The Influence of Hydraulic Fracturing on the Estimated Ultimate Recovery

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Abstract. The paper presents the numerical reservoir model constructed to study the influence of hydraulic fracturing on the effective oil recovery. The work of neighboring development wells is also addressed. The paper seeks to examine the way hydraulic fracturing in a development well affects the degree of recovery from the whole pool of the field. To solve this problem, the oil pool model developed by waterflooding is being considered. The paper examines the efficiency of hydraulic fracturing employed in wells at different locations. The study found that well stimulation technique affects the performance of near wells where there is an increase in the water cut of the production and a decrease in the oil rate.

1. Introduction

Today carrying out activities designated to increase afterflow and reduce water cut of recoverable reserves is a promising direction of technical progress in the oil and gas industry. In most oil-bearing geographic areas, the structure of reserves is deteriorating, highly productive deposits are being depleted and the rate of hard-to-recover reserves is increasing.

Hydrofracturing (HF), as one of the most widely used techniques, is an effective method of increasing well flow rates, since it raises the intensification of oil production located in a drainage area, and under certain conditions can significantly expand this area by exploiting poorly drained tight stagnant formations, and, therefore, substantially increases the ultimate oil recovery [1-4].

2. Materials and Methods

The paper studies the production of oil reserves from the reservoir with the use of hydraulic fracturing on the three-phase filtration model. The Tempest-More hydrodynamic simulation block (manufactured by Roxar / Smedvig) is used as a research tool for a number of reasons, namely:

1. It enables to simulate all existing three-phase filtration models with a high level of accuracy. The model assumes that the reservoir contains oil, dissolved gas and water.
2. It allows a spatial grid of different scale (local grid refinement and coarsening) to present a thorough filtration model in the most problematic reservoirs.
3. The simulator provides visualization of input and output data, which makes it possible to quickly evaluate the results and develop a strategy for further improvement of the filtration model.
4. Time of hydrodynamic calculations (depending on the dimension of the grid) acceptable for this class of tasks.

3. Results and Discussion

The paper is concerned with the section of the reservoir that contains vertical injection and development wells [5].

The authors explored the way in which hydraulic fracturing in a development well affects the degree of recovery from the whole pool of the field. To solve this problem, the oil pool model developed by waterflooding was considered. The main goal of the study was to estimate how hydraulic fracturing affects the overall technological efficiency of oil production over the deposit area [6, 7].

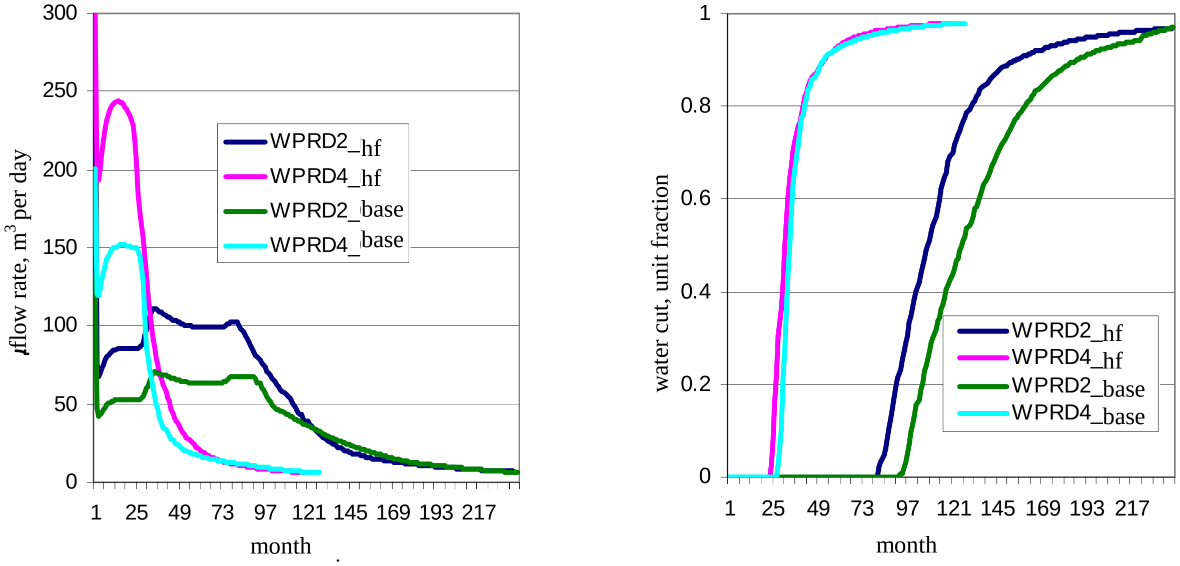
The well location in the framework of operating injection and development wells influences the hydraulic fracturing effect. In the paper, the efficiency of hydraulic fracturing in wells at different locations was considered. The considered nonfractured wells were selected as the basic variant. Let's consider the option when hydraulic fracturing is performed on the WPRD4 well. The indices obtained are compared with the base variant for the WPRD4well. Similarly, the parameters for the WPRD2 well were calculated.

The calculated WPRD2 and WPRD4 indices are presented in Fig.1.

