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Review Article

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Physical Method Development for İncreasing EOR the Performances Wells

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ABSTRACT

The article notes that more than 65% of the world's hydrocarbon reserves are difficult to master, information is given on the effectiveness indicators of various methods used to obtain residual resources, and a new method is proposed. For the first time in the world, the effect of nonlinear resonances in the productive layer is achieved by creating mechanical movements in the anchor of an electromagnetic device fed from a three-phase network reduced to the productive layer, which directly leads to a change in the conductivity of the layer.

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Introduction

Despite the fact that the consumption of petroleum products in the world is growing every year, the efficiency of modern industrial extraction of oil from fields in all oil-producing countries is considered unsatisfactory. After a certain period of time, the wells pass into a stage characterized by significant watering, which leads to a decrease in production. Since more than 65% of the worlds hydrocarbon reserves are difficult to master, the extraction of these reserves is considered one of the pressing issues of the day [1,2]. At the initial stage in newly commissioned working wells, the natural energy of the reservoir is maximally used for oil production. With a sharp decrease in formation pressure in wells, the following occurs [1-4]:

- Decrease in production of hydrocarbon reserves by more than 30% on average;
- İncrease in the fund of closed, that is, unused wells;
- İncrease in the number of deposits with hard-to-master resources;
- İncrease in the cost of hydrocarbon production;
- Reduction of the average debit of production

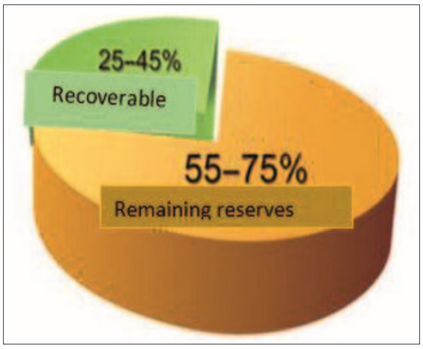

Figure 1: Intervals of Primary and Residual Resources

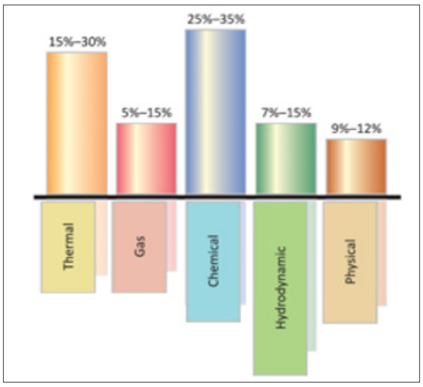

Figure 2: Efficiency İndicators of the Applied Methods

In all regions of the world rich in hydrocarbons, the percentage of utilization of available resources in reserve by traditional methods is 25-45% (Figure 1) [2,3]. Various methods are applied for the purpose of obtaining residual resources. The fact that the percentage rates of its consumed resources are variable in a large range depends on the indicators of the lay product.

In order to increase the efficiency of the development of deposits, various technologies are applied, which mainly include: methods of thermal impact on the layer, methods of impact on the layer with gases , methods of chemical impact on the layer, methods of hydrodynamic impact on the layer, methods of physical impact on the layer. Interest in methods of increasing production is growing every year, and research on the development of the most efficient technologies for oil extraction in old fields is being developed all over the world [2,3].

The efficiency percentages of the methods used to contribute residual resources to consumption are shown in Figure 2 [2]. There are many methods of physical impact on the productive layer, and one of them is the method of increasing oil production due to the creation of mechanical waves in productive layers.

Problem statement

The proposed technology consists in the use of a device that generates mechanical waves equal to the natural frequency of productive layers in hydrocarbon deposits. The wave of mechanical oscillations generated by this device changes the permeability of the reservoir by creating a mechanical resonance phenomenon in the productive layer and leads to an increase in well production.

Three-phase electromagnetic exciter, which is a source of small-frequency mechanical oscillations, a producer of mechanical oscillations with an amplitude of (1-20) mm, operating in the frequency range (0.1-10) hs [5]. These oscillations are converted into waves, transmitted over long distances in the productive layer of the well and directly affect the production by changing it conductivity.

