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Importance of Modeling Application to Increase Oil Recovery Ratio

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Abstract: The paper is devoted to the complex exploration of Stakhanovskoye oil field. To analyze the field there have been used 203 producing and 45 injection wells of Bobrikovsko-Radayevsky horizon, 184 producing and 40 injection wells of Turney stage. There have been made diagrams of permeability coefficient distribution value, rate of water encroachment and formation pressure coefficient. Based on them there have been determined weightiness and production rote change coefficients of the characteristics to find out geological heterogeneity of reservoir sections and geologic technological characteristics of the facilities examined. A special attention was paid to the efficiency analysis of non-stationary water-flooding applied. Model study exploration of the oil area by the introducers demonstrates the occurrence of numerous high coefficient residual oil saturation zones. There have been suggested measures (by the authors) directed to the rate of oil recovery and recovery factor increase. There have been determined the possible changes of oil recovery factor and there has also been demonstrated the effectiveness of measures suggested by the introducers (authors).

Key words: Modeling · Non-stationary water-flooding · Oil-recovery factor · Weightiness factor · Variability ratio · Residual oil saturation

INTRODUCTION

At present a great number of production facilities of Russian oil fields are at the latest stage of development and characterized by a high degree of production drowning and exhaustion (being worked out). Thus some negative tendency can be clearly observed: exhaustion of oil reserves and their production decline on the whole. Accordingly one of most important tasks of oil industry is to introduce measures promoting to increase oil recovery factor [1-4].

In oil field development water-flooding is one of the main bed stimulation methods [5-7]. Conventional water-flood methods proved to be not sufficiently efficient in geologic heterogeneity reservoir sections. Consequently low permeability reservoir zones stay uncovered horizontally. Non-stationary water-flooding permits to involve the stationary reservoir zones and uncovered oil interlayer's in development. In non-stationary water-flooding there may be observed cross-flooding of fluid flow in productive formations and pressure difference between zones. As a result oil recovery ratio increases.

For modeling of Stakhanovskoye oil field there have been used 203 producing and 45 injection wells of Bobrikovsko-Radayevsky horizon and 184 producing and 40 injection wells of Turney stage.

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Table 1: Weightiness coefficient value and variability ratio

	For permeability		For water encroachment		For formation pressure	
	kval	kvar	kval	kvar	kval	kvar
Bobrikovsko-Radayevsky horizon	18,231	70,314	0,138	0,338	0,423	0,198
Turney stage	5,765	75,174	0,25	0,356	0,949	0,153

