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Method of Determining the cause of Water Cut Wells

Vladimir Aleksandrovich Lushpeev, Olga Valerievna Tyukavkina and Mikhail Mikhailovich Vasyanovich

Branch of TSOGU in Surgut, Entuziastov str. 38; 628400, Surgut, Russia

Abstract: The main objects of the operation of large oil fields in Western Siberia are in the final stages of development, which is characterized by high water cut wells, the low rate of recovery of oil. The main reason for water cut wells is a breakthrough of water from injection wells and coning in reservoir with bottom water. This paper describes a method of determining the cause water cut wells for understanding under what operating conditions may well prevent premature breakthrough of bottom water and extend the free period of operation.

Key words: Coning . bottom water . production and injection wells . the maximum flow rate

INTRODUCTION

During the operation of oil wells with bottom water a tendency to the interface deformation of two phase is shown, which takes the undulating shape forming cones of water [1]. Under certain conditions of the selection deformed interface are in equilibrium (Fig. 1) and has no significant effect on the flow of production fluid to the well.

Equilibrium is characterized by marginal rates, above which the water breakthrough into the well (Fig. 2) [2]. If the rate of flow does not exceed the limit value, the water breakthrough will occur only when the vertex of the cone get interval of perforation, due to a general raising of OWC [3, 4]. The limiting flow rate depends on the physical properties of layer and fluids and the relative opening of the productive part of layer. In layers with low permeability strata along the implementation of the limit flow rates because of their smallness is not economically profitable [5, 6]. Also operation of wells with the maximum possible flow rate is not profitable, because the water breaks into the well quickly and it starts a united flow of oil and water [7].

Well, stopped because of the high water content can be invoked a second time with the same flow rates of oil. This is due to the fact that after stopping the well, after some time, due to redistribution of pressure and gravity, the cone of water is lowered without changing the residual oil in the drainage area of the well [8].
But the well must meet certain criteria:

- The presence of a sufficient number of recoverable reserves on the block;
- Compensation for block no more than 130%, the field experience shows, that "over pumped" blocks well, running out of the inactivity of oil;

Fig. 1: Cone in a static state

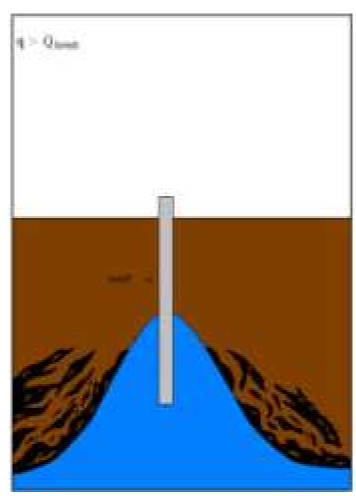

Fig. 2: The static cone broken

Corresponding Author: Lushpeev, Branch of TSOGU in Surgut, Entuziastov str. 38; 628400, Surgut, Russia

- Cone'sstatic broken,that may indicate the advanced roleof cone in watering of well, relative to injection wells;
- Watering of well because of the lifting of the cone of water [9].

The last two criteria are most important, because if you put the well, watering of which was the result of a breakthrough of water from the injection well, we get approximately the same flow rate and the same water content as before stopping [10, 11].

To check compliance with these criteria was selected three wells that were stopped earlier because of high watering. The wells are part of the South Fedorovsk field, divided into 5 blocks.

Well #11. refers to the first unit, which is being developed since 1983. Infill wells were drilled in 1995, the average water content was 86%.

Recoverable reserves are 23%. The unit is characterized by poor reservoir features.

Well #12. refers to the second unit, which is being development since 1981. Infill wells were drilled in 1993-1995. Recoverable reserves are 17.5%. This unite is quite high reservoir properties.

Well #5. refers to the fifth unit, which is being developed since 1979. Infill wells were drilled in 1992-1994. Recoverable reserves are 25%. The unit has poor reservoir properties.

The average current compensation of fluid production is 122% and the cumulative is 119.7%.

Based on the data presented above, one can conclude that all three wells corresponds the recoverable criteria selection and compensation liquid.

The calculations, which will definitely match the last two criteria are presented below.

