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HYDRODYNAMIC OIL AND GAS MIXTURE FILTRATION MODELS

Abstract: *In the article horizontal wells are considered in comparison with traditional vertical wells (VS), they have a significantly larger filter surface area, which allows to reduce the filtration resistance and, at the same pressure drop, to provide a higher flow rate. The use of horizontal wells is one of many alternative methods to increase the contact area of the "well-reservoir".*

Key words: *Horizontal, filtration, vertical, alternative methods, multiple.*

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Introduction

Mineral resources problems in the late XX and early XXI centuries are becoming acute global. They are vital for all countries of the world without exception and should be considered on the basis of general economic and political trends that have developed at the present stage. The scientific and technological revolution in the second half of the 20th century led to huge consumption of oil and gas. Currently, the global annual oil and gas production is 3 billion tons and 1.8 trillion, respectively. m3.

The economic potential of states is becoming increasingly dependent on the availability of national energy resources or the possibility of importing them. The governments of many countries, including the Russian one, began to consider ensuring an uninterrupted supply of hydrocarbon raw materials as one of the most important tasks of domestic policy. From the beginning of field development, 12.7 billion tons of oil and condensate and 6.5 trillion were extracted from the bowels of Russia. m3 of gas. However, in recent years there has been a significant decline in oil production. So in 1990, production fell by 53 million tons, in 1991. - over 100 million tons, and in 1992 the decline reached about 200 million tons. This was influenced not only by the economic and technical conditions for the exploitation of oil fields in the main oil producing regions, but also by geological ones. Over the past 20 years, the average reserves of new deposits have decreased by 4 times, the share of large deposits among newly discovered has decreased from 15 to 10%, the reservoir properties of productive deposits and the quality of the fluids saturating them are deteriorating.

Most HSs are used to prevent water and gas cones. The introduction of horizontal drilling in many cases allows us to increase the average production rate of wells at the field by a multiple, and increase the oil recovery rate to 60-80%. It is considered advisable to use gas in the development of offshore fields, in water protection zones, low-power reservoirs, in deposits with extensive water and gas zones, in the development of deposits of heavy, highly viscous oils and bitumen, i.e. where the use of conventional vertical and deviated wells is technologically or economically impractical. All authors note the need for preliminary good knowledge of the object of application for hydraulic wells, which automatically means the use of horizontal wells either in seasoned sufficiently monolithic reservoirs with a high degree of predictability of their development, or at upper geological objects, the structure of which is well studied by transit wells drilled at the lower objects of multilayer development deposits. Another field of application for HC is carbonate reservoirs, which in 80% of cases have a network of mainly vertical and subvertical fractures, and the reservoir properties of which change in many ways randomly and are hardly predictable regardless of the degree of drilling. Due to the higher cost of construction and ongoing maintenance of wells, it is advisable to use rarer grids of horizontal wells compared to vertical ones. HWs are most effective in comparison with aircraft in thin formations and in formations with active plantar waters and a gas cap. Low vertical permeability reduces the effectiveness of the HS; in formations with a high degree of stratification in the presence of aged impermeable interbeds, it is preferable to drill not horizontal but inclined wells, guaranteed to intersect all layers.

Another of the possible directions for the use of hydraulic wells is reservoirs with abnormally high reservoir pressure (AVP). Replacing vertical wells with horizontal wells at these facilities improves the stress state of the rocks along the inflow zone, allowing at the facilities with pressure drop to not exceed the critical differential pressure crushing the production casing.

Statement of the problem of fluid flow to a well with horizontal bores

Consider an oil reservoir consisting of a productive reservoir and bottom water exposed by a horizontal well. We study the hydrodynamic processes occurring in it under various modes of operation of the wells.

The development and widespread introduction of oil production technologies using horizontal wells determines the urgency of the task. Of practical interest is the forecast of the dynamics of multiphase flow in an inhomogeneous formation, which includes the oil-bearing layer and the water-pressure layer as components. The complexity of this task, along with the problems of calculating multiphase filtering processes, is enhanced by the nontriviality of the geometry.

The aim of the work is to develop a mathematical apparatus for modeling the multiphase filtration problem for the geometry of a horizontal well.

Consider a reservoir consisting of a gas cap, an oil reservoir, and bottom water exposed by a horizontal well. It is assumed that the formation is homogeneous boundary impermeable. It is necessary to determine the pressure field, the field of filtration rates, the field of saturations.