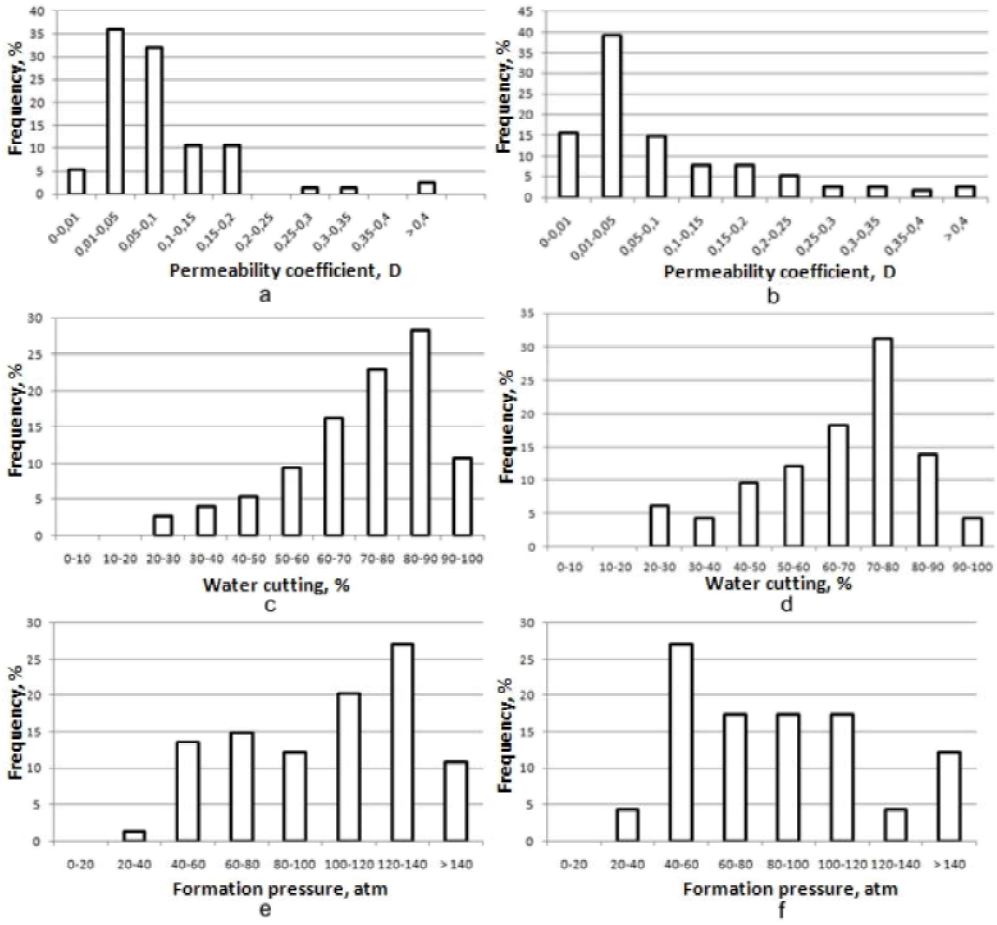

Fig. 1: Value distribution:
a – permeability coefficient in Bobrikovsko-Radayevsky horizon; b - permeability coefficient in Turney stage; c – rate of water encroachment in Bobrikovsko-Radayevsky horizon; d - rate of water encroachment in Turney stage; e – formation pressure coefficient in Bobrikovsko-Radayevsky horizon; f – formation pressure coefficient in Turney stage

To find out geologic-technological characteristics of the facilities examined there have been introduced the weightiness coefficient and variability ratio [8]. Figure 1 demonstrates diagrams of permeability coefficient distribution value, rate of water encroachment and formation pressure coefficient in Bobrikovsko-Radayevsky horizon and Turney stage. Table 1 demonstrates the weightiness coefficient and the variability ratio value of the factors considered.

According to figure 1 and table 1 we can draw next conclusion: weightiness coefficient and permeability change values demonstrate complexity of carbonate reservoir structure; as Stakhanovskoye oil field has been being developed more than 50 years and it is in the latest stage of development water encroachment contains a high weightiness coefficient value; reservoir pressure values demonstrate the oil field to have a good potential for further development.

Table 2: Planned measures

Measure	# well's	Measure	# well's
Lateral drilling	774_2C	Horizontal hole drilling	727_2C
Lateral drilling	753_2C	Lateral drilling	1892_2C
Lateral drilling	1927_2C	Lateral drilling	2033_2C
Lateral drilling	747_2C	Passing from reservoir 1 to reservoir 2. Passing to overlying bed	2045_2C
Lateral drilling	26CTX_2C		

Table 3: Probability dynamics of oil recovery ratio change on introducing recommendations in model study

		ORR						Rate of recovery %		
Oil field	Horizon	Initial	Present for 01.01.2012	Present for 01.01.2013	Increase for 2012	Productive probability at the expense of measures 01.2014-09.2017	% Increase	Present	Probabilistic	Increase
Stakhanovskoye	Bobrikovsko-Radayevsky horizon	0,373	0,304	0,306	0,002	0,003	0,828	2,94	3,93	0,99
Stakhanovskoye	Turney stage	0,303	0,202	0,206	0,004	0,004	2,124	3,93	5,12	1,19
Stakhanovskoye	Field as a whole	0,326	0,237	0,240	0,003	0,03	1,258	3,10	4,02	0,92

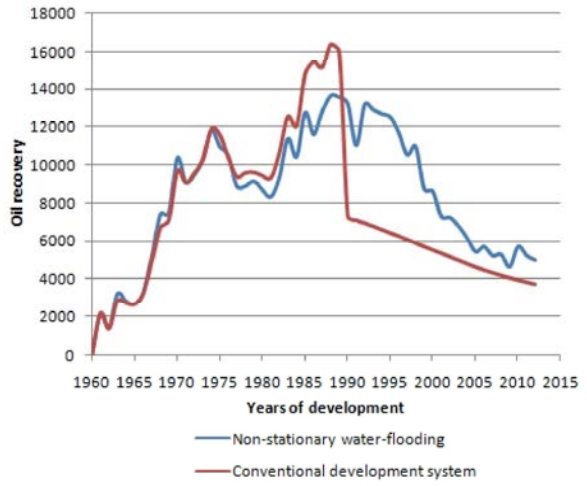

Fig. 2: Comparison of oil recovery rates by non-stationary and conventional flooding system

Then according to the tabular discharge results of the calculation there were determined all the oil recovery ratio changes possible in Bobrikovsko-Radayevsky horizon and Turney stage of Stakhanovskoye oil field. Modeling was done by the PC program product "GiD" module "Proxi-model". That is the simulation models with self-operating batcher of well productivity factor.

