Байбак Н.А. и др. Обзор популярных методов увеличения нефтеотдачи // Международный журнал информационных технологий и энергоэффективности. – 2023. –
Т. 8 № 11(37) с. 40–45

Международный журнал информационных технологий и энергоэффективности

Сайт журнала:
http://www.openaccessscience.ru/index.php/ijcse/

УДК 622.276.6

ОБЗОР ПОПУЛЯРНЫХ МЕТОДОВ УВЕЛИЧЕНИЯ НЕФТЕОТДАЧИ

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В статье дан краткий обзор распространенных методов увеличения нефтеотдачи. Были выявлены основные преимущества и недостатки описанных в данной научной работе методов. Был произведен сравнительный анализ данных технологий увеличения нефтеотдачи.

Ключевые слова: Методы увеличения нефтеотдачи, заводнение пласта, гидродинамический разрыв пласта, нагнетание паром, внутрипластовое горение, электромагнитное воздействие, газовые методы нагнетания, соляно-кислотная обработка.

EFFECTIVE METHODS OF ENHANCED OIL RECOVERY

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The article provides a brief review of effective enhanced oil recovery methods. The benefits and drawbacks of the methods described in this paper were identified. The study of oil recovery technologies was carried out.

Keywords: methods of enhanced oil recovery, reservoir flooding, hydrodynamic fracturing, steam flooding, fire flooding, electromagnetic action, gas injection methods, acid treatment.

Commercial oil production, in particular, high-viscosity and heavy oil, comes with great difficulties during the oil reservoir engineering. Basically, these problems are associated with changes in the permeability of rocks due to wellbore damage and a formation pressure decline. Variances of internal parameters of the trap (for example, pressure, flooding of the well, mineral content) provide an opportunity to fill the interstices with paraffins and resinous substance that are contained in the petroleum composition in the form of asphaltene deposits. Moreover, bottom-hole zone can be blocked up by mineralized reservoir water's salt and hydrates. This problem vastly reduces the efficiency and intensification of oil recovery. Therefore, scientific study of the most applicable oil recovery methods becomes an urgent task. This research gives a brief review of the most promising methods.

One of the most well-known and widespread methods of enhanced oil recovery is reservoir flooding. This technology is relatively simple in its implementation and cost-effective in comparison

to other methods. This technology is based on maintaining reservoir pressure by water injection. Flooding is carried out from different sides of the reservoir through injection wells. Methods of non-stationary flooding include cyclic flooding and changing the direction of filtration flows [1].

Another hydraulic method of increasing oil recovery is hydrodynamic fracturing (hydraulic fracturing). The technology is related not only to effects of fluid pressure, but also to the formation cracking. An excess pressure is created by pumping a viscous liquid in the downhole which leads to pressure increase by 1.5-2 times. This operation makes it possible to expand the size of interstices of the fluid seal and reservoir, which in turn results in the production increase. Sand or other fine-grained material can be injected to prevent fractures from closing with viscous fluid [3].

Heat treatment of the reservoir is one of the challenging and progressing method for high-viscosity oilfields. It is possible to change the rheological behavior of oil by heating it in the well, which affects the final production rate of the well. The most common methods of heat treatment are: the steam flooding, a hot water flooding, the fire flooding and an electromagnetic action. Steam or hot water injection are similar to reservoir flooding methods, the main difference lies in the fact of the physical basis of heat transfer from steam or water to oil [2].

Fire flooding is the process of injecting air into the formation to create a combustion front or a high-temperature zone. The temperature increase occurs by means of a chemical oxidation reaction between a part of the reservoir oil (heavy hydrocarbons) and oxygen of an exothermic nature. Actually, the combustion devices are gas burners, electric heaters and downhole thermal gas generators [1].

The electromagnetic action is caused by the influence of high and ultrahigh frequencies on the raw hydrocarbons. Under the external influence of microwave, a polarization effect occurs in the molecules, the dipole moments of the raw material molecules are reoriented along the field lines, which ultimately improves the flow melt index of the oil (a change in rheological behavior), reduces the surface tension at the phase boundary, and accelerates the filtration of displacing objects [3].

