Rapid assessment of perfect time for transferring wells to water injection for pressure maintenance in low-permeable sediments of Tyumen suite of LLC «RN-Uvatneftegas» oilfields

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Abstract. A significant part of the initial geological reserves of LLC «RN-Uvatneftegas» oilfields are concentrated in deposits with abnormally low reservoir properties (porosity, permeability). The organization strategy of pressure maintenance of such oilfields significantly affect to the economic profitability of the reservoir development. One of the major tasks to achieve this goal is to determine the perfect time for application injection wells in oil production before forming the pressure maintenance system. Often, the solution to this issue turns out to be labor-intensive. In this regard, the analytical tool has been developed that allows rapidly assess the perfect time for transferring wells to water injection for pressure maintenance forming. The developed tool is based on a statistical analysis of the decline rate of horizontal wells fluid rates at the RN-Uvatneftegas oilfields. And also a comparative analysis of the results of the developed tool and other existing methods was carried out. The analysis showed that the developed tool is distinguished by its accuracy, simplicity and efficiency of work.

1. Introduction
At present, in connection with the gradual depletion of traditional oil reservoirs, the question arises of involving in the development of oilfields with deteriorated reservoir properties (porosity, permeability). Therefore, the choice of the optimal method for the development of low-permeability reservoirs is the most important task for most oil companies [1]. At the same time, questions remain about the need for a pressure maintenance system and the period of its formation.

The effectiveness of the pressure maintenance system doesn’t raise doubts in the development of the Tyumen formation deposits with permeabilities of more than 10 mD. The classic development approach with the transfer wells to water injection in 3-6 months, allows to achieve high levels of production and final oil recovery factor [3]. At the same time, a decrease in the rate of drops in fluid flow rates of production wells can be noted in a few weeks.

When developing low-permeability formations, the influence of the pressure maintenance system on the rate of fall of the surrounding wells is insignificant, and the time of transition to injection is of fundamental importance from the point of view of the profitability of the project [2].

The RN-Uvatneftegas oilfields considered in the work are similar in geological structure and reservoir properties, their commercial oil-bearing capacity is associated with terrigenous deposits of the Tyumen suite, permeability varies from 1 to 7 mD, porosity averages 16%. The deposits are characterized by high heterogeneity, stratification factor 4-6 units, net-to-gross sand ratio 0.16-0.53 unit
fractions, rock compressibility 1.5-3.5 1/MPa*10^-4. The average net pay thickness is from 4.3 to 8 m. The initial reservoir pressure is 28 MPa, the gas saturation pressure is 12 MPa.

The development system of the RN-Uvatneftegas oilfields is predominantly single-row. The distance between the wells is 400-600 m, the average length of a horizontal well is 1000 m. The pressure maintenance system is in the stage of formation.

Taking into account the similarity of the geological structure, reservoir properties and well location systems for these oilfields, a unified approach was applied when forming the pressure maintenance system, which consists in analyzing the rate of decline in production rates of production wells depending on the time of transferring wells to water injection and with the subsequent assessment of additional oil production based on the obtained dependencies.

2. Analysis of the rate of decline in production wells at the RN-Uvatneftegas oilfields

In order to determine the perfect date for transferring wells to water injection, for production horizontal wells with the identified influence of the pressure maintenance system, a statistical analysis of flow rates was carried out. Numerical sector models with adaptation of bottom-hole pressure and production for RN-Uvatneftegas oilfields were built in the Kappa Topaze program. Based on the adapted models, the rates of fluid loss were predicted during the formation of the pressure maintenance system after 3 months, 6 months, 1 year, or simultaneously with production wells, as well as the option without the pressure maintenance system.

As a result, normalized production rates (i.e. the ratio of the current flow rate to the maximum) were calculated for permeabilities in the range from 1 to 7 mD (Figure 1). The minimum permeability at the RN-Uvatneftegas oilfields is 1 mD. The analysis showed that during the first six months the impact of the waterflooding system on well production rates is minimal, which makes it possible to transfer wells to water injection during this period of time. In the future, the degree of influence of the pressure maintenance system on the performance indicators becomes very significant, which is reflected in the amount of cumulative oil production throughout the entire area.