Limit water-free production rate of an oil well is given by:

$$Q_1 = Q_0 q(\rho_0 \bar{h}) \tag{1}$$

$$Q_0 = \frac{2\pi K h_0}{\mu} \Delta\rho g \tag{2}$$

$$\Delta\rho = \rho_в - \rho_н \tag{3}$$

where:

$q(\rho[rho]_0 \bar{h})$: Dimensionless flow rate limit defined with the graph (Fig. 3);
Q_0: Potential production rate;
K: Permeability;
μ[Mu]: Viscosity;
ρ[rho]$_w$, ρ[rho]$_o$: The density of water, oil;
h_0: Power of the oil-saturated reservoir;

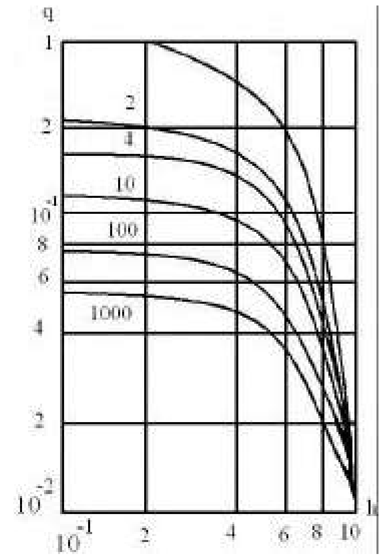

Fig. 3: The dependence of the dimensionless flow rate limit of the relative opening $\bar{h}$ for different values ρ[rho]$_0$ (the numbers on the curves)

$\bar{h}$: For the opening of the oil column, the total thickness of the oil-bearing;
ρ[rho]$_0$: Placement option;
Placement option is determined by the formula:

$$\rho_0 = \frac{R_0}{\chi^* h_0} \tag{4}$$

where:
R_0: Power circuit;
χ[chi]*: Anisotropy factor;
h_0: Power of the oil-saturated reservoir.

The limiting water-free production rate, which violates the static cone and the time at which the water will break through to the well.

Let's define a water-free production rate for the well #11, by formula (1), this first formula (2) define Q_0;

$$Q_0 = \frac{2 * 3{,}14 * 0{,}250 * 10^{-6} * 10}{1{,}4 * 10^{-3}} * 249 * 9{,}8 = \frac{6{,}28 * 0{,}000250 * 10}{1{,}4} * 2440{,}2 = 27\ m^3$$

then the formula (4) determine the placement option wells:

$$\rho_0 = \frac{250}{4 * 10} = 6{,}2;$$

further with the help of the graph (Fig. 3) define a dimensionless flow rate of anhydrous;

$$q(\rho[rho]_0\bar{h}) = 2$$

thereceiveddata into the formula (1);

$$Q_1 = 27 * 2 = 54 \text{ m}^3/\text{day};$$

let's define a water-free production rate for the well #12 for this by (2) we define $Q_{0;}$

$$Q_0 = \frac{2 * 3{,}14 * 0{,}260 * 10^{-6} * 10}{1{,}4 * 10^{-3}} 249 * 9{,}8$$
$$= \frac{6{,}28 * 0{,}000260 * 10}{1{,}4} 2440{,}2$$
$$= 28 \text{ m}^3$$

determine the placement option wells (4);

$$\rho_0 = \frac{250}{4 * 10} = 6{,}2;$$

further with the help of the graph (Fig. 5) determine the dimensionless flow rate of anhydrous;

$$q(\rho[rho]_0\bar{h}) = 2$$

thereceiveddata into the formula (1);

$$Q_1 = 2 * 28 = 56 \text{ m}^3/\text{day}$$

Let's define a water-free production rate for the well #5 for this by (2) we define $Q_{0;}$

$$Q_0 = \frac{2 * 3{,}14 * 0{,}205 * 10^{-6} * 9}{1{,}4 * 10^{-3}} * 249 * 9{,}8$$
$$= \frac{6{,}28 * 0{,}000205 * 9}{1{,}4} * 2440$$
$$= 20 \text{ m}^3$$

let's define a placement option wells (4);

$$\rho_0 = \frac{250}{5 * 9} = 5{,}5;$$

with the graph (Fig. 3) define a dimensionless flow rate of anhydrous;

$$q(\rho[rho]_0\bar{h}) = 2$$

Thereceived data into the formula (1)

$$Q_1 = 2 * 20 = 40 \text{ m}^3/\text{day}$$

The results obtained by limiting water-free production rate are shown in Table 1, where they can be compared with an average flow of the well.

