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Training and Prevention Possibilities of Water Coning

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Abstract

For oil reservoir witch has produced in active aquifer displacement mechanism, the water cones proof that the wells are produced with high oil flow rate a long time. High oil cumulatives has to be replaced in a reservoir by high water volumes from aquifer. The ending result of water cons is flooding of wells.

Key words: *water coning, high oil cumulative , perforations*

Introduction

An oil reservoir can be produced by several mechanisms of detente starting with the system rock - fluid and reaching to the gravitational one. When a probe opens a deposit due to pressure drop coat - well, the oil is forced through the pores into the wellbore, and then as appropriate natural or artificial lift to the surface. Some of the oil is produced through various mechanisms such as exit of gas solution, gas from the gas cap expansion or relaxation of the active aquifer.

Given the subject of this article we will treat only the push water regimen.

Underlying permeable porous layers saturated with water usually have a far greater extent than saturated hydrocarbons. Due to the exploitation of oil in a reservoir the pressure falls in the area where the operation is performed so that water penetrates into the reservoir to replace the oil extracted by the expansion of the water stretch. Although this mechanism has the advantage of producing crude oil the gas –oil ratio remains constant as the pressure created by active aquifer is large and the gas is unable to leave the solution. However,this has the disadvantage of forming cones of water. If wells are produced with low flow rates, the pressure difference between the initial pressure and the operation of the pushing water regime is low. But if the probes will be produced with high flow rates, the difference between the initial pressure and the occurrence of the regime pushing water will be high. But there is the advantage that after a period of time, the flow is reduced and the pressure reservoir can increase but only if is fulfilled the condition: the flow of water entering the reservoir is greater than the flow of oil extracted.

If probes are produced with excessive flow rates, regardless of the nature of the aquifer, appear water cones as it tends to replace the oil extracted from pore and the water is entering then the probe through perforations even if the probe perforations is based far superior isobath in contact water-oil.

When the water cone reached the perforations, it tends to become stable, contributing to an increased production of water due to oil relative permeability reduced by increasing water saturation. When water entered the well through perforations, the aquifer energy will not be used to push oil into the wellbore, but because of the aquifer energy, the cone of water will increase and the flow of oil will reach non-economic values, requiring to stop the production in the probe. But it should be specified that water production from these cones cannot be confused with the production of water that appears as a result of advancing water-oil contact, because the water flow increases slightly [4].

Changes in Crude Oil Saturation

It should be noted that a contact oil -water is not a horizontal plane situated at fixed isobath depth but is a transition zone from a saturation in water of 100% up to saturation in water with a lower value. In the next higher water saturation of 100% is an area with a minimum saturation of oil, but a probe that would open this area could produce only water as layer has a relative permeability to oil. It is the residual oil saturation; practically here the oil takes the spherical form of maximum resistance due to interfacial forces. This happens also with water cones.

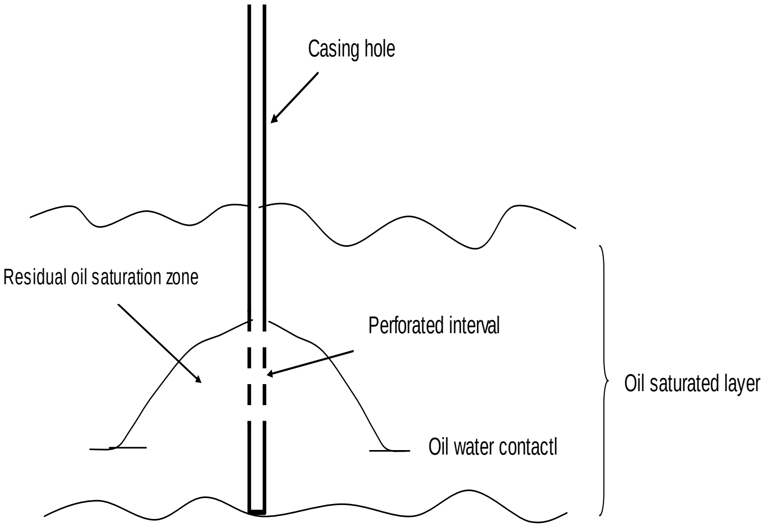

Fig. 1. Scheme of a water coning [1]

In case we have a stratified deposit and the water cones are formed at the lower penetrated layers, there is a possibility for water to flow through perforations into the layers of oil intake, resulting in a decreased oil production by blocking them with water.

