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MODELING OF WATER REGULATION IN WELLS WITH WATERED PRODUCTION IN HETEROGENEOUS OIL FORMATIONS

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ABSTRACT

At a certain stage of oil and gas production, by increasing the efficiency of regulating water volumes in wells with water-cut production, it is possible to reduce water cut and increase current oil recovery. When developing oil fields, in order to maintain reservoir pressure and increase the oil recovery factor, water or various additives are pumped into the objects.

During some stages of oil field development, various types of water (including water injected into the reservoir and external water filtered from the top) enter highly permeable areas and reach the production wells, and the amount of water in their products increases. In this regard, the main problem is the isolation of water entering the well by maintaining oil production.

The presented work describes the development of nanostructured gels that easily penetrate into the water-saturated depth of the formation in flooded wells, effectively blocking culverts, without changing the phase permeability of oil, mathematical modeling of the process, and analysis of the results.

QEYRİ-BIRCİNS NEFT LAYLARINDA MƏHSULU SULAŞMIŞ QUYULARDA SUYUN TƏNZİMLƏNMƏSİNİN MODELLƏŞDİRİLMƏSİ

XÜLASƏ

Neftqazçıxarmanın müəyyən mərhələsində məhsulu sulaşmış quyuların suyunun tənzimlənmə effektivliyini artırmaqla, quyu məhsulunun sulaşmasının aşağı salınması və cari neftvermənin artırılması mümkündür. Neft yataqlarının işlənməsi zamanı lay təzyiqinin saxlanılması və layların neftverməəmsalının artırılması məqsədi ilə obyektlərə su və ya onun müxtəlif əlavələri vurulur.

Neft yataqlarin işlənməsinin bəzi mərhələsində müxtəlif tip sular (o cümlədən, laya vurulan su və yuxari hissədən süzülən kənar su) yüksək keçiricilikli sahələrə daxil olaraq istismar quyularına çatır və onun məhsulunda suyun miqdarı artır. Bununla əlaqədar olaraq neftə görə hasilatın saxlanması şərti hesabına quyuya daxil olan suyun təcrid edilməsi əsas problem kimi mühüm aktuallıq kəsb edir.

Təqdim olunan işdə məhsulu sulaşmış quyularda layın su ilə doymuş dərinliyinə asanlıqla daxil olan, su buraxan kanalları effektiv şəkildə bağlayan, neftə görə faza keçiriciliyini dəyişməyən nanostrukturlu gellərin işlənməsi və prosesin riyazi modelləşdirilməsi, nəticələrin analizi verilmişdir.

Açar sözlər: *metal nanohissəcik, maye şüşə, riyazi model, təcrid, təzyiq, doyma, konsentrasiya*

МОДЕЛИРОВАНИЕ РЕГУЛИРОВАНИЯ ВОДЫ В СКВАЖИНАХ С ОБВОДНЕННОЙПРОДУКЦИЕЙ В НЕОДНОРОДНЫХ НЕФТЯНЫХ ПЛАСТАХ

РЕЗЮМЕ

На определенном этапе добычи нефти и газа,повышая эффективность регулирования воды в скважинах собводненной продукцией,можно добиться снижения обводненности и увеличения текущей нефтеотдачи. При разработке нефтяных месторожденийс целью поддержания пластового давления и повышения коэффициента нефтеотдачи пластов в объекты закачивают воду или различные ее добавки.

В некоторых этапах разработки нефтяных месторождений различные виды вод (в том числе вода, закачиваемая в пласт, и внешняя вода, отфильтрованная из верхней части) попадают в высокопроницаемые участки и достигают добывающих скважин, а количество воды в их продуктах увеличивается. В связи с этим основной проблемой является изоляция входящей в скважину воды за счет поддержания добычи по нефти.

В представленной работе даются разработка наноструктурированных гелей, легко проникающих в водонасыщению глубину пласта в обводненных скважинах, эффективно перекрывающих водопропускные каналы, не изменяющих фазовую проницаемость по нефти, математическое моделирование процесса, анализ результатов.

Ключевые слова: *наночастица металла, жидкое стекло, математическая модель, коэффициент изоляции, давление, насыщение, концентрация.*

INTRODUCTION

One of the most important issues of the modern stage of development of the oil and gas extraction industry is the issue of increasing oil and gas production. By increasing the oil yield in non-homogeneous formations, the rapid advance of injected water occurs and causes dilution of the extracted products.

There are a number of methods for preventing premature waterlogging of production wells: physico-chemical methods of creating a barrier to prevent water ingress; hydrodynamic methods calculated to create minimal impact on the well's optimal operating mode and the wetted parts of the productive horizon.

In this regard, the problem of limiting water flow is highlighted. To solve this problem, tamponade solutions, sediment forming solutions, gels, wetting modifiers, etc. There are quite a number of methods that allow solving using [1,2].

