

# The Efficiency of Drilling Wells in the Korobkovsky Area of Bavlinsky Field



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**Abstract.** Kizelian horizon of Tournasian in the Bavlinsky field is composed of limestone, the development of which was started in 1976. The block No.6 is the most drilled both by vertical and horizontal wells on the Kizelian area, which accounts for 53% of horizontal wells drilled in the field. In 2002, the Institute TatNIPneft in close collaboration with the geological survey of oil-and-gas production department Bavlyneft proposed a new complex technology for the development of carbonate reservoirs. The technology includes a nine-point areal location of wells with horizontal and vertical trunks and injection well in the center of the element. Drilling of the field is recommended in a certain order – primarily to drill wells for the inter-well pumping of water, and then, after studying the geological features of drillable element, to drill injection wells. According to the drilling results geological structure is studied, structure maps, general and oil-saturated strata maps are constructed. Reservoir capacity, reservoir pressure parameters are measured. Drilling of wells for inter-well pumping of water and injection wells from a single group can reduce the cost of high-pressure water pipelines and pumping of water without cooling it, i.e., to take advantage of the isothermal flooding. Annual growth of oil production in the Kizelian horizon of Korobkovsky area of Bavlinsky oil field has become the result of the technology application.

**Keywords:** oil production, experiment, well, Kizelian horizon.

**DOI:** 10.18599/grs.18.2.7

**For citation:** Podavalov V.B., Yartiev A.F., Morozov P.G. The Efficiency of Drilling Wells in the Korobkovsky Area of Bavlinsky Field. *Geosursy = Georesources*. 2016. V. 18. No. 2. Pp. 111-114. DOI: 10.18599/grs.18.2.7

Kizelian horizon of Bavlinsky field in the Republic of Tatarstan is oil-bearing in the carbonate deposits of Tournasian tier. The roof of the productive horizon is characterized by the best reservoir properties, as compared with the middle and bottom part of Kizelian horizon, composed of solid, weakly oil-saturated rocks. Oil deposit is of massive type. Kizelian horizon of Tournasian tier consists of limestone. Development of this site in Bavlinsky field was started in 1976.

The total thickness of Kizelian horizon averages of 21.4 m, the effective average net pay thickness – 5.8 m, stratification factor – 1.4 unit fraction, gross sand reservoir share – 0.69 unit fraction. Oil is characterized by medium viscosity of 20.8 mPa\*s, density – 872.5 kg/m<sup>3</sup> at reservoir conditions, saturation pressure – 3.3 MPa. According to the content of sulfur oil is sour.

Block number 6 is the most drilled both by vertical and horizontal wells on Kizelian object, which accounts for 53% of horizontal wells drilled at the field (Khisamov et al., 2015).

Fig. 1 shows the development system of Kizelian horizon in Korobkovsky site of Bavlinsky field.

In 2002, the Institute TatNIPneft in close collaboration with the Geological Survey of oil-and-gas department “Bavlyneft” proposed a new complex technology of carbonate reservoirs development.

The technology includes a nine-point areal location system of wells with horizontal and vertical shafts and injection wells in the center of the element. The distance from the injection to the horizontal production well is 450 m, to a vertical corner