The introducers' model study proved that if non-stationary water-flooding [9-10] hadn't been introduced in Stakhanovskoye field oil recovery ratio would have been less by 0,0272 of today. But one should bear in mind that since 1990 there has been introduced conventional flooding system. Figure 2 demonstrates logs characterizing recovery rates by cycling and conventional water-flooding.

The exploration data found out that in sprite of the effectiveness of non-stationary water-flooding employed there is much volume of reservoir oil in Stakhanovskoye oil territory. Consequently, it is expedient to introduce measures in order to increase ultimate oil recovery ratio.

Figure 3 present maps of residual oil reserves in both reservoirs to be explored and regions of work suggested near each well selected. Table 2 demonstrates work modeled and to be planed in Bobrikovsko-Radayevsky horizon and Turney stage.

There have been forecasted possible oil recovery ratio changes based on calculations of oil recovery change, liquid, water encroachment, water injection and formation pressure. All the data are presented in table 3.

According to table 3 introduction measures suggested from January 2014 to September 2017 will make possible to increase oil recovery ratio by 0,004 in Turney stage. That will equal 2,124% of the present ORR, 0,03 in Bobrikovsko-Radayevsky horizon (0,828%) and 0,03 in the oil field entirely (1,258%). That is equal to annual recovery of the whole field.

Rate of recovery will also increase by 0,3 of the value for 2012. In determining the characteristics there was taken into account the average annual change of oil recovery but not for the whole period as in calculating oil recovery ratio.

Thus, modeling of Stakhanovskoye field proved the effectiveness of non-stationary water-flooding employed at the territory. Besides according to the modeling results there have been suggested a number of measures for further development of the field, that will promote to increase essentially the rate of recovery and oil recovery ratio. Effectiveness of measures suggested rationality

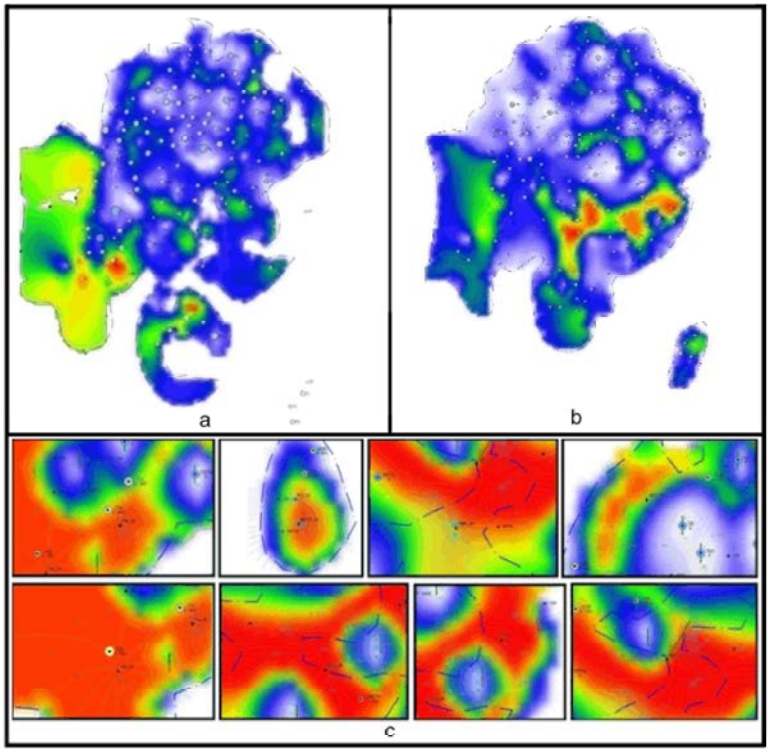

Fig. 3: Logs of residual oil reserves:
a – for Bobrikovsko-Radayevsky horizon; b – for Turney stage; c – region of work at wells selected

has been proved by calculations, demonstrating maximum increase of oil recovery factor providing the methods suggested have been employed. It is the most important factor in oil field development as oil production increase will ensure a high profit. It should be noted that accuracy of calculations and forecast would have been impossible without model study.

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