For this, various tamponage (adhesive) materials, including emulsion composition, polymer systems, cement mixtures, and gel-forming compounds are introduced into the wetted zone of oil wells.

A comprehensive analysis of the mentioned technologies was carried out, their capabilities were evaluated and their shortcomings were clarified. It was determined that one of the most promising methods of selective isolation of water flow is isolation with a composition based on alkaline silicate gel. Silicate gel formed by the interaction of silicate sodium and carbon agent is the best raw material for water flow isolation. Regardless of the size and geometry of the porous medium, it easily penetrates into the water-saturated depth of the formation and effectively closes the water-releasing channels. The study of the physico-chemical properties of the compositions based on silicate gels allowed to identify the optimal composition for filtration processes and the possibility of increasing the strength of the gel and the resistance to disintegration against water pressure by adding metal nanoparticles to it with a mass fraction of 0.05-0.07% was substantiated [3].

In addition, a mathematical model can be built to prevent the flow of water, and the problem can be solved. In order to solve the mentioned problem, many works have been devoted to the mathematical modeling of the process [4,5]. Despite the conducted research, the problems of prevention of fluidization of the formation and isolation of gels remain unsolved.

From this point of view, the establishment of a mathematical model that can take into account the real conditions and the evaluation of the isolation ability of gels based on it is of both scientific and practical importance.

RESEARCH METHOD

In the presented work, the two-dimensional problem of displacement of oil by water in a non-homogeneous layer is considered. Production and percussive wells are working in the formation. The outer boundaries of the layer are assumed to be impassable. The amount of water injected into the shock wells is given, while the volume of oil and water is predicted in the production wells.

The process of displacement of oil with water and subsequent isolation of the water flow is mathematically modeled with the help of the oil and water filtration equations, the balance equation of the gel distribution in the formation, which provides water isolation in the general flow, and the equilibrium equation:

$$\frac{\partial ms}{\partial t} + div\,(\frac{kf_w(s,c)}{\mu_w(p,c)} grad\ p_w) = Q_w(t)\delta(x,\ y) \qquad (1)$$

$$\frac{\partial m(1-s)}{\partial t} + div(\frac{kf_o(s,c)}{\mu_o(p,c)} grad\ p_o) = Q_o(t)\delta(x,\ y), \qquad (2)$$

$$\frac{\partial}{\partial t}\left[msc + m(1-s)\phi(c) + a(s,c)\right] + div(c\frac{kf_w(s,c)}{\mu_w(p,c)} grad\ p_w +$$

$$+\phi(c)\frac{kf_o(s,c)}{\mu_o(p,c)} grad\ p_o) = (cQ_w(t) + \phi(c)Q_o(t))\delta(x,\ y),$$

$$c(x,y,t) = \begin{cases} 0, t < T \text{until isolation} \\ c_*(x,y,t), t \geq T \quad \text{after isolation,} \end{cases} \qquad (3)$$

$$p_o - p_w = p_k(s,c), \qquad (4)$$

Initial and boundary conditions

$$s(x,y,t)\big|_{t=0} = s_0(x,y), \qquad (0 \le x \le l_x;\ 0 \le y \le l_y),$$

$$(5)$$

$$c(x,y,t)\big|_{t=0} = c_0(x,y), \qquad (0 \le x \le l_x;\ 0 \le y \le l_y),$$

$$\frac{\partial p_w}{\partial x}\Big|_{x=0,l_x} = 0, \qquad 0 \le y \le l_y,$$

$$\frac{\partial p_o}{\partial x}\Big|_{x=0,l_x} = 0, \qquad 0 \le y \le l_y,$$

$$\frac{\partial c}{\partial x}\Big|_{x=0,l_x} = 0, \qquad 0 \le y \le l_y,$$

$$\frac{\partial p_w}{\partial y}\Big|_{y=0,l_y} = 0, \quad 0 \le x \le l_x,$$

$$\frac{\partial p_o}{\partial y}\Big|_{y=0,l_y} = 0, \quad 0 \le x \le l_x, \qquad (6)$$

$$\frac{\partial c}{\partial y}\Big|_{y=0,l_y} = 0, \quad 0 \le x \le l_x$$

here, t -time; T - the time from the start of water injection to the entry of water into the operational well; x and y - spatial coordinates; m - porosity; s -saturation with water; c and $\varphi(c)$ - gel volume concentrations in water and oil phases; $a(s,c)$ - amount of gel absorbed per unit volume of porous medium; (x, y) - coordinates of wells; $Q_w(t)$, $Q_o(t)$ - - volume consumption of water pumped from the injection well and extracted oil; k_i - coefficient of absolute permeability of the porous medium; $f_w(s,c)$ and $f_o(s,c)$ - relative phase conductivities of water and oil phases in the environment; $\mu_w(p,c)$, $\mu_o(p,c)$ - viscosities of water and oil; p_w, p_o - pressures of water and oil phases; $p_k(s,c)$ -capillary pressure; l_x and l_y -are the length and width of the layer, respectively.