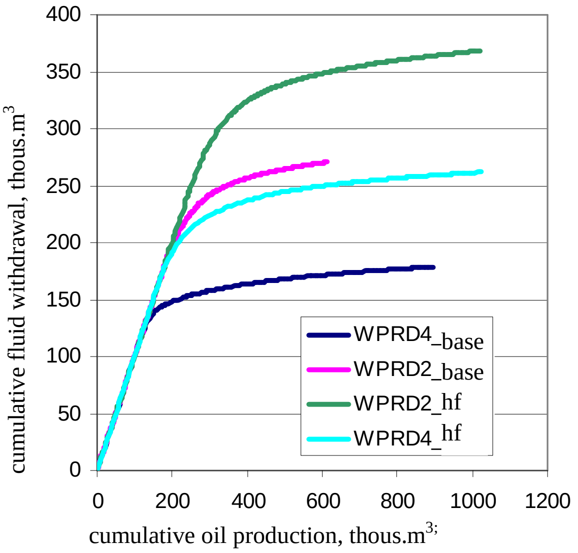
It can be clearly seen that the WPRD4 well has a high oil production rate in both considered variants, which quickly falls, though, as a result of waterflooding of the formation. The WPRD2 oil flow rate is less important, but it remains stable over a long period of time. These dependencies are explained by the location of wells relative to the number of injection wells.

Figure 1c shows that the WPRD2 well selects a greater volume of oil than the WPRD4 well with less cumulative fluid production. Hydraulic fracturing in the WPRD4 well considerably increases the oil production rate with an insignificant increase in the cumulative water withdrawals (760 thousand m^3 – fractured and 703 thousand m^3 – non-fractured wells). For the WPRD2 well, the application of hydraulic fracturing also increases oil production, but at the same time the amount of produced water increases significantly (342 thousand m^3 in the base variant and 653 thousand m^3 while fracturing).

The dynamics of cumulative absolute and relative effects following hydraulic fracturing was further reviewed (Fig. 2). The figure shows that the effect from WPRD2 fracturing is maximum and is more than 100 thousand m^3. The relative effect of hydraulic fracturing is also maximized for this well.

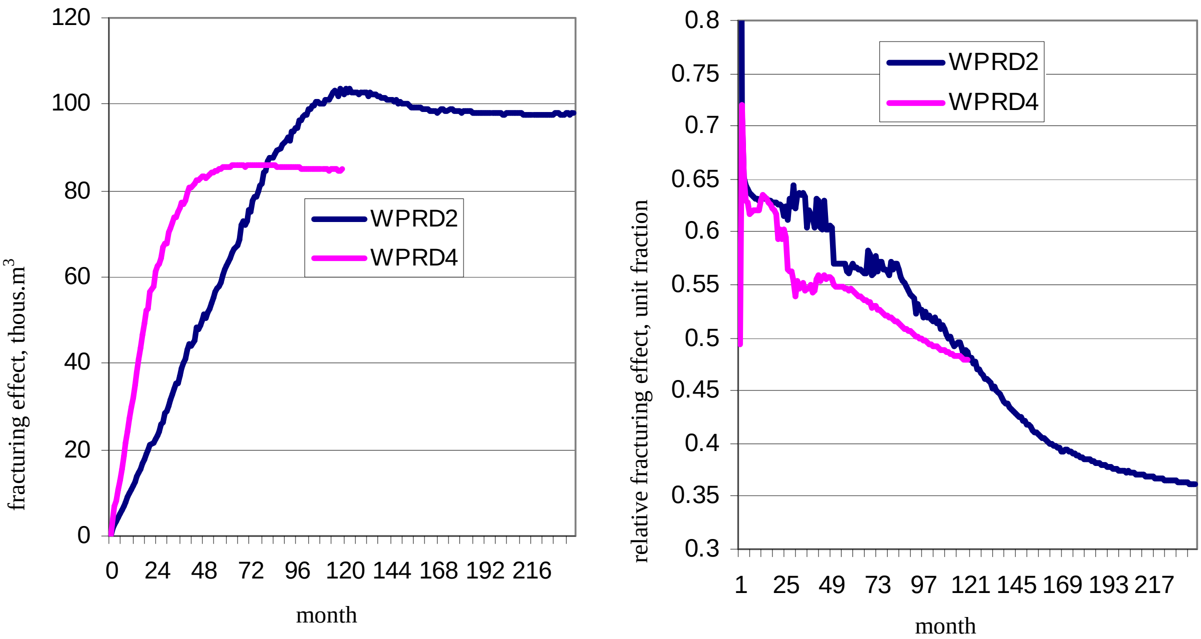


a в



c

Figure 1. WPRD2 and WPRD4 current operational performance, fractured and non-fractured, (basic variant) (a, b) and displacement characteristics (c)



a b

Figure 2. Hydraulic fracturing effect indicators (a) and relative fracturing effect (b) in WPRD2 and WPRD4 wells

4. Findings

Through the initial stage of well exploitation, the relative effect from fracturing is maximum. It begins to decrease sharply when water flooding is triggered.

Carrying out hydraulic fracturing in a well affects the performance of near wells, therefore, when determining the technological effect of hydraulic fracturing, it is necessary to take into account the work of near wells.

5. Conclusion

The paper presents the rationale for selecting the well-known Tempest-More block for hydrodynamic simulation to assess the influence of hydraulic fracturing under various conditions on the completeness of oil production. The methods for preparing initial data for numerical investigation (properties of oil, gas, water, phase permeability) as well as technological criteria for development and injection wells are also examined.

The influence of hydraulic fracturing on the development of oil reserves taking into account the work of near development wells is investigated on the numerical reservoir model. The effect of hydraulic fracturing in a cell disintegrates and makes the parameters of the near cells change slightly reducing oil production and increasing the volume of produced water, which reduces the economic efficiency of water withdrawal technology.

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