Geological and technological justification of the bottom-hole zone treatment of wells and formations of the Langepas group of fields

S A Yaskin¹, V V Mukhametshin² and L S Kuleshova³

¹ TPE “Urayneftegaz” LLC “LUKOIL–Western Siberia”, 116а, Lenin St., Uray, Tyumen region, Khanty-Mansi Autonomous Area – Yugra, 628285, Russian Federation
² Ufa State Petroleum Technological University, 1, Kosmonavtov st., Ufa, Republic of Bashkortostan, 450062, Russian Federation
³ Ufa State Petroleum Technological University, Branch of the University in the City of Oktyabrsky, 54а, Devonskaya St., Oktyabrsky, Republic of Bashkortostan, 452607, Russian Federation

E-mail: vv@of.ugntu.ru, markl212@mail.ru

Abstract. Based on the geological and routine analysis are represented the effective application areas of methods of simulating production and enhanced oil recovery of fields developed by the TPP "Langepasneftegaz". Based on laboratory experiments, the composition of composite systems of recovery methods on productive formations has been established. The technologies adaptation of the bottom-hole zone treatment of wells and formations of the Langepas group of fields was carried out.

1. Introduction

The fields developed by the TPP "Langepasneftegaz" are located in the Nizhnevartovsk district of the Khanty-Mansi national district in the central part of the Tyumen region.

The main share of the annual oil production of TPP "Langepasneftegaz" is obtained from facilities that are in the production decline stage, characterized by the high water cut of the produced fluid, active reserves depletion and an efficiency decrease of water flooding. The problem solution of production level stabilization of hydrocarbon crude is unthinkable without the use of new progressive methods and technologies that improving the effectiveness of traditional methods of stimulation formations, which is confirmed by the actual performance indicators of the TPP "Langepasneftegaz".

The emerging positive trend is particularly enhanced by the large-scale targeted use of a wide range of technologies, such as the development of the Uryevskoye field. It accounts for about 40 % of oil production in the Langepas region. The methods, that have a high technological effect and are provided with special installations for preparing and injecting large composition volumes into the formation have found widespread industrial introduction in this field. Such technologies are the use of SPL, thermotropic gellant "Metka", as well as the integrated technology of SPL+STEL.

Technologies currently being implemented involve the use of relatively small volumes of polymer solutions, to which some cross-linking agents are added to create a bond between individual polymer molecules. The bottomhole zone of the injection well is treated using this scheme. As crosslinkers,
salts of polyvalent metals (chromium, aluminum, iron) are used, which are capable of forming multiple bonds with polymer molecules in the form of branched structures with high rheological properties. The cross-linking agent turns the polymer solution into a gel (sometimes the polymer is crosslinked so tightly that the resulting compound resembles rubber). In some cases, pre-crosslinked dry polymer compositions are used in waterproofing processes. These compositions swell, increasing in free volume by 5-6 times when in contact with fresh water and by 2-3 times when in contact with mineralized water.

The essence of the method with the using of crosslinked polymer systems is the addition of a cross-linking agent to neighboring reactive groups of a polymer molecule. In this case, network polymer structures can be formed. In the course of the implementation of such technologies, it is possible to provide for using of slowly cross-linking polymer-crosslinker compositions, as a result of which they can be advanced deep into the highly permeable zones of the formation over considerable distances and, therefore, the distribution of flows in the formations can be effectively regulated.

One type of crosslinked polymer systems technology is polymer flooding technology combined with viscoelastic compositions, the essence of which is that during the injection of a polymer slug, the bottomhole zone of injection wells, as often as required, is treated with small (30-100 m³) volumes of crosslinked polymer systems with small (4–24 h) gelation time. In this case, the cross-linking agent is attached to reactive groups belonging to different polymer molecules. The resulting hydrogels have very low mobility, a high initial shear gradient, and pronounced viscoelastic properties.

Depending on the geological and physical parameters of the reservoirs, the state of field development and economic constraints, various technologies for using crosslinked polymer systems can be implemented to increase oil recovery and treat the bottomhole zone.

2. Materials and methods

Based on the generalization of the implementation results of physical-chemical methods on the fields Langepas region formulated ways of improving their effectiveness: the selection of the most efficient technologies; finding cheaper and technological agents; adaptation of technologies to the field situations Langepas region; scientific and technical support for technology implementation.