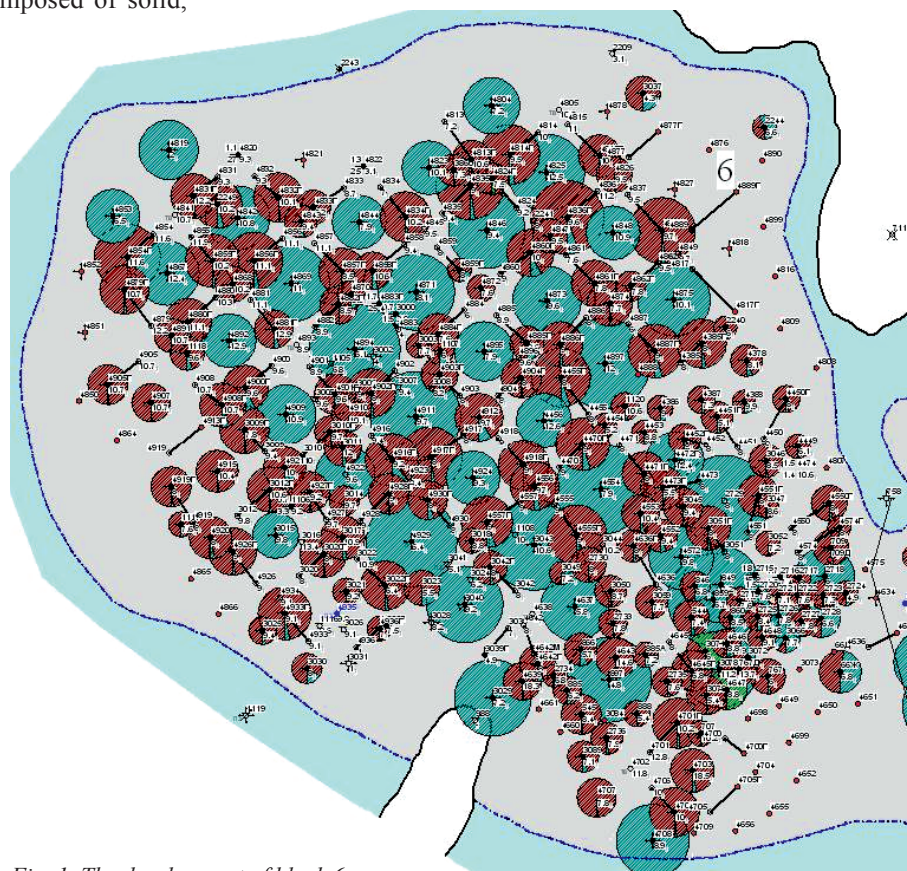


Fig. 1. The development of block 6 of Kizelian horizon in Korobkovsky area of Bavlinsky field.

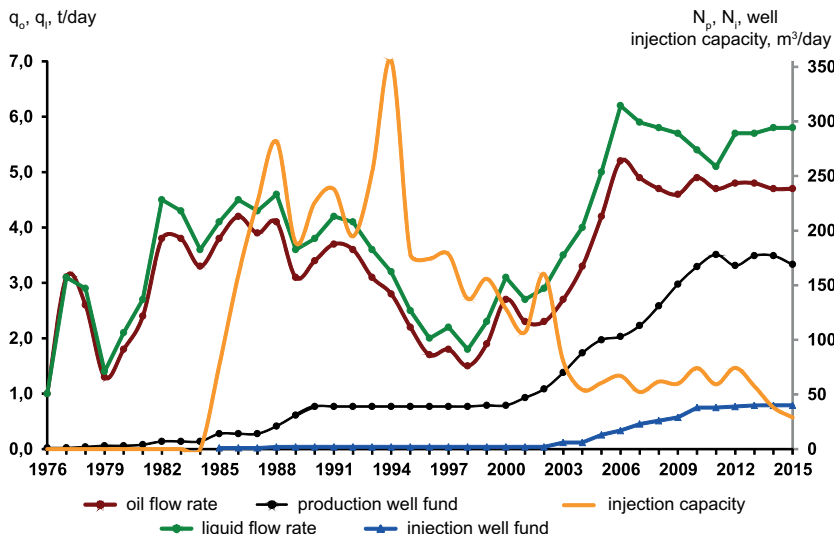


Fig. 2. Dynamics of the major development parameters of block 6 of Kizelian horizon in Korobkovsky area.

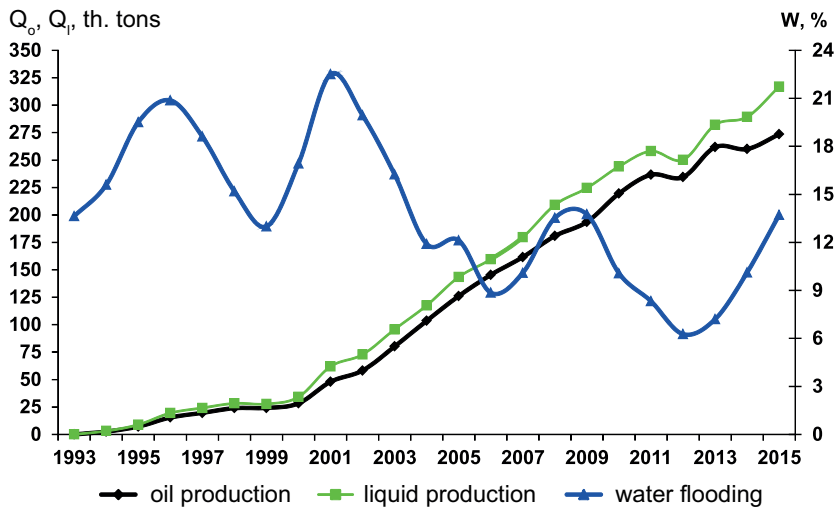


Fig. 3. Dynamics of horizontal well operation in Kizelian horizon of Korobkovsky area.

production well is 635 m. Drilling of deposit is recommended in a certain order: first the drilling of wells is performed for inter-well pumping of water and then, after studying the geological features of drillable element, to drill injection wells. According to the results of drilling, geological structure is studied, structural maps, general and oil-saturated strata maps are built. Measurements are made of reservoir capacity and reservoir pressure (Khisamov et al., 2001).

