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Analysis of the efficiency of the application of binary mixtures technology for the development of hard-to-recover fields of Western Siberia

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Abstract

In accordance with the current situation, when vertically integrated oil companies try to extract the maximum amount of oil in a short time, due to which the wrong development system is often chosen, the share of hard-to-recover reserves is growing every year. In accordance with this, there is a need to develop residual hard-to-reach reserves remaining in the subsurface. Binary mixtures is a method of complex impact on the reservoir, which characterizes this technology as the most promising among other existing methods of increasing oil recovery. The use of binary mixtures will increase the oil recovery of reservoirs by an average of 5-10%. This paper considers the principle of oil displacement using ammonium nitrate and the product of the decomposition reaction, analyzes experimental and industrial tests both in Russia and abroad, existing problems and development trends. Similar deposits are also proposed, where, according to the authors, the applicability of this technology has a positive tendency to implement and increase the development potential.

Keywords: Enhanced oil recovery method, binary mixtures, hard-to-recover hydrocarbon reserves, enhanced oil recovery methods, oil recovery factor, bottomhole zone of the formation, well;

1. Introduction

Currently, due to the deterioration of the quantitative and qualitative characteristics of the hydrocarbon resource base, the task of developing and implementing technologies for extracting hard-to-recover hydrocarbon reserves (HRHR) is being updated. According to the Ministry of natural resources of the Russian Federation, the share of HRHR in Russia is about 65%. This statistic reflects the urgency of the problem related to the development of HRHR to increase oil recovery factor (ORF) and involves the use of new technologies in oil production, increasing oil recovery from existing reservoirs, where it is impossible to get significant residual reserves of conventional methods. In accordance with this, the author proposes to use a fundamentally new method of increasing oil recovery, based on the interaction of ammonium nitrate and sodium nitrtir.

2. Materials and methods

Currently, a topical issue for consideration is the development of hard-to-recover hydrocarbon reserves (HRHR). For the first time the classification of HRHR was proposed by N. N. Lisovsky and E. M. Halimov in 1994 [4]. It was based on the boundary values of a number of geological and

technological parameters, as well as the degree of remoteness from existing oil and gas production centers. In the modern sense, hard-to-recover reserves are reserves of deposits (deposits, objects of development) or parts of the deposit, characterized by relatively unfavorable geological conditions for the extraction of oil and (or) its physical properties, the development of which is economically inefficient by existing technologies in the current tax system. The new inventory classification became the basis for HRHR incentives.

Many enhanced oil recovery methods (EORM) are used to develop HRHR, which can be divided into four types:

- chemical methods such as surfactant flooding, polymer flooding, micellar flooding, and injection of liquid solvents or other chemicals;
- microbiological methods, such as introduction of bacterial products into the reservoir or its formation directly in the oil reservoir;
- gas methods, such as injection of hydrocarbon gases, carbon dioxide, nitrogen or other gases injected into the formation either alone or mixed with liquids;
- thermal methods, such as displacement of oil by heat carriers, impact by means of intraplate exothermic oxidative, or other types of reactions [5].

At the moment, the method of multistage hydraulic fracturing (MHF) in horizontal wells is widely used for the fields of Western Siberia, but the application of this method is limited by geological conditions of occurrence and anisotropy of physical properties of reservoir layers. Among other things, vertically integrated oil companies (VIC) operating in the territory of Western Siberia are aimed at extracting the maximum amount of hydrocarbons in a short time, that is why the wrong development system is often chosen, the rapid deterioration of the filtration-capacitive properties (FCP) of reservoir layers and, accordingly, the question of profitability of hydrocarbon production arises, as there is a need to apply expensive methods to extract residual reserves.

A huge number of deposits in Western Siberia are represented by low permeable reservoirs and hard-to-recover reserves. The average oil recovery factor (ORF) in fields with hard-to-recover reserves does not exceed 0.4. This means that unless fundamentally new methods are applied to improve the production of reserves, about 60 % of the initial oil reserves will remain undeveloped. Even in a wider range, 0.10 – 0.60, ORF change for individual developed fields in Western Siberia [3].

Thus, from the above it can be seen that the issue of increasing the ORF in the already developed fields becomes relevant. One of the methods of increasing oil recovery is thermochemical binary mixture (BS) technology. In this paper we will consider the method of increasing oil recovery, based on the solution of the problem of recovery of residual reserves using thermochemical technology of binary mixtures. Binary mixtures are aqueous solutions of nitrate (ammonia or organic) and initiators of their decomposition reaction (metal hydrides or sodium nitrite). Aqueous solutions of BS reagents are pumped into the well through different channels. They come into contact in the bottomhole zone of the formation (BZF) and react by releasing heat and gas, leaving the formation under the pressure created by the reaction. Figure 1 shows the scheme of injection of reagents into the well [2].