The analysis and synthesis of the laboratory results on the technologies adaptation to enhance oil recovery, oil production intensification and water cut reduction to the field situation of TPP "Langepasneftegaz" optimized technological parameters and compositions of composite systems of stimulation methods.

3. Results and Discussion

To efficiency improvement of mud-acid treatment of wells acid dispersions of the following compositions are proposed:
- acid dispersion № 1: neonol AF-6-1.75 %; sulfonol-1.25 %; hydrochloric acid (12 %) - 50 % (HCl-6 %); hydrofluoric acid (5 %) - 47 % (HF-2.4 %);
- acid dispersion # 2: OPT-BHA-8.0 %; sulfonol-3.0 %; hydrochloric acid (12 %) – 50 % (HCl – 6%); hydrofluoric acid (5%) – 39 % (HF-2%).

These acid compositions were recommended for BHT production and injection wells. In addition, an acidic micro-emulsion of the following composition can be used for BHT injection wells: neonol AF-6 – 5 %; SNOB – 2.5 %; hydrochloric acid (12 %) – 50 % (HCl – 6 %); hydrofluoric acid (5 %) – 40 % (HF – 2 %).

Gel compositions based on waste from the WMS-5 catalyst production and water solutions of hydrochloric acid are recommended as rigid water-insulating compositions 7.5/7.5 – 8/8 % by weight.

To simultaneously increase the displacement efficiency and the sweep efficiency, the following compositions are recommended:
- synterol AFM-12-volgonat-PAA with a SAS concentration of 5-10 g/dm³ at a ratio of 7: 3 and 6: 4 and a polymer concentration of 0.5-1, .0 g/dm³;
- synterol AFM-12-sulfonol-PAA with a ASA concentration of 5-10 g/dm³ at a ratio of 5: 5 and a
polymer concentration of 0.5-1.0 g/dm$^3$;
- neonol Af9-6-volgonat with a SAS concentration of 10 g / dm$^3$ at a ratio of 7: 3 and 6: 4 and subsequent polymer injection with a concentration of 0.5–1.0 g/dm$^3$.

For high-temperature formations have been optimized the compositions of thermotropic gel-forming compositions "Metka", "Galka", PB-3P-1, which can be used both at the early and late stages of field development.

By changing the ratio of components and introducing additional components into the composition, their surface-active, rheological and kinetic parameters can be adjusted to adapt to specific geological and physical conditions. The use of inorganic gelling based on the aluminum salt-urea-SAS-water system leads to an increase in the heterogeneous stratum coverage of water flooding, conformance control and enhanced oil recovery of the heterogeneous stratum.

The following gelling compositions are recommended for cooled layers: "GALKA-THERMOGEL" (40-70 °C)," GALKA-THERMOGEL-NT "(20-40 °C) based on urea and aluminum chloride, as well as a composition consisting of the reagent "Metka" and Cenomanian water (based on methylcellulose and urea).

A method and computer program for calculating the thermal field of bottom-hole formation zones have been developed. Studies of thermal profiles of injection wells when cold water is injected into them allowed us to formulate the main technological requirements for thermotropic gelling, clarify the processes mechanisms occurring in the bottom-hole zone, and rank the target objects by the types of recommended thermotropic systems.

To calculate the parameters of high conductivity zones of productive formations has developed a method and were conducted indicator studies at the Pokamasovskoe and Lokosovskoe fields. Studies on the tracer fluid injection at the Pokamasovskoe and Lokosovskoe fields of the TPP "Langepasneftegaz" have revealed the presence of zones of low filtration resistance in these fields and the general patterns inherent in these zones. Based on the literature data analysis, it can be argued that the conducted field tests are one of the largest among such studies conducted in Russia and abroad. Studies have shown that the channel volumes of low filtration resistance are very low, the cumulative volume of these channels in the influence zone of injection wells is measured in units or tens of m$^3$ (the maximum value is 55 m$^3$). The relative share of these channels from the gross pore volume of the productive reservoir is hundredths or thousandths of a percent. Due to the higher channel properties, the relative share of water flow filtered through high productivity zones is significantly higher and reaches tenths of a percent (maximum value of 2.4 %).