In case of vertical production wells, these developments of the water are called cones as have been described above. In case of horizontal production wells, these developments water are called ridges and practically are the result of big pressues failures in the vicinity of the wellbore [2]. The creation of these ridges is difficult to achieve because the pressure drop in the vicinity of the bore hole should be made constant over the entire length of the drain, but considering the fact that a horizontal probe production even produce higher flow rates than vertical wells, however the length of the deposit open along the drain is much greater than in a vertical wells and thus a pressure drop across the full length of the drain is difficult to be performed, it follows that the formation of water ridges is difficult to realise, the basic condition is the drain production work along its entire length so that there is a pressure drop as small as between entry and end of drain, otherwise it can lead to the formation of water cones to flood only a portion of the drain, a difficult thing to repair knowing that the horizontal wells for capital repair works have a high degree of difficulty on the one hand due to steep, on the other hand due to the construction of the well [2].

The following characteristics must be considered:

- Critical flow, which, however, required to be larger than the economic limit capacity;
- The time required to water flooding of the production drain, also called flooding time;
- Providing the possible oil flow to be produced after flooding by plug or drain water crest.

As long as the flow of oil well will be less than the critical flow forming cones of water will be avoided. But if the flow of oil will be equal to or greater than the critical one, the water from the aquifer will tend to move towards perforations where it will reached after a period of time [3].

Critical flow is calculated according to the equation deduced by Muskat, Wyckoff and Chaney [3]:

$$q_c = \frac{0.003073 k_o h^2 \Delta\rho}{B_o \mu_o} q_{cD} \tag{1}$$

where: k_o – relative permeability to oil; h – the thickness of productive layer; $\Delta\rho$ - the difference in density of the two phases, oil and water; q_{cD} – critical flow is introduced into the equation adimesionally; B_o – crude oil volume factor; μ_o – oil viscosity.

Basically the more productive layer thickness is greater, the critical flow rate is higher.

Also, when the water saturation increases, the relative permeability to oil decreases, and clearly the relative permeability to water increases.

A necessary method for preventing water cones is to not perforate the productive layer close to the water- oil contact, but if the history of production of wells located close to water - oil contact is considered inherent the formation of water cones, it is imperative necessary to drill only a small portion of the middle layer, especially when the gas- oil contact is close to perforations. It should be noted that: advancing toward perforations cones water is favoured by a large vertical permeability and low permeability but high on the vertical and horizontal advancement discouraging the formation of cones [5].

Other methods relate to prevention of the water cones progression. Basically they were formed due to over exploitation, but there need to stabilize the cones of water so they do not reach the perforations. This can be done either by surgery for closing a portion of the range pierced and resurgery of the left one, requiring both investment and production downtime, or might start to occur well at a rate less than the critic. But the basic premise here is that the rate of production is higher than the economic limit flow. From the need to obtain high productions, oil saturated multilayers are perforated throughout their entire length, but although the early exploitation of oil flow from these layers are high after certain periods of time these practices are proving to be costly. From a perforated layer can extract only the amount of oil to be recovered with possible operating current method, the variation in length of perforated interval will cause only initial flow and operating period of this layer [1].

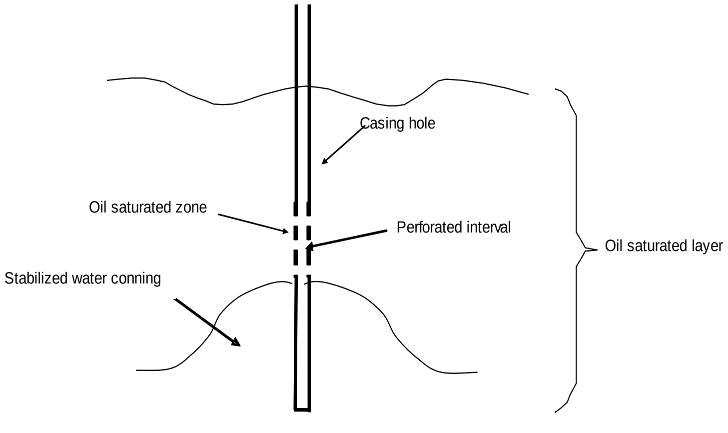

Fig. 2. Scheme of a stabilized cone water [1]

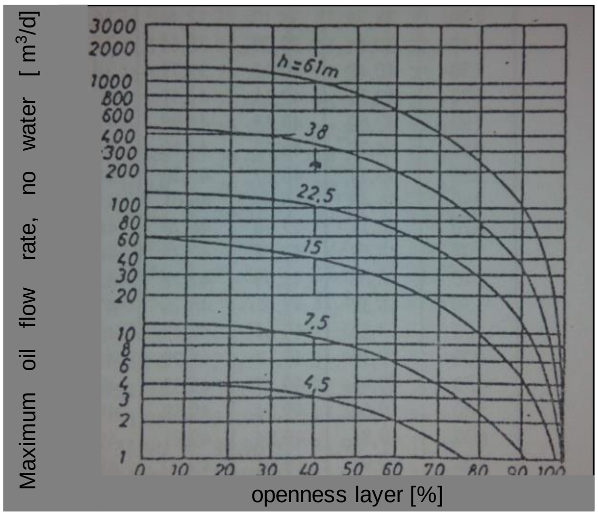

Fig. 3. Flow variation depending on the opening layer [4]

It can use a combined approach of drilling and production part of the productive layer below the critical flow is less attractive at first, but that will prove more economical during the operation.