Figure 3: General View of the Device
a. Control Unit b. Three-Phase Electromacnetic Vibro Exciter

The device is lowered into the well bottom (fiq.4) of the well-productive layer hidrodinamical system, which is fed by cable from a three-phase electrical network with a frequency of 50 Hz, creating mechanical oscillations with a polygarmonic composition in the producter layer spase.

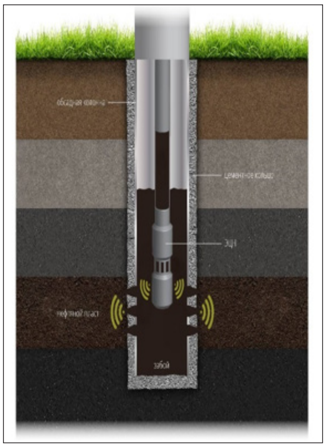

Figure 4: General View of the İnstallation

By changing the parameters of these oscillations using a control device located on the surface of the earth (a in Figure 3), the formation of a set of nonlinear resonances in the layers is achieved.

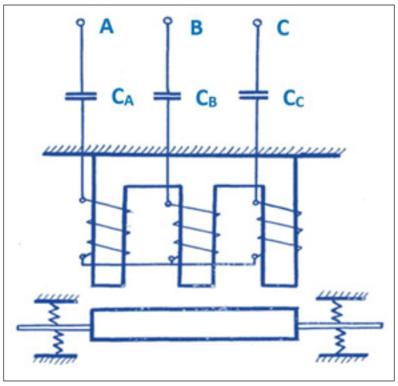

Figure 5 a: Three-Phase Electromagnetic Exciter prinsipial schem

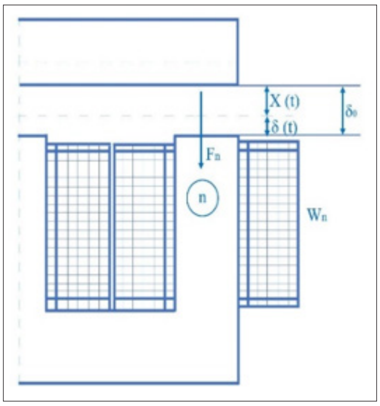

Figure 5 b: Cross-Section of the Three-Phase Electromagnetic Exciter

Realisation and Results

The principle scheme of a three-phase electromagnetic exciter generating small-frequency mechanical oscillations is shown in figure 5a and the cross-section of this device is shown in figure 5b [5,6,7]. The equations of the electrical circuit voltages changing of this unit are expressed by formulas (1) as follows [5]:

$$U_A = i_A r_A + \frac{1}{C_A}\int i_A dt + W_A \frac{d}{dt}(\Phi_A)$$

$$U_B = i_B r_B + \frac{1}{C_B}\int i_B dt + W_B \frac{d}{dt}(\Phi_B) \qquad (1)$$

$$U_C = i_C r_C + \frac{1}{C_C}\int i_C dt + W_C \frac{d}{dt}(\Phi_C)$$

Where: $U_{A(B.C)}$ - phase voltages corresponding to phases A, B and C;

$r_A = r_B = r_C = r$ - active resistances of windings

located in phases A, B and C;

$C_A = C_B = C_C = C$ - electrical capacitors located in phases A, B

and C;

$W_A = W_B = W_C = W$- number of turns of windings corresponding

to phases;

$\Phi_{A(B.C)}$- phases A, B and C are magnetic torrents in the

corresponding magnetic circuits.

The mechanical oscillations of the exciter the find is expressed by the following equation (2) [5]:

$$m\frac{d^2x}{dt^2} + r_{mex}\frac{dx}{dt} + \frac{1}{\lambda}x = F_\Sigma \qquad (2)$$

In this equation: m- the generalized mass set in motion by the anchor;

r_{mex} — friction resistance;

$\frac{1}{\lambda}$ — stiffness of the spring;

x- is the mechanical displaysment movement of the anchor of the exciter..

