observed. This leads to uneven water flooding coverage. Simultaneously, a considerable volume of water is injected and produced, resulting in increased costs for electricity, transportation, and processing of the extracted products. Therefore, during reservoir development, the regulation of water injection and fluid production volumes, as well as the reduction of operational costs and the improvement of recovery efficiency, are critical. The analysis of water influence in complex heterogeneous formations and the enhancement of monitoring methods for its implementation are current and priority challenges in oil production, particularly in oil and gas extraction.
Keywords: technological parameters, oil production, reservoir development, polymer injection, water injection

Introduction

Under current conditions, the injection of additional volumes of water into the formations may significantly complicate the future development of oil fields. In this regard, the isolation of water entering the wells and the search for methods to combat increasing water cut while maintaining oil production rates have become increasingly urgent issues.

One of the possible solutions to this problem is the use of methods and technologies aimed at limiting the non-productive flow and production of water through the formations. Such methods and technologies include flow diversion techniques and profile modification methods. The use of various chemical reagents, including water-soluble polymers and polymer-based compositions, plays a significant role in controlling the injection profile in injection wells and restricting water production in production wells.

To date, a large volume of field and experimental data has been collected, demonstrating the high efficiency of the method for isolating water influxes by injecting water-soluble polymers and polymer-based compositions into water-saturated formations.

At the same time, a detailed analysis of both foreign and domestic studies on water flow restriction using polymer solutions and polymer-based compositions has enabled a more realistic assessment of the capabilities of this method and the identification of its limitations. It has been established that one of the reasons for the low efficiency of treating the bottomhole zone of wells with polymer solutions or polymer-based compositions is both the improper selection of wells and the choice of the technological scheme for hydroisolation operations required to implement this method. In this regard, the proposed study addresses this problem through two main approaches.

Objective

Development of oil reservoirs with heterogeneous permeability using polymer solutions. It is well known that the ratio of the viscosities of the water injected and the reservoir oil is one of the key factors determining the oil recovery factor from the formation. The importance of this parameter increases significantly in highly heterogeneous formations, including layered heterogeneous complexes. To mitigate the adverse effects of viscosity instability on the water flooding process and its regulation in oil reservoirs, various methods are employed, including the injection of polymer solutions into the formations. Considering the selective effect of polymer solutions on the phase permeability of reservoir fluids, they have found wide application in enhancing the oil recovery factor and regulating water flooding in formations. Moreover, the use of polymers is one of the most effective methods for increasing reservoir sweep efficiency during water flooding. However, in some cases, their effectiveness is limited. The process is insufficient for achieving higher formation sweep, and the injected water reaches production wells before penetrating low-permeability zones.

The study of the flow of polymer solutions and subsequently injected water showed that, in addition to water thickening (viscosity increase), the mobility of polymer solutions and injected water is determined by the interaction between polymer molecules, the porous medium, and the flowing water. It was found that after injecting a polymer solution into layered formations followed by water injection, a diversion process begins. As a result, lower-permeability interlayers are subjected to more intensive water influence, increasing the thickness sweep efficiency factor of the layered formation. Reducing this factor to 1 can decrease the increase in oil recovery factor by 30%.

On the other hand, studies conducted in the previous chapter on the mechanism of diversion formation showed that its magnitude is strongly influenced by several factors, including the location of its formation, the heterogeneity of permeability within the formation, and polymer consumption. Based on this, when studying the possibilities of enhancing the efficiency of polymer flooding in heterogeneous formations, attention is given to the investigation of the effect of formation position and the magnitude of diversion on the oil recovery factor.

Methods

Influence of parameters on the efficiency of polymer solution flooding in multilayer reservoirs. A layer model (1) with a length of 0.75 m and a diameter of 0.03 m was packed with quartz sand fraction d < 0.1 mm, and its gas, oil, and water permeabilities were determined. In the experiments, oil from the X horizon of the "Günəşli" field and gas from the "Bulla Deniz" field were used. The component composition of the gas is presented in the corresponding table.

Next, the layer model is saturated with formation waters taken from the "Günəşli" field and introduced into the apparatus.