Gas methods of enhanced oil recovery have also widely used in petroleum recovery. The gas is injected into elevated areas of the reservoir to create an artificial gas cap, which boosts up an oil recovery factor. The fluid is taken from wells located lower in the formation structure. The gas quickly breaks through from injection wells to production wells in highly permeable zones due to state of aggregation of displacing agent and its low viscosity. In order to prevent this, gas is combined with water– a water-gas effect. Carbon dioxide, hydrocarbon gas (associated petroleum gas), nitrogen and air are also used as an injection agent. Practically, the method of water-alternating-gas was used on the wells of the Samotlor field. Water and hydrocarbon gas of the 1st stage of separation were used as the agent. As a result, the flow rate of the well increased by 7-15% in comparison with the flooding method [4].

Nevertheless, it is necessary to mention methods of oil recovery aimed at changing the characteristics of the rock. One of the most ambitious method is the hydrochloric acid treatment of wells. The basis of this technology is the effect on the throughput characteristics of the reservoir. With the help of acid injection, voids, cavities, channels of corrosion are formed in rocks, resulting in an increase in the formation reservoir properties. The following methods are: conventional hydrochloric acid treatment, acid bath, hydrochloric acid treatment under pressure and step-by-step hydrochloric acid treatment [6].

Conventional hydrochloric acid treatment is based on the ability of hydrochloric acid to dissolve carbonate rocks, for example, limestones and dolomites. The reaction products are removed from the reservoir along with the inflow of oil from the well in a suspended state. It is possible to expand the size of microcracks and channels, improving the connectivity between them by the hydrochloric acid.

Hydrochloric acid treatment under pressure (15-30 MPa) gives an opportunity to push hydrochloric acid into small and narrow pores and subsequently increase them to more permeable conditions. The reaction rate significantly decreases by pushing acid through. At the same time, the efficiency of acid treatment and the throughput of low-permeable rocks are improving [6].

Acid baths (emulsions) are used to block highly permeable rocks. Petroleum acid emulsions consist of 70% acid solution, 30% degassed oil, and heavy hydrocarbons (for example, tar or fuel oil) may also be contained there. The resulting oil-acid emulsion is pumped into the bottom-hole zone, penetrates the zones of high permeability and fills them [6].

It is worth noting that a single hydrochloric acid treatment leaves less permeable interlayers practically untreated. Hence, stepwise hydrochloric acid treatment is the rational way of oil recovery [5].

Thus, based on this review article, it is possible to identify the benefits and drawbacks of each method (Table 1).

Table 1 – Characteristics of enhanced oil recovery

Method	Benefits	Drawbacks
Water flooding	Less expensive, the simplicity of the construction of engineering communications and the ease of the water injection.	The low efficiency factor, the difficulty of retaining the necessary reservoir pressure, increased water rate due to outflow into the feeding zone, the formation of watering cones, the need for water availability, the creation of stable emulsions of oil with water.
Hydraulic fracturing	Decreasing the resistance of the downhole, increasing permeability, increasing the effective radius of the well, reducing the water content of the fluid.	Uncontrolled crack expansion, increased well flooding, high cost of implementation, inability to reuse the well, high environmental damage
Fire flooding	High efficiency of heat transfer in the reservoir and improvement of oil's properties	The consumption of part of the oil, the loss of heavy hydrocarbons, the complexity of process management, high energy costs.
Electromagnetic action	High efficiency of electromagnetic generators, high heating rate of the bottom-hole zone, demulsification of oil, reduction of the crystallization point of paraffins.	The absence of modern high-frequency installations and systems for introducing electromagnetic energy into the reservoir, high energy consumption, the need for an electrical power, the impact of radiation on staff.
Gas injection	An opportunity of using an inexpensive agent (air), the dissolution of some agents in water, the possibility of combining with other methods of oil recovery.	Hydrate formation, gas breakthrough into producing wells, reduction of injectability during the transition from one agent to another.
Acid treatment	Simplicity of technology, low cost of materials, efficiency of the method, technological development	The possibility of settlement of sediment and blockage of microcracks, the effect on properties of oil, oil consumption.

