IMPROVEMENT OF THE DEVELOPMENT EFFICIENCY OF RESERVES DIFFICULT TO RECOVER USING HORIZONTAL AND MULTIBRANCH WELLS ON THE EXAMPLE OF NEKRASOVSKY FIELD DEVELФOPED BY CARBON-OIL LLC

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Abstract. In connection with the growth of oil reserves difficult to recover in the structure of reserves, the task of efficient development is becoming more complicated. The development of carbonate reservoirs having a complex structure and containing heavy oil is caused by the low rates of extraction and values of oil recovery factors. At present, there are no low-cost technologies that ensure high efficiency of development of such fields. The pilot site of the Bashkirian stage drilled with wells of various structure was considered, including the first in the Republic of Tatarstan experience of drilling complexly designed wells with two horizontal boreholes in complex carbonate reservoirs containing heavy oil and selective operation of each borehole using double elevator unit of dual completion. The average characteristics of wells with various designs are compared, and measures for improving efficiency of further exploitation of these wells are given.

Keywords: oil reserves difficult to recover, carbonate reservoirs, horizontal wells, multistage wells
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In connection with the growth of oil reserves difficult to recover in the structure of reserves, the task of efficient development is becoming more complicated. The development of carbonate reservoirs having a complex structure and containing heavy oil is caused by the low rates of extraction and values of oil recovery factors. At present, there are no low-cost technologies that ensure high efficiency of development of such fields. In these conditions, one of the methods of increasing the efficiency of reservoir development is the use of horizontal and multibranch wells. The present paper considers a pilot site where Bashkirian stage of the Nekrasovsky field is being developed, drilled by wells of various designs. It has the first experience in the Republic of Tatarstan of drilling and developing wells of complex construction (with two horizontal boreholes) in complex carbonate reservoirs containing heavy oil and selective operation of each borehole using double elevator unit of dual completion.

Nekrasovsky field of heavy oil is confined to the inner side of the Aksubaevo-Melekess depression of the Republic of Tatarstan. Geologically it refers to the category of complex structures, with a high degree of heterogeneity in the section and along the strike. The main objects of development are carbonate reservoirs of the Bashkirian stage of the Middle Carboniferous, which are characterized by low reservoir properties, weak hydrodynamic connection with aquifer and inter-well zones.

In order to increase the efficiency of field development, a drilling program was developed and implemented by a system of horizontal and multibranch horizontal wells (Fig. 1).

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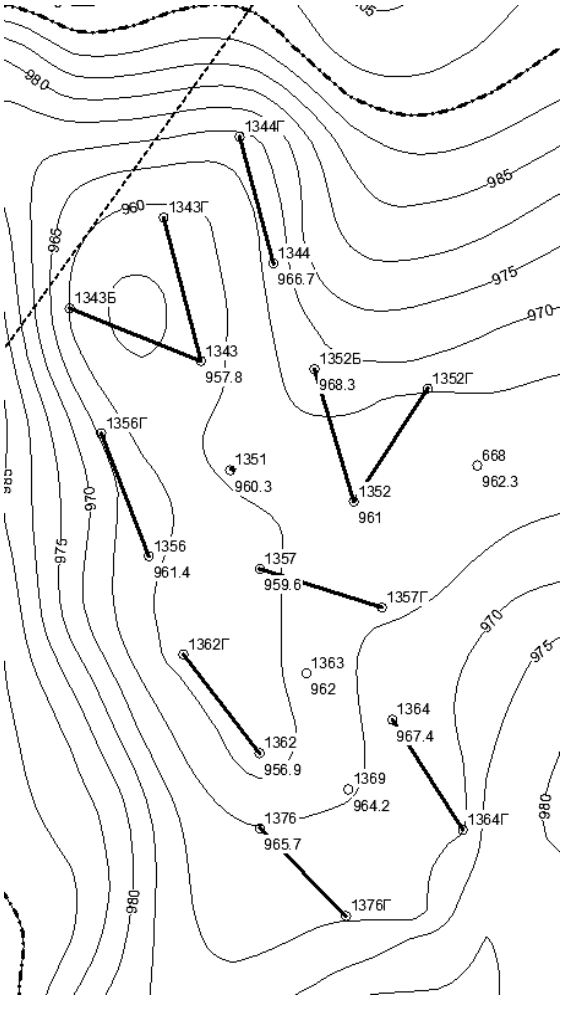