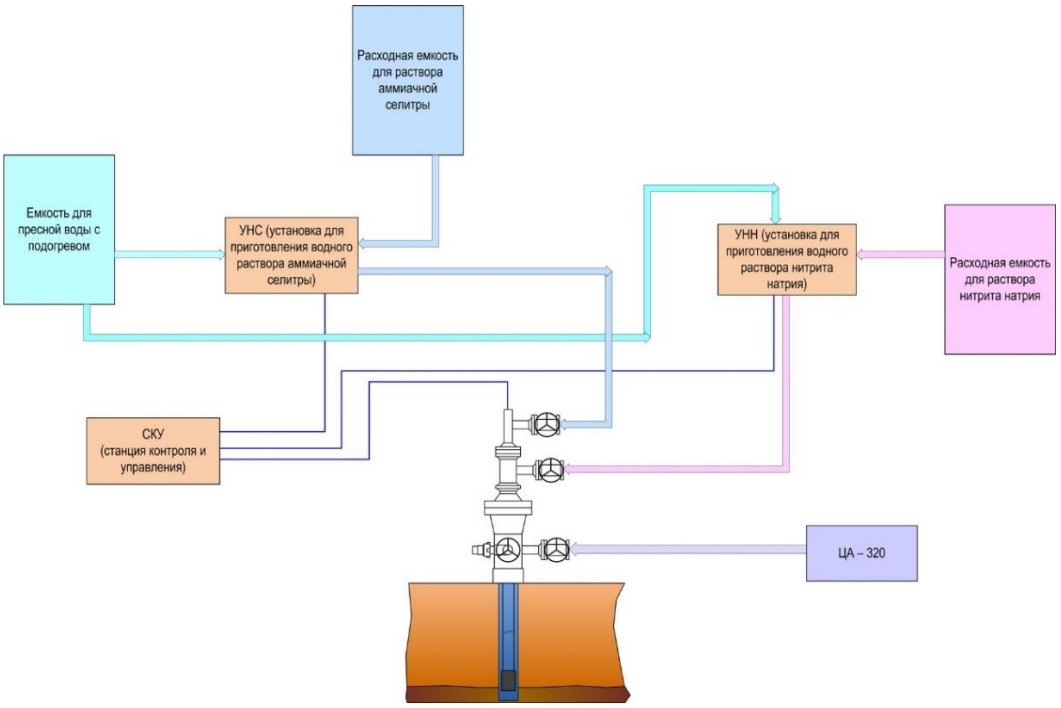

Figure 1. Scheme of binary mixtures injection

Until 2011, the process of pumping binary mixtures into wells was carried out in an uncontrolled mode, and the Rostekhnadzor authorities prohibited pumping a large number of mixtures, so it was necessary to use BS in small doses, to be more precise, no more than one ton of explosive nitrate. In 2010, a continuous monitoring system as well as optimization of the BS reaction in wells was developed and tested, and permission was obtained from Rostekhnadzor to pump saltpeter in unlimited quantities. The system of controlled injection of saltpeter and the initiator of decomposition, can be considered as a process in which saltpeter is converted into gas and heat by reaction: $NH4NO3 \rightarrow N2 + 2H2O + 0.5O2 + Q1$. This reaction heats up the formation and creates conditions for the gas lift, which works due to the energy of oxidation of oil with oxygen, which was released in the decomposition reaction of saltpeter.

3. Results

The results of pilot tests of binary mixtures were obtained at the Usinsk field (LLC "LUKOIL-Komi") in wells No. 1242 and No. 3003. Production in 2012 increased by an average of 4.95 and 8.44 tons per day, respectively, and the mass of additional oil in 2012 amounted to 2400 tons. Analyzing the data, we can judge the positive effect of the application of BS technology (table 2) [1].

Further, a number of tests were carried out at the end of 2011, the beginning of 2012 at the same field, but other wells were tested. In 2012, these wells produced 13.232 tons of additional oil, an average of 2.646 tons per well.

The publicity of BS technology on the Internet led to negotiations with foreign firms. Thus, after the treatment of wells No. 8 and No. 10 at the Eastland field in Texas, USA, which were stopped in 1994 as fully developed, as a result of the treatment, gave a fountain on well No. 8: oil-about 30%, water-about 70 % and in well No. 10: oil-about 10 %, water-about 90 %.

Table 1. Results of pilot tests of BS technology at wells No. 1242 and No. 3003 of Usinsk Deposit

№ well	Pump brand	Month	Start date	Basic debit	Number of days	Average flow rate, t/day	Additional oil production, t	Specific yield, t/day	Plan specific flow rate
1242	Electrical screw pump ESP – 25 - 1500	November 2011	09.11. 2011	0	22.00	5.82	128.00		
		December 2011			30.83	5.50	169.57		
		January 2012			31.00	4.63	143.00		
		February 2012			29.00	4.94	143.26		
		March 2012			31.00	3.98	123.38		
		Total			143.83		707.73	4.92	8.5
3003	ESP – 25 - 1500	January 2012	04.01. 2012	1.93 t/s	28.00	10.6	242.9		
		February 2012			23.00	10.6	199.6		
		March 2012			30.75	9.98	247.6		
		Total			81.75		690.10	8.44	6.5

4. Discussion

Besides, analyzing the profitability of this method, it should be noted that the value of this technology is determined by market competition, and until 2012, BS was the second only to such methods of increasing oil recovery as hydraulic fracturing and steam-thermal technology SAGD. In 2012 – 2014, BS technology provided oil production cost of 10-35 dollars per barrel ahead of the profitability of both leading technologies of the West [5].

Due to the low cost of the components of binary mixtures and high market price of oil, (provided that the value of the is equal to 67.17) and also due to the fact that there is no need to drill new wells and carry additional loss of time and money, this method is, in the author's opinion, suitable for use in Western Siberia.

Table 2. Economic indicators of applicability of binary mixtures.

Ammonium nitrate, RUB / t.	Sodium nitrite, RUB / t	Market value of Urals crude oil, RUB / bar.
9700	77000	4664.29

5. Conclusion

Analyzing the effectiveness of the use of technology BS in Usinskoye field, characterized by high viscosity oil, like most fields in Western Siberia, as well as relatively similar geological structure, and based on international experience showing the efficacy of BS after a long idle wells, taking into account the economic component of this technology, it can be concluded that the

application of this technology in the fields of Western Siberia will justify the economic and technological indicators. And

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