The choice of technologies for restoring the properties of the bottomhole zone of wells in deposits with low-viscosity oils

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Abstract. Based on the analysis of many years of experience in the operation of the Tuymazinskaya group of oil fields, it has been established that one of the most effective methods for restoring the injectivity of injection wells is chemical treatment of the bottomhole zone of wells with various acid compositions in conjunction with well reperforation and the use of coiled tubing technologies.

1. Introduction
The bottomhole zone (BHZ) condition is constantly changing during the entire period of well operation, from drilling to abandonment. As a rule, the permeability of the bottomhole formation zone is significantly lower than the permeability of the remote formation zone. Already at the stage of drilling, during the initial opening of the productive formation, irreversible processes occur in the near-wellbore zone, significantly changing the structure of rocks and their permeability.

The main factors affecting the pollution of productive formations are repression, the duration of its action, the composition and properties of the drilling fluid. Deterioration of reservoir properties occurs as a result of the penetration of various solutions, solid particles into the BHZ, as well as their interaction with formation fluids and rock-forming minerals of the formation.

Formation water is a concentrated solution of inorganic salts (55–270 g / l) with a very wide range of ions (Na⁺, K⁺, NH₄⁺, Ca²⁺, Mg²⁺, Cl⁻, Br⁻, HCO₃, CO₃²⁻, SO₄²⁻, etc.). Thus, the BHZ is clogged with swelling clay particles and the products of interaction of the drilling fluid filtrate with the formation fluids, and the formation rock is blocked by an oil-water emulsion, while the pore space is clogged with the solid phase of the drilling fluid.

Open reservoirs, underground mineralized waters of deep horizons are used as sources of water supply for the maintain formation pressure system, as well as industrial wastewater: a mixture of bottom water and fresh water from ground sources. The intensity of BHZ contamination significantly depends on the physicochemical properties and composition of the formation fluid, and fluid for reservoir pressure maintenance.

Water injected into the reservoir causes contamination of the bottomhole zone of injection wells. All this impairs the wells' connectivity with the formation and makes it difficult for oil to flow from the formation to the well and water to enter the formation from injection wells. When injecting wastewater from oil fields containing different amounts of oil and oil products into the reservoir, both the perforations and the porous medium of the bottomhole zone of the wells are contaminated, i.e., the
oil saturation BHZ of the injection well increases, which must be reduced to improve the phase permeabilities for water.

The main pollutants of BHZ are salt deposits, asphalt-resin-paraffin deposits (ARPD), corrosion products, clays, silica sand and other minerals. The formation of pollution has a number of negative consequences: equipment failure; decrease in the productivity of wells and other technological facilities; increase in the number and duration of expensive and time-consuming repairs; leading to a significant shortage of oil, an increase in energy consumption; general deterioration of technical and economic indicators. Often, pollution in the BHZ is a conglomerate of various agents that form a complex system. Consequently, before carrying out geological and technical measures, it is necessary to analyze the causes of contamination blocking the BHZ of injection wells and draw up a program of geological and technical measures (GTM) to restore injectivity.

2. Materials and methods

The main tool for stabilizing production levels and improving the efficiency of oil field development is the GTM. The objectives of their implementation are maintaining the planned volumes of oil production, intensifying oil production, and increasing oil recovery [1–10].

With an increase in the well stock, the role of GTM increases. This is especially true for the treatment of the bottomhole zone, optimization of the technological modes of well operation, regulation of the water injection pressure in the formations and packs, separate and focal waterflooding.

The tasks to be solved within the framework of planning measures are determining the purpose of carrying out, the choice of technology for stimulating the well, the selection of the required resources. Operational control and monitoring are carried out at all stages of planning.

The sequence of stages of the GTM planning process can be distinguished [11-14]:

• identification of the foci of injection wells with the presence of potential in the production fund associated with an increase in the energy of the reservoir, as well as the study of materials for hydrodynamic and geophysical studies of wells;
• production forecasting after technological optimization and well stimulation;
• formation of a sequence of activities. A number of measures is carried out to increase or level the injectivity profile of the problem zone of formation development, as well as technological and economic efficiency.

To assess the technical condition and operation of the BHZ injection well, geophysical surveys of the wells are regularly carried out. This type of research allows you to evaluate:

- tightness of the production string, tubing string and packer fit;
- circulation behind the string of liquid during water injection;
- construction of the injectivity profile of the bottomhole formation zone;
- total acceleration, bottomhole pressure, plotting the pressure drop curve at the bottom of the well after shutdown.