For the mathematical description of the above processes, taking into account the set conditions, a multiphase filtering model is suitable [1]. We assume that filtering is significant in the vertical direction, and horizontal filtering occurs mainly in the direction of the 0X axis, i.e. the flow in the direction of the 0Y axis is neglected, introducing the width and other variables as functions of the considered plane coordinate system, the mathematical model of the two-dimensional profile two-phase filtration in the region {0 <x <L1, 0 <z <L2} can be represented as

$$\Delta y\frac{\partial}{\partial t}\rho_\alpha+\frac{\partial}{\partial x}(\rho_\alpha u_\alpha)+\frac{\partial}{\partial z}(\rho_\alpha w_\alpha)=0\,,\ \alpha=\overline{1,3} \qquad (1)$$

Where

$$u_\alpha=-\frac{\Delta y K\, f_\alpha}{\mu_\alpha m S_\alpha}\left(\frac{\partial p}{\partial x}\right),\ w_\alpha=-\frac{\Delta y K\, f_\alpha}{\mu_\alpha m S_\alpha}\left(\frac{\partial p}{\partial z}-\rho_\alpha g\right), \qquad (2)$$

$\rho_{\alpha.}=m\rho_\alpha^0 S_\alpha$, Δy - the width of the filtration area (hereinafter, α = 1 gas phase, α = 2 phase of water, α = 3 phase of oil). Adding obvious equality

$$\sum_{\alpha=1}^{3} S_\alpha=1\,, \qquad (3)$$

and phase equations

$$\rho_\alpha^0=\rho_{\alpha 0}^0\left(1+\beta_\alpha(p-p_0)\right) \qquad (4)$$

Where ρ_α^0 - phase density α at $p=p_0$, p_0 - initial reservoir pressure, β_α - phase compressibility factor α, we obtain a system of partial differential equations that allows us to calculate the desired quantities.

The relative phase permeabilities are determined from the relations

$$k_1=\left(\frac{S_1-0.1}{0.9}\right)^{3.5}\left[1+3(1-S_1)\right],\qquad 0.1\le S_1\le 1\,,$$

$$k_1=0 \qquad 0\le S_1\le 0.1\,,$$

$$k_2=\left(\frac{S_2-0.2}{0.8}\right)^{3.5},\qquad 0.2\le S_2\le 1\,,$$

$$k_2=0,\qquad 0\le S_2\le 0.2\,,$$

$$k_3=\left[\frac{0.85-(S_1+S_2)}{0.85}\right]^{2.8}\left[1+(2.4+16.5S_1)S_2\right],$$

$$0\le S_1+S_2\le 0.85,$$

$$k_3=0,\qquad 0.85\le S_1+S_2\le 1\,, \qquad (5)$$

At the border of the filtration area, the absence of costs is specified

$$\left.\frac{\partial p}{\partial x}\right|_{x=0}=\left.\frac{\partial p}{\partial x}\right|_{x=L_1}=0\,,\ \left.\frac{\partial p}{\partial z}\right|_{z=0}=\left.\frac{\partial p}{\partial z}\right|_{z=L_2}=0\,. \qquad (6)$$

Pressure set at production well

$$p\ (x_0,z_0,0)=p^0(t)\,. \qquad (7)$$

The initial distribution of phase and pressure saturations is also considered to be given.

$$S_\alpha(x,z,0)=S_\alpha^0\,,\ p\ (x,z,0)=p_0\,,\ \alpha=\overline{1,3}\,. \qquad (8)$$

The obtained mathematical model (1-8) allows us to determine the pressure field, velocity field, saturation field and their change in time. That is, it makes it possible to conduct multivariate studies of hydrodynamic processes both in the vicinity of the well and in the remaining areas of the considered element of the reservoir.

Improved hydrodynamic model of oil and gas mixture filtrationin an oil reservoir with horizontal wells.

Traditionally, the development of hydrocarbon deposits is provided by drilling from the surface of the wells. At the same time, a pressure lower than the reservoir pressure is maintained at the bottom of the well. Under the influence of this pressure drop, liquid hydrocarbons move and flow into the well, from where they are extracted to the surface. A significant limiting factor that impedes the movement of fluids in the reservoir is the fact that as you approach the well, the filtration area is significantly reduced, and the filtration rate, accordingly, increases significantly; as a result, the pressure gradient increases significantly. As a result, the largest part of the pressure drop - the main driving force - is spent in the bottomhole zone of the well.

Horizontal wells (GS) in comparison with traditional vertical wells (VS) have a significantly larger filtration surface area, which allows to reduce the filtration resistance and, with the same pressure drop, to ensure a higher flow rate. The use of horizontal wells is one of many alternative methods to increase the contact area of the "well-reservoir".