The problem of predicting the application of physical-chemical methods to enhanced oil recovery in specific geological and physical conditions of productive formations has been successfully solved. The justification for the use of physical and chemical EOR in a group of fields should be based on the positive experience of using these methods in close geological and physical conditions [1-9]. To determine the proximity or similarity of the geological and physical conditions of different formations of fields, a procedure for grouping the productive formations under consideration is necessary. For this purpose, the grouping of fields in the Langepas region by the method of pattern recognition theory (main components, cluster analysis) according to a set of controlled geological and geophysical parameters allowed us to identify four fairly homogeneous groups, and in each group are typical objects for each group.

As a result of geological-routine analysis of the selected objects with the most efficient system development (formation SFP8 Urevenskoye field), and the objects projected recovery rates which do not reach the design level (formations SE1 Las-Eganskoye field, BW6 Potochnoe, and ACB1/3 South-Pokachevskoye fields). As a result of the performed mathematical modeling and the conducted technical and economic analysis, the optimal technologies set enhanced oil recovery, oil production intensification and reducing the water cut is established differentially for the selected field groups. The first methods group is aimed at conformance control of injection wells, as well as at stimulating the fluid influx to the producing wells and reducing the water cut of the extracted products, and it is recommended to perform the processing systematically, i.e. simultaneous processing of
injection (sedimentation-forming compositions) and production (methods of stimulating production). These methods include cyclic water flooding, water solutions of CP, MAT. The second and third groups of technologies are aimed at the pre-washing of remaining oil. They include the following methods: SPDS, ESS, ESS+STEL, RT-3P-1 (OPS), RT-3P-1 (OPS), aluminosilicate, SAS+alkali+polymer. These methods are used in monolithic relatively homogeneous formations with low clays content. The fourth group of technologies is aimed at stimulating inflows in development wells, filter cake removal of formations, and reducing the water cut of extracted products. The group includes STEL, MAT, SPL (injection wells), SPL (development wells), SPL+STEL, the aluminosilicate.

4. Conclusion
A complex of laboratory, theoretical, hydrodynamic and geological field researches on the adaptation of various methods of exposure to specific geological and physical conditions and develop hardware components set for their implementation allowed to significantly increase technical and economic efficiency, targeting and success of the technology, reasonably go from the stage of industrial experiment works to large-scale commercial introduction of physical-chemical methods of enhanced oil recovery, oil production intensification and water cut reduction at the region fields.

References
[1] Beaudette-Hodsman C, MacLeod B and Venkatadri R 2008 Production of High Quality Water for Oil Sands Application Int. Thermal Operations and Heavy Oil Symp. (Calgary, Alberta, Canada, 20-23 October 2008) p 8. DOI: 10.2118/117840-MS
[2] Mukhametshin V V and Kuleshova L S 2019 Justification of Low-Productive Oil Deposits Flooding Systems in the Conditions of Limited Information Amount SOCAR Proceedings 2 16–22. DOI: 10.5510/OGP20190200384
[3] Bortolotti V, Macini P and Srisuriyachai F 2009 Laboratory Evaluation of Alkali and Alkali-Surfactant-Polymer Flooding Combined with Intermittent Flow in Carbonatic Rocks Asia Pacific Oil and Gas Conf. & Exhibition (Jakarta, Indonesia, 4-6 August 2009) p 13. DOI: 10.2118/122499-MS
[4] 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 Georesources 21(3) 55-61. DOI: 10.18599/grs.2019.3.55-61
[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] Hodgin J E and Harrell D R 2006 The Selection, Application, and Misapplication of Reservoir Analogs for the Estimation of Petroleum Reserves SPE Annual Technical Conf. and Exhibition (San Antonio, Texas, USA, 24-27 September 2006) p 15. DOI: 10.2118/102505-MS
[7] 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
[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] 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
[10] Akhmetov R T, Kuleshova L S and Mukhametshin V V 2019 Application of the Brooks-Corey model in the conditions of lower cretaceous deposits in terrigenous reservoirs of Western Siberia IOP Conf. Ser.: Mater. Sci. Eng. 560(1) 012004. DOI: 10.1088/1757-899X/560/1/012004