Based on the analysis of the interpretation of well logging data, conclusions are drawn about the current state of the injection well. In the event of a leak in the production casing or underground equipment, measures are taken to restore the tightness. If fluid circulation behind the string is detected up or down the perforation interval, remedial work is carried out to eliminate this circulation behind the string by squeezing the slurry and re-perforating the bottomhole perforation.

Of special importance are the data obtained in the course of constructing the injectivity profile, which makes it possible to identify the intervals of perforation and interlayers of the production object with the lowest and highest permeability. As a result of the uneven operation of the perforated interval of the formation, flushed channels and cracks are formed, which lead to an increase in the water cut of the production wells. If necessary, works to level the acceleration profile by mechanical and chemical impact methods on the bottomhole zone of the well are carried out.

The mechanical method means cumulative perforation of the bottomhole zone of the injection well with a density of 10-15 holes per 1 m, which allows not only to increase the filtration characteristics of
the formation, but also to include previously unused areas of the formation.

3. Results and Discussion

Nowadays, in the conditions of the Tuimazinskaya group of fields, in order to restore and increase the injectivity of injection wells, physicochemical methods are used to influence the BHZ:

- acid treatment by the well workover team;
- acid treatment using coiled tubing equipment;
- repeated perforating and blasting operations in combination with acid treatment.

When acid treatment is carried out by the workover team, the underground equipment is being extracted, gauging and pressure testing of the production string is being performed, the bottom of the well is being flushed, clay acid solution is being injected (24% HF). These actions are done in case of impact on terrigenous reservoirs of the Bobrikov-Radaevsky and Pashiysky horizons or hydrochloric acid (12% HCl) for carbonate reservoirs of the Tournaisian stage of the Kizelovsky horizon.

The advantages of this type of treatment are the ability to assess the technical condition of the well and revision of underground equipment, the disadvantages are the need to prepare the working site, discharge and kill the well, as well as the repair time, which is about 160 hours, depending on the depth of the production facility.

When conducting GTM with the use of coiled tubing equipment, continuous coiled tubing is lowered into the well through the tubing string, through which acid solutions are pumped into the BHZ of the injection well.

The advantage of this type of treatment is that there is no need to discharge and kill the well, as well as a significantly shorter time for processing - no more than 72 hours. The disadvantage is the inability to assess the technical condition of the well and revise the underground equipment.

When conducting GTM with a workover crew, it is possible to reperforate the production casing in the formation interval with subsequent acidizing, which allows increasing the permeability more significantly due to the formation of additional perforations, and it is also possible to include previously unused formation intervals.

This method is characterized by the same disadvantages as during acid treatment by the workover crew, and an increase in the duration of the repair, which will be about 200 hours, depending on the depth of the perforation interval. The advantage is a more efficient increase in the porosity and permeability of BHZ, the possibility of increasing the perforated thickness of the formation.

The study analyzes works on restoration and increase of injectivity of injection wells of Tuimazinskaya group of fields. As the initial information, it analyzed the effectiveness of work on 182 wells of the Tuymazinskaya group of fields. Reservoirs are divided into 3 generalized groups of wells with similar geological and physical characteristics:

- terrigenous reservoir of the Sbob + rad formation;
- carbonate reservoir of STkiz, Dfams formation;
- terrigenous reservoir of Dpash formation.

To assess the effectiveness of the method, an increase in the injectivity of the well after the work was taken in relation to the injectivity before the work, which makes it possible to exclude the influence of various parameters of the formation and the technology of work.

As can be seen from the diagram in the figure, the most effective is the production casing reperforation method in the formation interval followed by acid treatment, which is explained by the combination of various stimulation methods.
Figure 1. The effectiveness of methods for restoring the injectivity of injection wells: □—an increase in acceleration, after GTM / up to GTM, fraction of units. Sbob + glad □— increase in injectivity, after GTM / before GTM, share of units STkiz, Dfams; □— increase in injectivity, after GTM / before GTM, unit share of Dpash.

After the measures are taken, the actual effect is calculated, schedules are built and analyzed, the main reasons for not achieving the planned indicators and measures for their compensation are determined. The following table presents the results of such an analysis.

| Table 1. Comparative analysis of the used methods |
|------------------------------------------------|
| **GTM type** | **Increase in injectivity in layers, after GTM / before GTM, unit fractions** |
|             | Sbob + glad | STkiz, Dfams | Dpash |
| Acid treatment using coiled tubing equipment | 2.62        | 2.64          | 2.31  |
| Acid treatment by the workover team          | 2.81        | 2.39          | 2.42  |
| Reperforation + acidizing by workover team   | 3.57        | 4.42          | 5.34  |

4. Conclusion

Many years of experience in the operation of the Tuimazinskaya group of oil fields has established that one of the most effective methods for restoring the injectivity of injection wells includes chemical treatments of BHZ with various acid compositions in conjunction with well reperforation and the use of coiled tubing technologies.