Fig. 1. Fragment from the map of the Bashkirian stage roof in the Menchinsky uplift of the Nekrasovsky field

System development of deposits with horizontal wells requires a certain location of the boreholes in the reservoir. Drilling wells requires drilling of an initial vertical section. Thus, in system development of deposits with horizontal wells, it becomes necessary to connect two independent segments of a straight line (the vertical part of the borehole and the horizontal borehole). In general, the problem is solved in three-dimensional space (Khabibullin, Galikeev, 1992). Among the possible solutions are drilling in two vertical planes (Galikeev, 2000), i.e. when developing deposits with horizontal well systems, the wells become three-dimensional, but most importantly – the opening of productive deposits is not point-like, but linear. The hydrodynamics of the system well – reservoir is drastically changed.

The development of well construction technology and field development should be expected in the distribution of drilling multilateral and multibranch wells (Fig. 2). Conditionally multibranch wells can be attributed to two-dimensional wells in productive sediments (within a single bed), and multilateral wells - to three-dimensional ones (with the location of boreholes in different beds).

Currently, there is a complexity classification of completing and fastening the joints of multilateral wells, which is called TAML (Technology Advancement for Multi-Laterals). The operation method of individual boreholes, and the depletion degree of individual zones of the reservoir are of great interest.

In 2014-2015 at the Nekrasovsky field LLC Carbon Oil drilled 13 wells with horizontal trunks, including

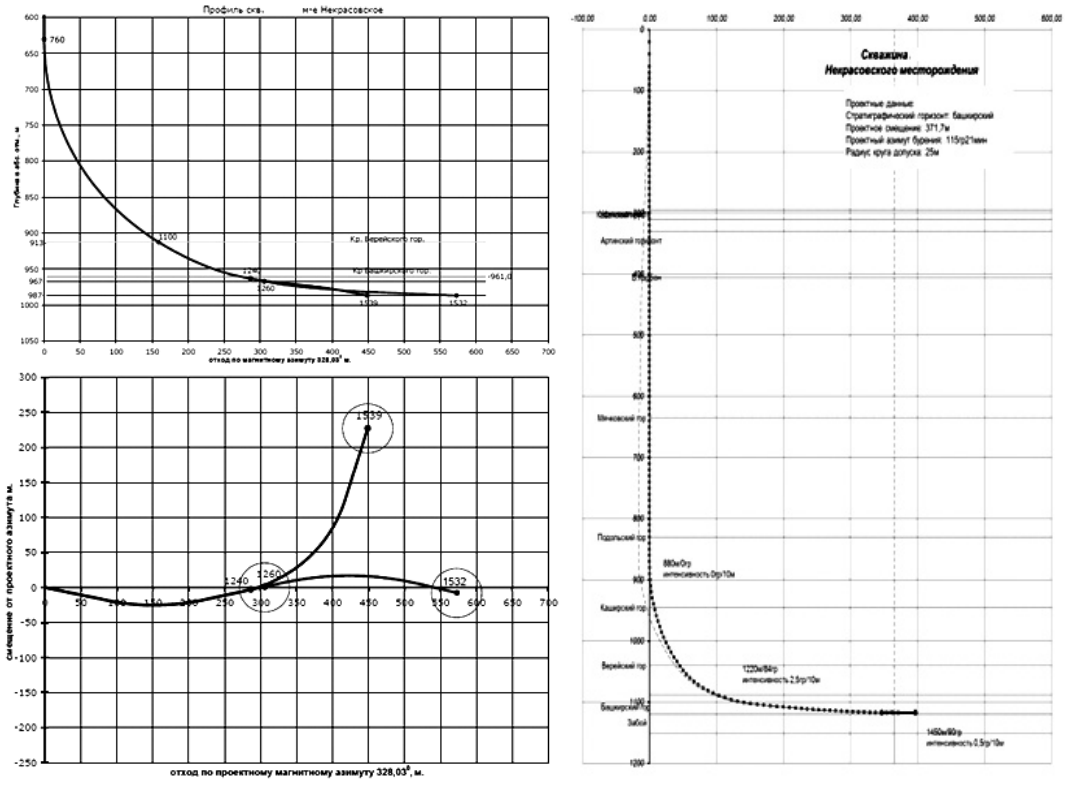

Fig. 2. Wells that were drilled and put into operation at the Menchinsky uplift of the Nekrasovsky field (multibranch horizontal wells, horizontal wells, controlled directional wells)

two with two boreholes, each of which is operated by a separate elevator.