The displacement of water from the porous medium is carried out by gas-oil supplied from a container. Gas-oil in the container, oil from a vessel with a volume of 700 cm³, and gas from a cylinder are supplied under a pressure of 8.0–8.5 MPa. Subsequently, to achieve better mixing, the container is rotated around its own axis with the gas-oil.

During the displacement of water from the porous medium by gas-oil, the volumes of the produced fluids are measured. The porous medium is considered fully saturated with fluids when the oil, gas, and water produced from the layer model reach approximately 20, 0.535–0.540 and 183–190 cm³, respectively.

Water displacement was carried out under a constant pressure drop of 0.1 MPa. The residual water in the porous medium was initially determined as the difference between the volumes of initially

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saturated and displaced water. The volumes of oil and gas were calculated based on the initial and residual oil volumes in the container with gas-oil, as well as the volumes of oil and gas introduced during the displacement of water by gas-oil.

In the experiments, the phase permeabilities of the porous medium for gas, water, and oil were 3.7, 2.0, and 1.4 μm², respectively, and the gas-oil gas factor ranged from 20 to 24 m³/m³. The oil saturation degree of the porous medium was 55.5% and 58% of the pore volume, while the water saturation was 15.5%. The volume of gas in the porous medium at a pressure of 8.2 MPa was 3.2 liters. Thus, the porous medium with a pore volume of 250–260 cm³ was saturated with 34.5–39.0 cm³ of bound water, 144–152 cm³ of oil, and 3.11–3.2 liters of gas. The initial experiment on fluid filtration through the layer model was conducted with a pressure difference of 0.12 MPa between the inlet and outlet of the reservoir model. During the process, the oil, gas, and water filtered from the porous medium enter the separator, where they are separated and measured.

Table 1. Component composition of gas taken from the "Bulla Deniz" field

Gas composition	%
Methane	93.31
Ethane	4.62
Propane	1.05
Isobutane	0.23
n-butane	0.34
Isopentane	0.14
n-pentane	0.09
Hexane	0.01
CO_{2s}	0.21

The following experiment is similar to the initial one, but includes the operation of selective isolation of gas and water flow. For this purpose, a 0.5% solution of "L" ionomer is injected from the outlet side of the model in a volume corresponding to 9% of the pore volume. Upon injection of the polymer solution, the volumes of oil, water, and gas entering the separator from the inlet of the reservoir model are quantitatively separated and measured. These measured volumes are subsequently incorporated into the final assessment of oil, water, and gas saturations within the reservoir model." After retaining the polymer solution within the porous medium for 48 hours, the displacement process of oil, gas, and water through the porous medium is initiated, during which measurements are conducted..

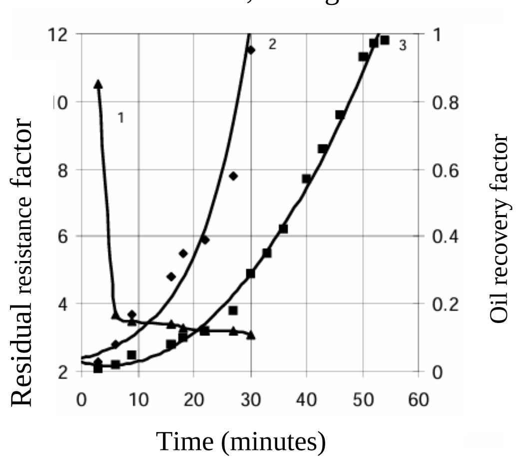

Figure 1. Variation of the residual resistance factor (curve 1) and gas relative permeability (curve 2) after cleaning and treatment of the porous medium with polymer solution (curve 3)

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As shown in figure, treatment with the "L" ionomer solution results in an increase in gas production in the porous medium in the presence of oil and water phases. The initial value of this increase (within the first 3 minutes) is 10.5 (curve 1). Shortly after the onset of the depletion process (within 6 minutes), the growth sharply decreases and then stabilizes. This behavior is explained by the immediate displacement of a portion of the polymer solution from the porous medium at the beginning of the depletion process. In the initial experiment, the gas production from the porous medium was 3.11 liters (corresponding to 12 pore volumes) over a depletion time of 30 minutes (curve 2). Under these conditions, the gas recovery factor is 0.95.
In the experiment involving gas flow isolation, the depletion time of 3.2 liters of gas from the porous medium increased to 54 minutes, with a gas relative permeability of 0.98 (curve 3). The difference in gas depletion time is associated with the occurrence of gas production. The experiments also demonstrated that, at the water saturation levels established in the tests, treatment of the porous medium with polymer solution completely isolates the water flow from the water reservoir model.