Table 1: Comparison of the calculated limit to the actual flow rate

Well #	Q_{cp} m^3/day	$Q_{\Pi p}$ m^3/day
11	32	54
12	62	56
5	41	40

Average flow rate of wells #12 and #5 was higher than the calculated limit, hence it can be concluded that there was a violation of the static cone. The average production rate of well #11 contrast, was significantly lower than estimated.

Breakthrough time of bottom water is calculated using the formula Masket, it needs to determine the number of selected oil before the cone of water breaks to the well

$$Q = \alpha * m * h_0^3 * \frac{K_г * D}{K_в} \tag{5}$$

where, α[Alfa]: The product of the recovery factor on the block shrinkage ratio of oil;
Oil shrinkage factor is as follows:

$$\upsilon = \frac{b-1}{b} * 100 \tag{6}$$

b: Volume factor;
D: The correction factor is determined by the formula:

$$D = \frac{100(h_0 - d)}{h_0} \tag{7}$$

h_0: Net pay thickness of the reservoir, m;
d: The depth of the opening of the oil-saturated reservoir, m.

Next, determine the time (day) in a breakthrough that will happen to the water hole:

$$T - \frac{Q}{q} \tag{8}$$

where:
Q: The number of selected oil to the water to break through to the well, m^3:
Q: Average production rate, m^3 [4].

We define the well 11 of selected oil before the water breaks through to the well, we use the formula (5), first opredelv shrinkage ratio of oil (6);

$$\upsilon = \frac{1{,}206 - 1}{1{,}206} * 100 = 17{,}08;$$

value of this ratio will be used in the calculation of all the wells.

The product of the block on the recovery factor of oil shrinkage factor of 8.5;

Determine the correction factor D according to the formula (7)

$$D = \frac{100(10-9)}{10} = 10$$

The received data into the formula (5);

$$Q = 8{,}5 * 0{,}24 * 10^3 * \frac{0{,}250 * 10^{-6} * 10}{0{,}200 * 10^{-6}} = 25500\ \mathrm{m}^3$$

To determine the inrush of water to a well use the formula (8). Data on average well production rates in Table 1.

$$T = \frac{25500}{32} = 796\ day$$

The well #12. Determine the volume of the selected oil to water breakthrough.

The product of the block on the recovery factor of oil shrinkage factor is 10.2.

Determine the correction factor D according to the formula (7)

$$D = \frac{100(10-9)}{10} = 10$$

The received data into the formula (5)

$$Q = 10{,}2 * 0{,}24 * 10^3 * \frac{0{,}260 * 10^{-6} * 10}{0{,}190 * 10^{-6}} = 33498\ m^3;$$

determine the breakthrough time of water to the well (8)

$$T = \frac{33498}{62} = 540\ day.$$

The well #5. Determine the volume of the selected oil to water breakthrough. The product of the block on the recovery factor of oil shrinkage factor is 7.6.

Determine the correction factor D according to the formula (7)

$$D = \frac{100(10-9)}{9} = 11{,}1$$

The received data into the formula (5)

$$Q = 7{,}6 * 0{,}24 * 9^3 * \frac{0{,}205 * 10^{-6} * 11{,}1}{0{,}150 * 10^{-6}} = 20160\ m^3$$

determine the breakthrough time of water to the well (8)

Table 2: Estimated and actual time of the break water to a well

Well #	Tday	T_{fact}day
11	796	520
12	540	570
5	491	440

$$T = \frac{20160}{41} = 491\ day$$

The results for water breakthrough time to wells are shown in Table 2, where they can be compared with the actual time over which the well has started to give water.

By calculating the theoretical time of waterless operation well before the appearance of the cone of water, compare it with the actual operation of waterless time. If the actual time of the well waterless more than calculated, the watering was due to the lifting of the cone of water, if less, due to water breakthrough from the injection well.

Field experience shows that if the watering has occurred due to lifting of the cone of water is then preferably selected from the underlying water zone with substantially reduced radius of the supply circuit and break the water injected from the injection wells did not occur.

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