Controlled directional and horizontal wells were drilled with bits of diameter 155.6 mm, 114 mm production columns were run in hole. Multibranch horizontal wells were drilled with bits of diameter 215.9 mm, combined columns 146/168 mm were run in hole, one borehole is cased and not cemented, and the second borehole is open.

It should be noted that only domestic equipment has been used in the construction, development and operation of wells, including deflected wedges (Galikeev, 2000). The development and further operation of each borehole were selective from each other.

For the first time in the two-borehole horizontal well, the equipment of double-elevator construction for dual completion with the separation of boreholes and separate operation of each was introduced (Fig. 3). The problem of separating the two horizontal boreholes by packer consisted in a secure fit of the packer in the interval with an angle of more than 83 degrees. Several options were considered: layout with thrust, rotary axial packers. Calculations of loads on the "head" of the packer gave the result of insufficient weight for securely fit of the packer in the horizontal part of borehole due to weight loss when the tubing string was laid. The issue was solved together with the specialists of the Packer Research & Production Company by fitting a packer with the help of a hydraulic jack that creates an additional 13 tons of weight on packer. After fitting, the working tool was separated by means of a fitting tool from the remaining part of the long elevator column and was raised. Then the pipe pump with the shank and counter part of the tool with the centralizers was run in hole, the remaining part of the column was docked with the packer, the tightness of fitting and docking was checked by swabbing from under the packer on the tubing and tracking the level in the annulus. To operate the open borehole, the tubing pump was run to the tubing.

The advantage of these wells is in increasing the degree of the deposit coverage at a smaller amount of drilling (multibranch horizontal well covers an area of 3 controlled directional wells over the drainage area). Ultimately, it affects on the increase in recovery factor with a reduction in the cost for construction and operation, as well as reducing the impact on the environment. With the help of wells of this design, it is possible to drill a field with a smaller number of wells and ensure a more complete development of the deposit.

To compare the performance of wells of various designs, a 19-month mode of operation was considered. The comparative average parameters of the operation of controlled directional wells, horizontal wells and multibranch horizontal wells are presented in Table 1

The performance of wells in the dynamics is shown in the graphs – Fig. 4-7:

Accumulated oil production (Q_{accum}) in the controlled directional wells for 19 months is in average 1144 tons of