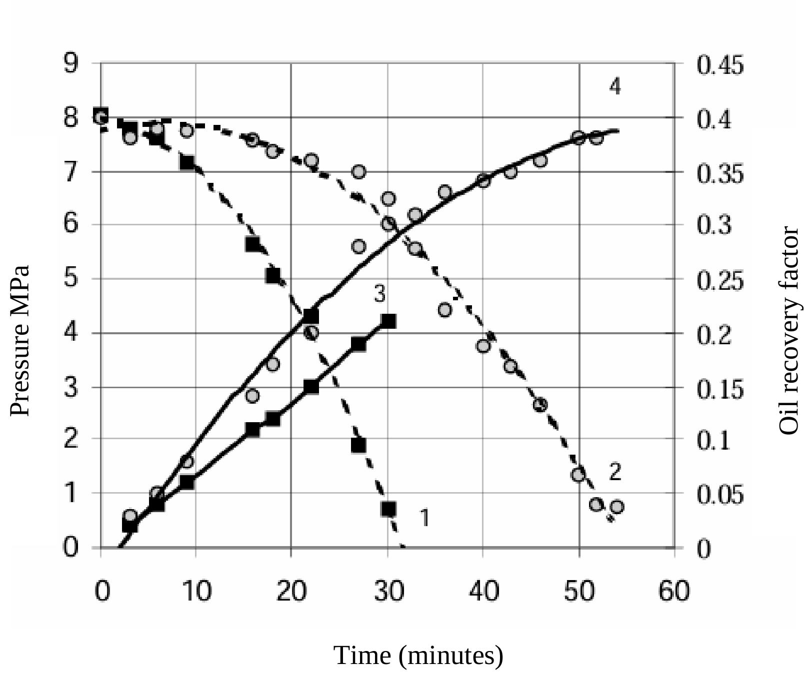

Figure 2. Variation of pressure (curves 1 and 2) and oil recovery factor (curves 3 and 4) over time without treatment (curves 1 and 3) and with polymer solution treatment of the porous medium (curves 2 and 4)

Conclusion and recommendations

1. Methodological foundations have been developed for diagnosing the characteristics of reservoir system conditions and for regulating the technological processes of oil production to enhance the efficiency of waterflooding in complex hydrocarbon reservoirs.
2. Areas of application and criteria for selecting monitoring and diagnostic methods to evaluate the effectiveness of water influence on complex structured production facilities are proposed and justified, taking into account the dynamic characteristics of technological processes under conditions of significant uncertainty.
3. Material balance leads to significant errors in forecasting production indicators for complex-shaped oil reservoirs. The suitability of using capacity-resistant models of the CRMT type has been established for evaluating the efficiency of waterflooding processes in complex oil reservoirs.
4. Based on the analysis of produced oil-to-water ratios, a specific water-cut interval has been identified for the proper application of methods to evaluate the efficiency of waterflooding in

complex reservoirs.
5. For the first time, methodological foundations for a comprehensive approach to analyzing the characteristic features of the evolutionary development of reservoir systems have been developed to enhance the efficiency of waterflooding in complex oil reservoirs under conditions of insufficient data.