HWs are most effective in comparison with aircraft in thin formations and in formations with active plantar waters and a gas cap.

Another of the possible directions for the use of hydraulic wells is reservoirs with abnormally high reservoir pressure (AVP). Replacing vertical wells with horizontal wells at these facilities improves the stress state of the rocks along the inflow zone, allowing at the facilities with pressure drop to not exceed the critical differential pressure crushing the production casing.

It is considered advisable to use gas in the development of offshore fields, in water protection zones, low-power reservoirs, in deposits with extensive water and gas zones, in the development of deposits of heavy, high-viscosity oils and bitumen, i.e. where the use of conventional vertical and deviated wells is technologically or economically impractical.

The development and widespread introduction of oil production technologies using horizontal wells determines the urgency of the task. Of practical interest is the prediction of the dynamics of multiphase flow in the formation, which includes gas cap, oil-bearing and water-pressure formations as constituent elements. The complexity of this task, along with the problems of calculating multiphase filtering processes, is enhanced by the nontriviality of the geometry.

The aim of the work is to develop a mathematical apparatus for modeling the multiphase filtration problem for the geometry of a horizontal well.

Consider a reservoir consisting of a gas cap, an oil reservoir, and bottom water exposed by a horizontal well. It is assumed that the formation is homogeneous boundary impermeable. It is necessary to determine the pressure field, the field of filtration rates, the field of saturations.

For the mathematical description of the above processes, taking into account the set conditions, a multiphase filtering model is suitable [1]. We assume that filtering is significant in the vertical direction, and horizontal filtering occurs mainly in the direction of the 0X axis, i.e. the flow in the direction of the 0Y axis is neglected, introducing the width and other variables as functions of the considered plane coordinate system, the mathematical model of the two-dimensional profile two-phase filtration in the region {0 <x <L1, 0 <z <L2} can be represented as

$$\Delta y\frac{\partial}{\partial t}\rho_\alpha+\frac{\partial}{\partial x}(\rho_\alpha u_\alpha)+\frac{\partial}{\partial z}(\rho_\alpha w_\alpha)=0\,,\alpha=\overline{1{,}3} \qquad (9)$$

Where

$$u_\alpha=-\frac{\Delta y K k_\alpha}{\mu_\alpha m S_\alpha}\left(\frac{\partial p}{\partial x}\right),\, w_\alpha=-\frac{\Delta y K k_\alpha}{\mu_\alpha m S_\alpha}\left(\frac{\partial p}{\partial z}-\rho_\alpha g\right), \quad (10)$$

$\rho_{\alpha.}=m\rho_\alpha^0 S_\alpha$, m - porosity ρ_α^0 is the true porosity of phase α, S_α - the saturation of the porous medium with phase α, μ_α the viscosity of the phase α, K - absolute permeability k_α is the relative permeability of phase α, Δy - width of the filtration area, g - acceleration of gravity, (hereinafter = 1 gas phase, α = 2 phase of water, α = 3 phase of oil).

Adding obvious equality

$$\sum_{\alpha=1}^{3} S_\alpha=1\,, \qquad (11)$$

and phase equations

$$\rho_\alpha^0=\rho_{\alpha 0}^0\left(1+\beta_\alpha(p-p_0)\right) \qquad (12)$$

Where $\rho_{\alpha 0}^0$ - phase density α at $p=p_0$, p_0 - initial reservoir pressure, β_α - phase compressibility factor α, we obtain a system of partial differential equations that allows us to calculate the desired quantities.

The relative phase permeabilities are determined from the relations

$$k_1=\left(\frac{S_1-0.1}{0.9}\right)^{3.5}\left[1+3(1-S_1)\right], \qquad 0.1\le S_1\le 1\,,$$

$$\mathrm{k}_1=0 \qquad 0\le S_1\le 0.1\,,$$

$$k_2=\left(\frac{S_2-0.2}{0.8}\right)^{3.5}, \qquad 0.2\le S_2\le 1\,,$$

$$k_2=0, \qquad 0\le S_2\le 0.2\,,$$

$$\mathrm{k}_3=\left[\frac{0.85-(S_1+S_2)}{0.85}\right]^{2.8}\left[1+(2.4+16.5S_1)S_2\right],$$

$0\le S_1+S_2\le 0.85$,

$$k_3 = 0, \qquad 0.85 \le S_1 + S_2 \le 1, \qquad (13)$$

At the border of the filtration area, the absence of costs is specified

$$\left.\frac{\partial p}{\partial x}\right|_{x=0} = \left.\frac{\partial p}{\partial x}\right|_{x=L_1} = 0, \quad \left.\frac{\partial p}{\partial z}\right|_{z=0} = \left.\frac{\partial p}{\partial z}\right|_{z=L_2} = 0. \qquad (14)$$

Pressure set at production well

$$p\left(x_0(t), z_0(t), t\right) = p^0(t) \qquad (15)$$

Where $x_0(t), z_0(t)$ - coordinates of the production well.