The system of equations (1)-(4) of the filtration model is solved within the conditions (5), (6), and with the help of numerical calculation methods and the Maple program, the unknown quantities s - water saturation, c - gel concentration in the water phase, and p_w - pressure of the water phase are found .

Thus,

$$s_w = \frac{\int_0^{t_o} Q_o(t)dt}{\pi(R^2 - r_c^2)h_1 m_0}, \qquad (7)$$

$$Q_o(t) = Q_0 \cdot e^{-\alpha t},$$

$$\phi(c) = c/2, \qquad (8)$$

$$p_w(t_o) = p_o(t_o) + Q_o(t_o)\frac{\mu_o h_2 (s_w)^2}{\pi R_w^2 k_2 (1-s_w)^2} \qquad (9)$$

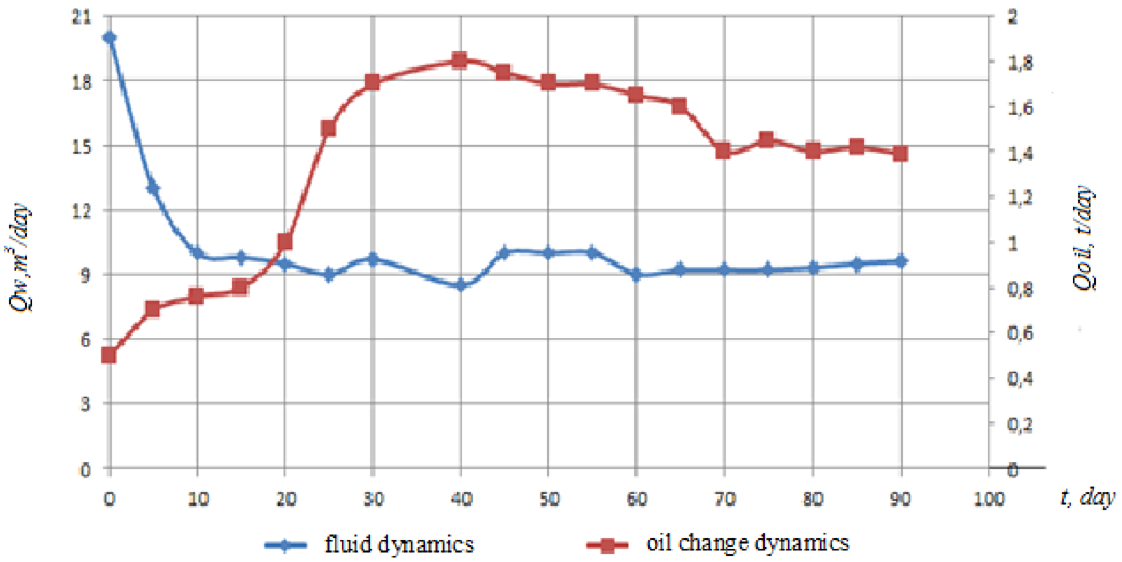
From the following values of reservoir parameters and also from the properties of fluids

$$k_1 = 0.05\cdot 10^{-12} - 10^{-12} m^2;$$

$$k_2 = 0.05\cdot 10^{-12} - 10^{-12} m^2;\ s_0(x,y) = 0.2;\ c_0(x,y) = 0;\ a(s,c) = 0; \qquad (10)$$

$$\mu_o = 3\cdot 10^{-9} MPa\cdot s, \quad \mu_w = 1\cdot 10^{-9} MPa\cdot s$$

calculations were made taking into account formulas (7)-(9) and a graph was constructed based on the obtained results.



Graph. After the selective isolation of the production well from water change in flow rate of fluid and oil

CONCLUSION

After the adaptation of the hydrodynamic model to the drainage area, the possibility of increasing the current oil yield by adjusting the technological process was predicted. The calculation result of the isolation process is presented in the graph above. In Gafik, after the selective isolation of the production well from water, the dynamics of flow depending on the working time of liquid and oil are shown. When the well is put into operation after isolation from water, the production due to oil increases sharply in the initial moments.

The proposed calculation model allows to choose the capillary phenomena in the isolation of the water flow, the degree of isolation and the depth of penetration of the isolation agent, the most optimal moment of action, the necessary degree of isolation (residual resistance factor). The degree of isolation of the water flow significantly affects the efficiency of the process, and by adjusting the degree of isolation, a significant increase in oil recovery is ensured at any stage of reservoir development. As the penetration depth of the isolation agent increases, high isolation efficiency is achieved.

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