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ƏSAS TEXNOLOJİ PARAMETRLƏRİN HASİLAT QUYULARININ MƏHSULDARLIĞINA TƏSİRİNİN TƏDQİQİ

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XÜLASƏ

Hazırda bütün dünyada neft yataqlarına əsas təsir üsulu müxtəlif geoloji quruluşa və konkret işlənmə şəraitinə malik neft yataqlarının işlənməsinin ən intensiv və sərfəli üsulu kimi su basmasıdır.Neft yataqlarının müxtəlif tip və rejimlərinin, mürəkkəb geoloji strukturların (tektonik pozğunluqlar, çoxlaylılıqlar, qalınlığın, məsaməliliyin, məhsuldar layların sahə və bölmə üzrə keçiriciliyinin dəyişməsi) mövcudluğu, lay mayelərinin mürəkkəb fiziki-kimyəvi xassələri, işlənmə sistemləri, bütün bunlar su basma prosesinə müxtəlif dərəcədə təsir göstərir [1].
Lay təzyiqini saxlamaq və nefti sıxışdırmaq üçün laya əhəmiyyətli həcmdə su vurulur, ehtiyatların qeyri-bərabər hasilatı isə neftlə doymuş layların parçalanması və yüksək heterojenliyi ilə asanlaşdırılır[2]. Yatağın işlənilməsi zamanı yüksək keçiriciliyə malik ərazilərdə cəmlənmiş neft ehtiyatlarının istehsalının sürətləndirilməsi, suyun kəsilməsinin sürətlə artması, neftin çıxarılması sürətinin azalması müşahidə olunur ki, bu da sulaşmanın qeyri-bərabər örtülməsinə şərait yaradır, eyni zamanda əhəmiyyətli həcmdə su vurulur və çəkilir ki, bu da elektrik enerjisi, hasil edilən məhsulların nəqli və emalı üçün maddi xərclərin artmasına səbəb olur.

Ona görə də yatağın işlənməsi zamanı suyun vurulması və maye çəkilmə həcminin tənzimlənməsi və istismar xərclərinin azaldılmasına və işlənmə prosesinin səmərəliliyinin artırılmasına yönəldilmiş mürəkkəb heterojen laylarda suyun təsirinin təhlili və həyata keçirilməsinin monitorinqi metodlarının təkmilləşdirilməsi vəzifəsi neft hasilatında, xüsusilə neft və qaz hasilatında aktual və prioritet problemlərdir

Açar sözlər: texnoloji parametlər, neft hasilatı, yatqların işlənməsi, polimerlə təsir, suvurma

ИССЛЕДОВАНИЕ ВЛИЯНИЯ ОСНОВНЫХ ТЕХНОЛОГИЧЕСКИХ ПАРАМЕТРОВ НА ПРОИЗВОДИТЕЛЬНОСТЬ ДОБЫВАЮЩИХ СКВАЖИН

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РЕЗЮМЕ

В настоящее время во всем мире основным методом воздействия на нефтяные месторождения является заводнение, которое считается наиболее интенсивным и экономически эффективным способом разработки нефтяных месторождений с различной геологической структурой и конкретными условиями эксплуатации. Наличие различных типов и режимов нефтяных месторождений, сложных геологических структур (тектонических нарушений, многослойности, изменений толщины, пористости, проницаемости продуктивных пластов по площади и по разрезу), а также сложные физико-химические свойства пластовых флюидов и системы разработки — всё это в той или иной степени влияет на процесс заводнения. Для поддержания пластового давления и вытеснения нефти в пласт закачивается значительный объем воды, при этом неравномерная добыча запасов облегчается разрушением нефтенасыщенных пластов и высокой гетерогенностью. В процессе разработки месторождения наблюдается ускоренное извлечение запасов нефти, сосредоточенных в зонах с высокой проницаемостью, быстрое увеличение водопроницаемости, снижение скорости добычи нефти, что способствует неравномерному охвату заводнением. Одновременно происходит закачка и отбор значительного объема воды, что приводит к увеличению материальных затрат на электроэнергию, транспортировку и переработку добываемой продукции. Поэтому при разработке месторождения актуальными и приоритетными задачами в добыче нефти, особенно нефти и газа, являются регулирование объемов закачки воды и откачки жидкости, снижение эксплуатационных затрат, а также совершенствование методов анализа воздействия воды и мониторинга их реализации в сложных гетерогенных пластах с целью повышения эффективности процесса разработки.

Ключевые слова: технологические параметры, добыча нефти, разработка месторождений, воздействие полимерами, заводнение.

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