It is recommended to perform offset vertical profiling in injection wells for fracture studies. Pressure of cracks closure is determined. The required volume of water injection is estimated from the conservation of the initial reservoir pressure after the liquid withdrawal from the reservoir. The bottom part of the formation is perforated in injection wells. Anticipatory cyclic water injection is conducted, thus preparing the formation for oil extraction. Injection of reservoir water as a displacing agent must be alternating (Bakirov et al., 2013).

Drilling of wells for inter-well water pumping and injection wells from one cluster can reduce the cost of the water main pipes of high pressure and pump water without cooling it, i.e. take advantage of the isothermal flooding.

After specification of the geological structure of the drillable element, deviated and horizontal wells are drilled equidistant from injection wells. The horizontal shaft, as well as perforations in the deviated production wells must be carried out in the top part of the reservoir. This ensures a uniform coverage with filtration flow from the bottom up. Withdrawal of well production, as water injection is performed in a cyclic mode.

Development parameters	After the introduction of technology														
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
Production well fund, well	58	70	89	97	102	111	132	150	158	170	168	177	177	172	
including horizontal (put in over year)	3 (2)	8 (5)	14 (6)	23 (9)	27 (4)	37 (10)	46 (9)	57 (11)	65 (8)	71 (6)	71(0)	71(0)	71(0)	71(0)	
Injection well fund, well	2	6	6	14	21	24	25	29	38	38	39	40	40	40	
including horizontal				1	2	2	2	2	2	2	1	1	1	1	
Oil production over year, th. tons	37,4	53,8	83,2	127,8	157,5	174,4	204,0	223,2	249,3	277,2	278,9	285,5	287,5	293,6	
including by horizontal	2,7	11,1	26,5	48,1	66,4	80,6	104,7	121,8	146,0	165,3	169,4	178,4	175,6	181,2	
Liquid production over year, th. tons	45,8	63,9	94,6	140,3	169,9	189,0	225,6	251,5	278,9	306,9	305,5	315,8	326,5	343,6	
including by horizontal	2,9	12,0	28,0	51,5	69,3	84,4	112,2	131,8	155,7	173,7	175,7	189,7	189,4	201,0	
Water flooding over year, %	18,3	15,8	12,1	8,9	7,3	7,7	9,6	11,3	10,6	9,7	8,7	9,6	12	14,6	
Cumulative oil production, th. tons	578,9	632,8	716,2	844,1	1002,1	1175,7	1379,6	1602,8	1852,1	2129,3	2408,2	2693,7	2981,2	3274,8	
including by horizontal	2,7	13,8	40,3	88,4	154,8	235,4	340,1	461,9	607,9	773,2	942,6	1121,0	1296,6	1477,8	
Average flow rate, th. tons:															
- in whole	2,3	2,7	3,3	4,2	5,2	4,9	4,7	4,6	4,9	4,7	4,8	4,8	4,7	5,1	
- by vertical	2,1	2,2	3,2	3,1	3,4	4	3,1	3,2	3,8	3,2	3,3	3,7	3,6	3,7	
- by horizontal	3,8	5,9	6,8	8,3	8,4	8,1	7,7	7,3	7,0	6,8	6,8	8,4	7	7,5	
Water injection over year, th. m³	39,8	31,3	48,1	104,2	147,4	175,5	271,4	279,0	338,3	270,2	348,2	276,5	183,1	72,0	
- sewage	39,8	29,2	37,8	40,8	53,6	58,3	68,3	55,4	72,1	48,4	47,7	50,9	52,5	32,3	
- formation		2,1	10,3	63,4	93,9	117,2	203,1	223,6	266,3	221,8	300,5	225,6	130,6	39,7	

Table 1. Development parameters of Kizelian horizon of Korobkovsky area after the introduction of technology.