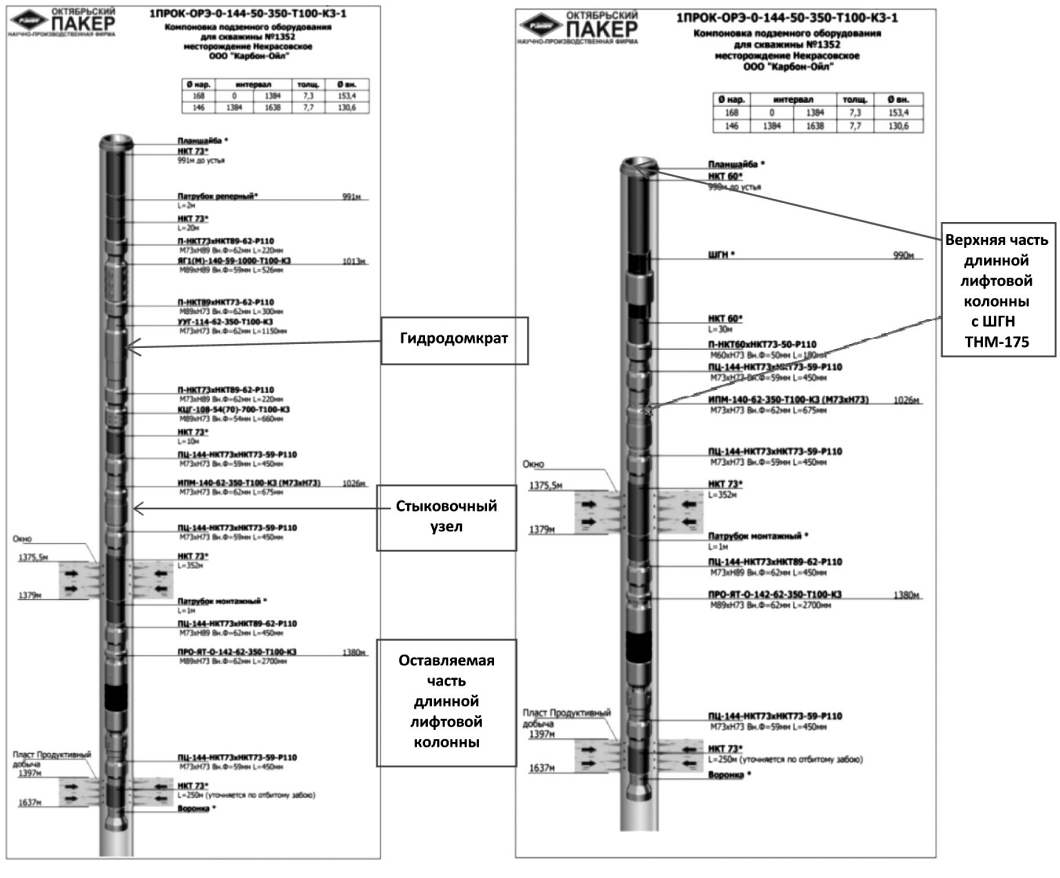

Fig. 3. Scheme for the introduction of double elevator immersed pumping equipment

oil per well; in horizontal wells Qaccum is in average 1.7 times higher and an average of 1906 tons of oil per well; in multibranch horizontal wells Qaccum is in average of 2.2 times higher than that of controlled directional wells and 1.5 times higher than that of horizontal wells and an average of 2,945 tons of oil per well.

The development of heavy oil deposit with horizontal wells makes it possible to shorten the development term of the field due to higher rates of extraction, to increase the rate of extraction from the initial recoverable reserves by 18.7%, from the current recoverable reserves by 20.2% and to improve the economic indicators of the project.

The calculation of technical and economic indicators of drilled wells showed as follows:

- the payback period of the controlled directional wells is 6.9 years, the index of profitability is 1.2;
- the cost of drilling horizontal wells is 24% higher in comparison with the controlled directional wells, payback period of horizontal wells is 4.4 years, the index of profitability is 1.34;
- the cost of drilling the multibranch horizontal wells is twice as high as that of controlled directional wells and 1.65 times that of horizontal wells, while the payback period is 5.7 years, the index of profitability 1.3.

If all types of wells are drilled with the standard bit diameters, the best results of payback and index of profitability are for multibranch horizontal wells.

Analyzing the work of the three patterns of the Menchinsky uplift of the Nekrasovsky field drilled with wells of various designs, it can be concluded that horizontal wells are more effective than controlled directional ones, the use of uncemented shanks in

Type of well/ No. well (Horizontal well), well design	Q_{liquid}, m^3/day		Q_{oil}, t/day		Bottom-hole pressure, atm.		Q_{accum} for 19 months tons of oil	Perforate/Filter part of Horizontal well, filter+trunk of Multibranch horizontal well, m	Botomm-hole treatment by acidic compositions, m^3/Ru
	initial	current	initial	current	initial	current			
Directional wells (average)	5,8	1,2	5,1	1,1	20	21	1144	6,4	3,1 / 65
Horizontal wells (average)	8,4	3,0	7,7	2,7	31	26	1906	231	15 / 60
Multibranch horizontal wells (average)	13,9	4,6	12,7	4,2	30	26	2945	244 / 312	15/50 13/45

Table 1. Average parameters of the operation of controlled directional wells, horizontal wells and multibranch horizontal wells