In conclusion, it must be noted that the technique of reservoir flooding and hydrochloric acid treatment stands out from other methods. Both technologies are inexpensive. The most common technology of water flooding. It is also worth considering that the use of hydrochloric acid treatment directly depends on geological conditions. The most promising method for development is the acid treatment systems. No less important to mention the electromagnetic action technology, which requires new innovative technologies and equipment. The rest of methods are unstable and high-cost, which indicates their low applicability in oil production.

Список литературы

1. Сулаев В. В. Методы повышения нефтеотдачи пластов и критерии их применимости / В. В. Сулаев//Научный альманах.–2019.–№ 8-1(58).–С.200-203. – ред. TGTMXO.
2. Орловский С. Л. Анализ методов интенсификации добычи и способов повышения нефтеотдачи пластов на Северо-Лабатюганском месторождении/С.Л.Орловский// Нефтегазовые технологии и новые материалы. Проблемы и решения: Сборник научных трудов. Том 7 (12). – Уфа: Общество с ограниченной ответственностью "Издательство научно-технической литературы "Монография", 2018.–С.210-213.–ПОД ред. УУФИМИ.
3. Прокопцев В. О. Физические методы повышения нефтеотдачи пластов (обзор) / В. О. Прокопцев//Оборудование и технологии для нефтегазового комплекса. - 2015. – № 3. – С. 53-60. – РЕД. TWDLNB.
4. Трофимов А.С. Газовые методы как методы повышения нефтеотдачи пластов / А.С.Трофимов, С.В.Поняев, С.В.Мигунова//Новые технологии разработки нефтяных и газовых месторождений: материалы Международного технологического симпозиума, РАГС при Президенте Российской Федерации, Москва, 17-19 марта, 2004 / Р.Г.Шагиев, М.Г.Тарасевич, М.А.Черемисин. – М.: Институт нефтегазового бизнеса, 2004. – С.399-402. – ПОД ред. HBFHCF.
5. К вопросу о выборе технологии кислотного воздействия для интенсификации добычи нефти /Ю.В.Зейгман, А.В.Лысенков, В.В.Мухаметшин [и др.] // Геология, геофизика и разработка нефтяных и газовых месторождений.–2017. – № 6. – С.44-50. – ЭДН ИРХЕХ.
6. Миннимухаметова А.А. Солянокислотная обработка скважин /А.А.Миннимухаметова // Символ науки: Международный научный журнал. – 2016. – № 8-1(20). – С. 25-27. – ЭДН ВИНВУФ.

References

1. Sulaev V.V. Methods of increasing oil recovery and criteria for their applicability / V. V. Sulaev//Scientific Almanac. – 2019. – № 8-1(58). – pp. 200-203. – EDN TGTMXO.
2. Orlovsky S.L. Analysis of methods of production intensification and methods of increasing oil recovery at the Severo-Labatyuganskoye field/S.L.Orlovsky//Oil and gas technologies and new materials. Problems and solutions: A collection of scientific papers. Volume 7 (12). – Ufa: Limited Liability Company "Publishing House of Scientific and Technical Literature "Monograph", 2018. – pp. 210-213. – EDN UUFIMI.

3. Prokoptsev V.O. Physical methods of increasing oil recovery (review)/V.O.Prokoptsev // Equipment and technologies for the oil and gas complex. - 2015. – No. 3. – pp. 53-60. – EDN TWDLNB.
4. Trofimov A. S. Gas methods as methods of increasing oil recovery/A.S.Trofimov, S.V.Ponyaev, S.V.Migunova//New technologies for the development of oil and gas fields: Proceedings of the International Technological Symposium, RAGS under the President of the Russian Federation, Moscow, March 17-19, 2004 / R. G. Shagiev, M. G. Tarasevich, M. A. Cheremisin. – Moscow: Institute of Oil and Gas Business, 2004. – pp. 399-402. – EDN HBFHCF.
5. On the issue of choosing acid exposure technology for oil production intensification / Yu.V.Zeigman, A.V.Lysenkov, V.V.Mukhametshin [et al.]//Geology, Geophysics and development of oil and gas fields. – 2017. – No. 6. – pp. 44-50. – EDN YRHEKH.
6. Minnimukhametova A.A. Hydrochloric acid treatment of wells/A.A.Minnimukhametova // Symbol of Science: International Scientific Journal. – 2016. – № 8-1(20). – pp. 25-27. – EDN WINVUF.