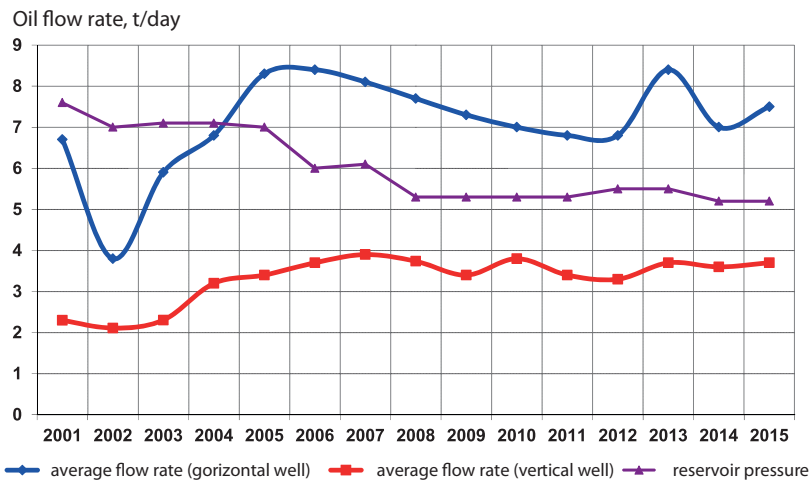


Fig. 4. Dynamics of production rates for vertical and horizontal well in Kizelian horizon of Korobkovsky area.

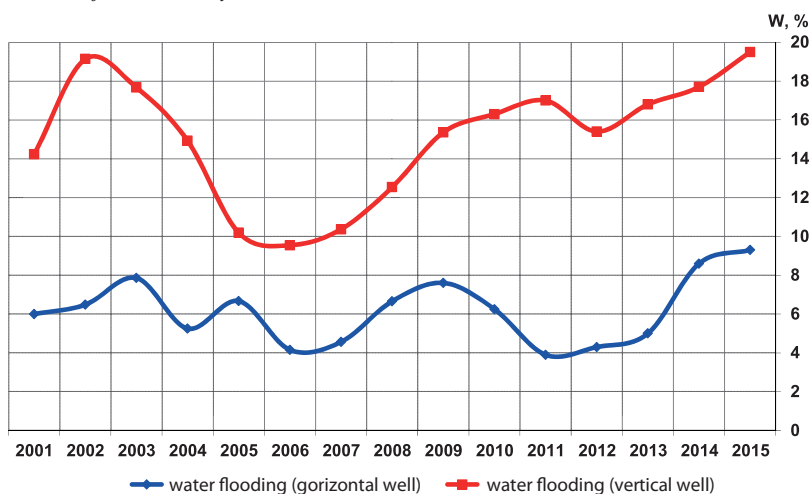


Fig. 5. Dynamics of water cut for vertical and horizontal well in Kizelian horizon of Korobkovsky area.

To increase the rate of oil recovery and enhanced oil recovery, application of subsequent hydrochloric acid treatment is provided with decreasing productivity of wells by diverter technologies. Since 2002, the drilling and operation of Korobkovsky site is made by adopted technology.

The dynamics of main indicators of Kizelian horizon development in Korobkovsky site of Bavlinsky field is shown in Fig. 2-3 since the beginning of commercial operation of an industrial facility.

During the analyzed period (1976-2015), the annual daily average oil production rate and fluid had wave pattern, and since the use of new technology, there has been a tendency to increase. Since the average flow rate increased from 2.3 tons/day in 2002 to 5.1 tons/day in 2015 due to the introduction of new and optimization of existing wells (Fig. 2).

Basic technological parameters of development based on works on the experimental plot since 2002 are given in Table 1.

To date (01.01.2016) there are 172 production wells (71 – horizontal wells) and 40 injection wells (1 – horizontal well), of which 8 are in the permanent operation from the group pumping station (KNS-12), the remaining injection wells are operated from wells that provide technical water in a cyclic mode.

In 2015, the oil production of the object in question amounted to 293.6 thousand tons, the recovery rate of the initial recoverable reserves – 6.9%, 343.6 thousand tons of was produced with water cut of 14.6%. In order to maintain reservoir pressure 72 thousand m<sup>3</sup> of water was pumped.

Figures 4-5 show the dynamics of horizontal and vertical wells after the introduction of technology. Oil flow rates for horizontal wells since 2002 (3.8 tons/day) increased to 7.5 tons/day in 2015. However, it should be noted that the average maximum flow rate (8.4 tons/day) was achieved in 2006 and 2013.

It is not correct to compare the current average production rate of horizontal wells with flow rate of 2001. Thus, well stock in 2001 was only 3 wells, including 2 horizontal wells drilled in 2001, and in 2015 there are 71 horizontal wells in operation.

The average annual production rate of oil by vertical wells increased slightly from 2.2 tons/day in 2002 to 3.7 tons/day in 2015. Maximum annual average production rate was achieved in 2007; it amounted to 4 tons/day.

Water cut in both vertical and horizontal wells did not significantly increase as compared to 2002. In 2015, the water cut of vertical wells was less than 20%, and for horizontal wells it was less than 10%.

The result of the experiment was the annual growth in oil production for Kizelian horizon in Korobkovsky area. 7 horizontal wells are remained to be drilled and put into operation.

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*Manuscript received April 04, 2016*