The initial distribution of phase and pressure saturations is also considered to be given.

$$S_\alpha(x,z,0) = S_\alpha^0, \; p\left(x,z,0\right) = p_0, \alpha = \overline{1,3}. \qquad (16)$$

The obtained mathematical model (9-16) allows us to determine the pressure field, velocity field, saturation field and their change in time. That is, it makes it possible to conduct multivariate studies of hydrodynamic processes both in the vicinity of the well and in the remaining areas of the reservoir under consideration.

Conclusion

Traditionally, the development of hydrocarbon deposits is provided by drilling from the surface of the wells. At the same time, a pressure lower than the reservoir pressure is maintained at the bottom of the well. Under the influence of this pressure drop, liquid hydrocarbons move and flow into the well, from where they are extracted to the surface. A significant limiting factor that impedes the movement of fluids in the reservoir is the fact that as you approach the well, the filtration area is significantly reduced, and the filtration rate, accordingly, increases significantly; as a result, the pressure gradient increases significantly. As a result, the largest part of the pressure drop - the main driving force - is spent in the bottomhole zone of the well. Most HSs are used to prevent water and gas cones. The introduction of horizontal drilling in many cases allows us to increase the average production rate of wells at the field by a multiple, and increase the oil recovery rate to 60-80%.

References:

1. Rosenberg, M.D., & Kundin, S.A. (1976). *Multiphase multicomponent filtration during oil and gas production*. (p.335). Moscow: Nedra.
2. Basniev, K.S. (1986). *Development of natural gas fields containing non-hydrocarbon components*. (p.208). Moscow: Nedra.
3. Kniazeff, V.I., & Naville, S.A. (1975). Two-phase flow of volatile hydrocarbons. *Soc. Petrol. Eng. J.*, No. 1, 37-44.
4. Nigmatullin, R.I. (1987). *Dynamics of multiphase media*, part 1. (p.464). Moscow: Science.
5. Tikhonov, A.N., & Samarsky, A.A. (n.d.). On homogeneous difference schemes. *ZhVM and MF*, 19.1, N 1, pp. 12-21.
6. Samarsky, A.A. (n.d.). Local-one-dimensional difference schemes for multidimensional equations of hyperbolic type in an arbitrary region. *ZhVM and VM*, 19,4, N 4, pp. 7-13.
7. Yanenko, N.N. (n.d.). *The method of fractional steps for solving multidimensional problems of mathematical physics.* (p.129). Novosibirsk, Nauka, 19.7.
8. Abramov, Yu.S., Danilov, V.L., & Katz, R.M. (1974). Spatial two-phase filtration to imperfect wells in an oil reservoir. I*zv. USSR Academy of Sciences, MZHG*, N3, pp. 27-33.
9. Konovalov, A.N. (1970). On the numerical solution of multidimensional filtration problems of a two-dimensional incompressible fluid. *Izv. SB USSR Academy of Sciences, Technique Series*, N 8, no. 2, pp. 28-37.
10. Rachford, H.H. (n.d.). Numerical calenlation of immiscible displacement by a moviny reference paint method. *Sa.Petrol.End.I.N* ,, 19,8, p. 20-25.
11. Snuder, G.I. (n.d.). Two2pahk reservuar flow colenlation. *Soc. End. J.* 19.9, pp.107-115.
12. Taranchuk, B.V., & Miracles, L.A. (1974). A numerical method for solving some problems of planar two-phase filtration in a region with 2 wells. V sb. *Number met. fur. continuous media, N.*, v. 5, N 4, pp. 90-108.
13. Cassulli, V., & Qrunspam, P. (1972). Nunerical solution of missitle and immisceble fluid flams in porous media. *SPEJ*, N22, v.5, pp.35-44.
14. Mrosovsky, G. (n.d.). TWO dimensional radial treatment of wells within a three dimensional reserwoir model. *SPEI of AIME*, p. 59-98.