![Figure 1. Normalized flow rates for the conditions of the low-permeability Tyumen suite of the RN-Uvatneftegas oilfields. It can be seen from the graphs that the greater the permeability of the exploitation object, the better the effect of the pressure maintenance system.](image-url)
3. Influence of the pressure maintenance system on normalized flow rates

To estimate the time of transferring wells that were in production for injection, the previously normalized flow rates are divided by the normalized flow rates of the same wells during their operation in the depletion mode. This approach allows calculating the matrix of coefficients of the pressure maintenance system on technological indicators depending on the permeability and the time of application injection wells in oil (Figure 2). As can be seen from the figure, the degree of influence of these parameters is very significant. The results obtained are the basis for the analytical method proposed below for assessing the time of transferring wells to water injection for pressure maintenance forming.

![Figure 2: Influence of pressure maintenance system on normalized liquid flow rates. The curves on the graph show how the normalized fluid rates change at a certain permeability, depending on the option of transferring the well to water injection for pressure maintenance forming.](image)

4. Rapid assessment of perfect time for transferring wells to water injection for pressure maintenance forming

Based on the calculated matrix of influence coefficients, an assessment of the average increase in normalized production rates for a certain period of time is carried out, depending on the permeability.

The dependence of the average increase in normalized flow rates on permeability formed the basis of the developed program for assessing the perfect time for transferring wells to water injection for pressure maintenance forming. The basis of the proposed express assessment is as follows: the starting parameters of the injection well, operating as a production well, and the wells surrounding it are multiplied by the coefficients of the average increase in normalized flow rates, as a result of which the average liquid flow rate for the study period is calculated for various options for transferring wells to water injection has been calculated. Then, to move from average fluid flow rates to the cumulative fluid production, the average flow rate is multiplied by the number of days of the study period. Then the resulting fluid production is converted to oil, taking into account the displacement characteristics and reserves for each well of the study area. Next, the program calculates the accumulated discounted production. Based on the maximum value of the accumulated discounted production, the perfect variant of transferring the well to water injection is determined (Figure 3).
Figure 3. Rapid assessment of the perfect time for transferring wells to water injection for pressure maintenance forming.

In the work, a calculation was made to determine the perfect date for transferring a well to water injection in a section of one of the RN-Uvatneftegas oilfields and the results were compared with the calculation from the GDM (Figure 4).

The perfect time for transferring the well to water injection for both options was 6 months. Thus, the instrument calculates with sufficient accuracy and, at the same time, is distinguished by its efficiency.

Figure 4. Cumulative discounted oil production calculated using GDM and developed instrument. The perfect time for transferring a well to water injection for both options is 6 months.

5. Development prospects
In the future, the developed tool is planned to be replicated for the field as a whole, i.e. in the oilfields where it is planned to form a pressure maintenance system after the injection wells are commissioned, the program will automatically determine the surrounding wells and load their daily indicators, which will be previously entered into the database.

As a result, the perfect dates for transfer to water injection will be determined for each injection well for the field as a whole (Figure 5-6).
Figure 5. Map of current production on the map of initial oil pay thicknesses.

Figure 6. Model of rapid assessment of the perfect time for transferring wells to water injection using the example of the Nemchinovskoye oilfield.

6. Conclusion

Thus, the work analyzed the real experience in the development of low permeability deposits of the Tyumen suite at the RN-Uvatneftegas oilfields, obtained the actual rates of decrease in fluid flow rate and determined the degree of influence of the time of transferring wells to water injection on the productivity of the dynamics of the rate of decrease in fluid flow rate.

A method has been developed to determine the perfect time for the formation of the pressure maintenance system and, on the basis of it, a tool has been developed that allows for a rapid assessment of the perfect time for transferring wells to water injection.

Comparison of the calculations with the GDM showed sufficient convergence of the results, while the labor costs from the implementation of the developed tool are reduced by 10 times.

References

[1] Khasanov M M, Krasnov V A, Korotovskikh V A 2017 Scientific and technical bulletin OAO «NK «Rosneft»» Determination of the optimal period of oil wells operation vol 38 Moscow pp 19-21

[2] Sitnikov A N, Pustovskikh A A, Belonogov E V, Samolovov D A 2016 Oil industry Methodology for determination of low-permeability reservoirs optimal development by wells with multi-stage fracturing vol 1 Moscow pp 56-59

[3] Belonogov E V, Pustovskikh A A, Sitnikov A N 2018 Oil industry Methodology for determination of low-permeability reservoirs development vol 1 Moscow pp 49-51