Critical flow can be also determined by using diagrams prepared by prof. Dr. Eng. Alexandru Soare. Knowing the actual productive layer thickness and percentage in which this layer is opened, it can determine critical flow needed to produce cones probe in order to avoid the formation of water. Having saturated with oil layer thickness given and presented in Table 1 it can be seen: the openness of a layer is higher, the critical flow is lower.

Table 1. Maximum flow that can exploit a probe to avoid water cones.

Layer thickness [m]	Opening degree [%]	Flow [m3/zi]
7.5	15	12
	45	**8**
	75	3
15	25	50
	45	**36**
	65	20
38	20	400
	45	**300**
	70	140

It also can be seen: the actual thickness of the layers increases, the same degree of openness, the maximum flow that can be produced with a layer increases.

Conclusions

The data shows that for a deposit site which is produced in water pushing the regime the critical flow will be established according to certain parameters such as:

- Thickness of productive layer, the bigger the effective thickness is the higher is the critical flow rate.
- If the deposit is hosted by sand poorly consolidated or unconsolidated critical flow values will not lead to lower mechanical particles into the wellbore, which would lead to lower output and sanding wells.
- The higher water saturation increases and decreases relative permeability to oil according to equation 1 and therefore critical flow will decrease (fig. 3).
- The higher the viscosity of the oil is, the smaller will be the critical flow rate. During operation of a reservoir viscosity varies with pressure, it must taking in consideration this variation when designing a process of injection water which wants to increase the pressure reservoir, because when you realize the phenomenon of "filling", ie the pressure reservoir will exceed the saturation pressure, gas will enter the solution and the viscosity of the crude oil flow will decrease and so will critically increase

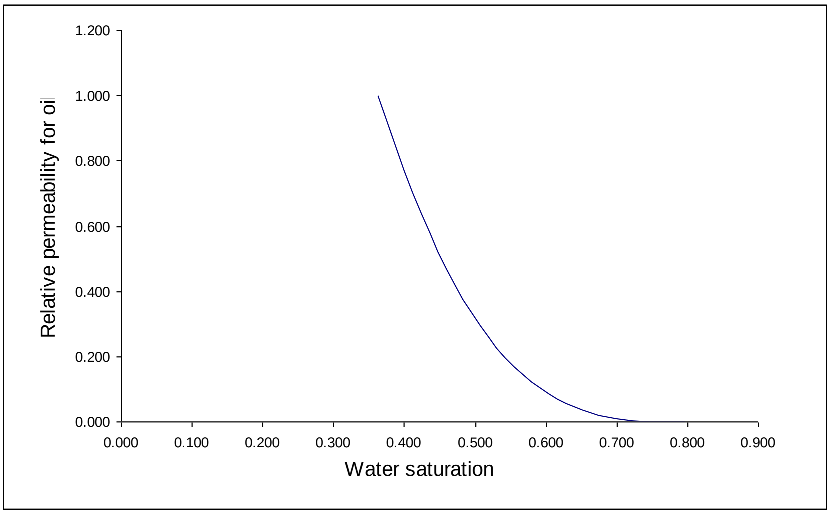

Fig. 4 . Oil relative permeability variation depending on water saturation [3]

It must be pursued the difference between the dynamic pressure at the sole probe and pressure reservoir, whereas a big difference between these two pressures would lead to a flow probe development, which would be favorable to form water cones.

The site experience shows that the critical flow of a well is determined by trial and error until you get to the required operation without mechanical impurities and with no possibility of forming cones of water.

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Posibilitățile de formare şi prevenire a conurilor de apă

Rezumat

În cazul zăcămintelor de țiței produse cu ajutorul mecanismului de dezlocuire al acviferului active, conurile de apă fac dovada exploatarii sondelor cu debite mari perioade indelungate de timp. Cumulativele mari de țiței produs vor fii inlocuite în zăcământ cu volume de apă din acvifer. Rezultatul final al acestor conuri de apă fiind inundarea sondelor.