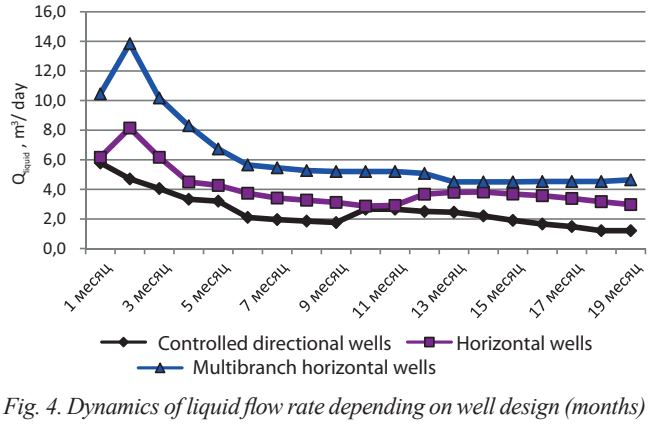

Fig. 4. Dynamics of liquid flow rate depending on well design (months)

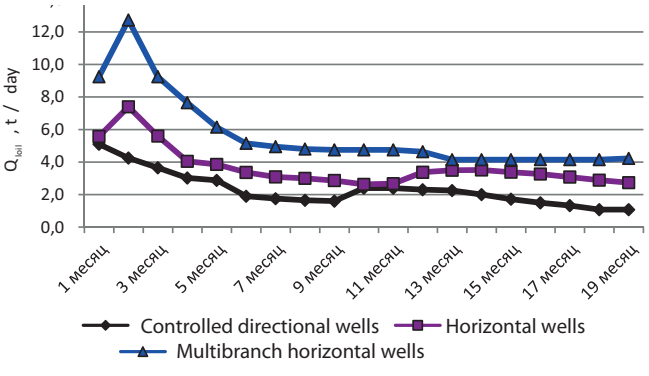

Fig. 5. Dynamics of oil flow rate depending on well design (months)

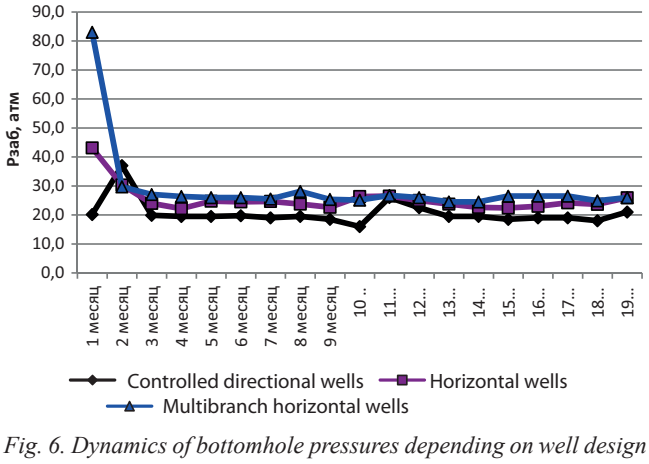

Fig. 6. Dynamics of bottomhole pressures depending on well design (months)

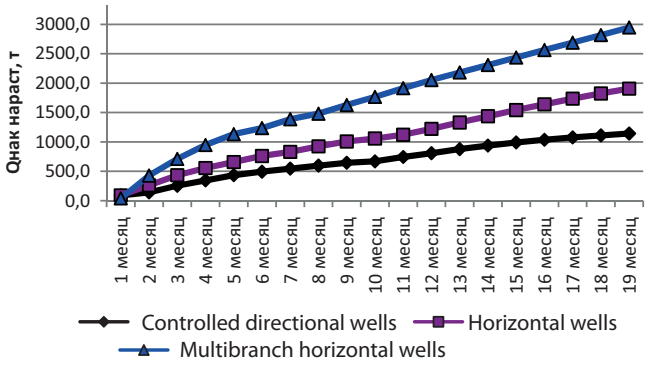

Fig. 7. Accumulated oil production depending on well design (months)

the horizontal well design does not always lead to an increase in initial and current oil production rates and to the growth of accumulated recovery in comparison with the cemented ones; and in some cases on the contrary, cemented endings of horizontal boreholes with conducted intermittent botomm-hole treatment showed great efficiency at production and technical and economic performance. To maintain well flow rates of all the structures considered it is necessary to create waterflooding centers and develop a system of reservoir pressure maintenance, as well as periodic intermittent treatment of wellbores with acidic compositions.

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