References

[1] Muslimov R K 2005 Modern methods of oil recovery increasing: design, optimization and performance evaluation (Kazan: FEN) 688 p

[2] Yakupov R F, Mukhametshin V Sh, Khakimzyanov I N and Trofimov V E 2019 Optimization of reserve production from water oil zones of D3ps horizon of Shkapovsky oil field by means of horizontal wells Georesursy 21(3) 55-61. DOI: 10.18599/grs.2019.3.55-61

[3] Mukhametshin V V and Kuleshova L S 2020 On uncertainty level reduction in managing waterflooding of the deposits with hard to extract reserves Bull. of Tomsk Polytechnic University. Geo Assets Engineering 331(5) 140–146. DOI 10.18799/24131830/2020/5/2644

[4] Economides J M and Nolte K I 2000 Reservoir stimulation (West Sussex, England: John Wiley and Sons) 856 p

[5] Stenkin A V, Kotenev Yu A, Mukhametshin V Sh and Sultanov Sh Kh 2019 Use of low-mineralized water for displacing oil from clay productive field formations IOP Conf. Ser.: Mater. Sci. Eng. 560(1) 012202. DOI: 10.1088/1757-899X/560/1/012202
[6] Alvarado V, Reich E M, Yunfeng Y and Potsch K 2006 Integration of a Risk Management Tool and an Analytical Simulator for Assisted Decision-Making in IOR SPE Europec/EAGE Annual Conf. and Exhibition (Vienna, Austria, 12-15 June 2006) p 6. DOI: 10.2118/100217-MS

[7] Rogachev M K and Mukhametshin V V 2018 Control and regulation of the hydrochloric acid treatment of the bottomhole zone based on field-geological data J. of Mining Institute 231 275-280. DOI: 10.25515/PMI.2018.3.275

[8] Valeev A S, Kotenev Yu A, Mukhametshin V Sh and Sultanov Sh Kh 2019 Substantiation of the recovery of residual oil from low-productive and heterogeneous formations in Western Siberia by improving the waterflood system using gas and water-gas impacts IOP Conf. Ser.: Mater. Sci. Eng. 560(1) 012204. DOI: 10.1088/1757-899X/560/1/012204

[9] Kuleshova L S, Kadyrov R R, Mukhametshin V V and Akhmetov R T 2019 Auxiliary equipment for downhole fittings of injection wells and water supply lines used to improve their performance in winter IOP Conf. Ser.: Mater. Sci. Eng. 560(1) 012071. DOI: 10.1088/1757-899X/560/1/012071

[10] Bou-Mikael S, Asmadi F, Marwoto D and Cease C 2000 Minas Surfactant Field Trial Tests Two Newly Designed Surfactants with High EOR Potential SPE Asia Pacific Oil and Gas Conf. and Exhibition (Brisbane, Australia, 16-18 October 2000) p 12. DOI: 10.2118/64288-MS

[11] Tyncherov K T, Mukhametshin V Sh, Paderin M G, Selivanova M V, Shokurov I V and Almukhametova E M 2018 Thermoacoustic inductor for heavy oil extraction IOP Conf. Ser.: Mater. Sci. Eng. 327(4) 042111. DOI:10.1088/1757-899X/327/4/042111

[12] Rogachev M K, Mukhametshin V V and Kuleshova L S 2019 Improving the efficiency of using resource base of liquid hydrocarbons in Jurassic deposits of Western Siberia J. of Mining Institute 240 711-715. DOI: 10.31897/PMI.2019.6.711

[13] Yakupov R F, Mukhametshin V Sh and Tyncherov K T 2018 Filtration model of oil coning in a bottom water-drive reservoir Periodico Tche Quimica 15(30) 725-733

[14] Briones M, Zambrano J A and Zerpa C 2002 Study of Gas-Condensate Well Productivity in Santa Barbara Field, Venezuela, by Well Test Analysis SPE Annual Technical Conf. and Exhibition (San Antonio, Texas, 29 September-2 October 2002) p 9. DOI: 10.2118/77538-MS