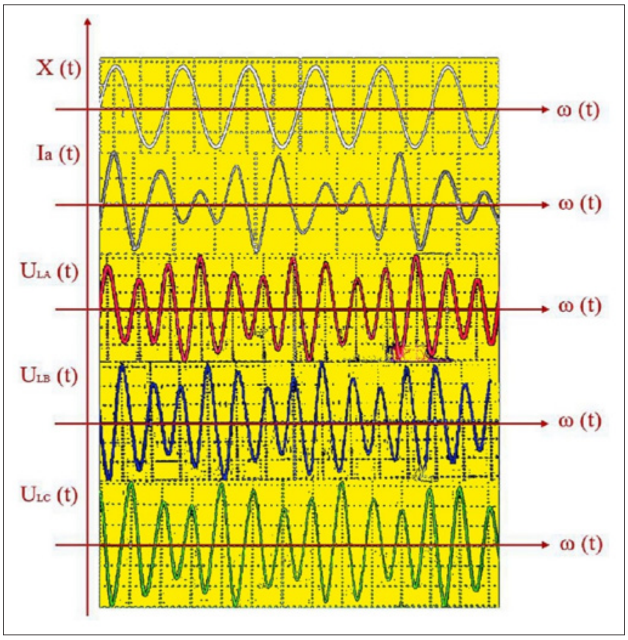

Figure 6: Oscillograms of the main Parameters of the Device

The traction force created at the anchor by the a three-phase electromagnetic exciter for the purpose of creating waves acting on the productive layers is determined as follows [5,8]:

$$F_{\Sigma} = F_{\Sigma}(t) = h\left[\Phi^2_{\Sigma_A}(t) + \Phi^2_{\Sigma_B}(t) + \Phi^2_{\Sigma_C}(t)\right] \quad (3)$$

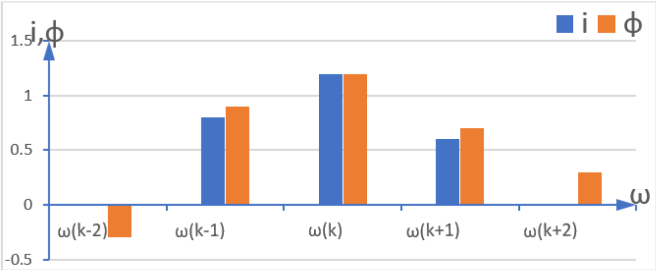

Figure 7: Additional Harmonics Formed by the Current and Magnetic Torrents of the Exciter

When the vibro exciter is fed from a three-phase electrical network, a phase winding in the electrical circuit (Figure 5a) and an electric capacitor connected in series with it, respectively, create a resonance of voltages in its circuit (Figure 6) [5,6,7]. Mechanical motion arising in the system of inssalation including of electrical, magnetic and mechanical (spring) circuits in the exciter leads to the formation of neighboring harmonics with a frequency as different as the frequency of mechanical motion depennding on electrical and magnetic parameters (Figure 7) [5, 9].

The tensile force generated at the anchor of the electromagnetic exciter is determined by means of equation (3), and in that equation at least two adjacent harmonics of the magnetic torrents must be taken into account, which translates equation (3) to (4):

$$\frac{1}{h}F_{\Sigma}(t) = \begin{bmatrix} \Phi_{(\kappa-1)_m} \cdot sin\left(\omega_{(k-1)} \cdot t + \alpha_{(k-1)}\right) + \Phi_{(\kappa)_m} \cdot sin\left(\omega_{(k)} \cdot t + \alpha_{(k)}\right) + \\ + \Phi_{(\kappa+1)_m} \cdot sin\left(\omega_{(k+1)} \cdot t + \alpha_{(k+1)}\right) \end{bmatrix}^2$$

$$+ \begin{bmatrix} \Phi_{(\kappa-1)_m} \cdot sin\left(\omega_{(k-1)} \cdot t + \alpha_{(k-1)} - 120^0\right) + \Phi_{(\kappa)_m} \cdot sin\left(\omega_{(k)} \cdot t + \alpha_{(k)} - 120^0\right) \\ + \Phi_{(\kappa+1)_m} \cdot sin\left(\omega_{(k+1)} \cdot t + \alpha_{(k+1)} - 120^0\right) \end{bmatrix}^2$$

$$+ \begin{bmatrix} \Phi_{(\kappa-1)_m} \cdot sin\left(\omega_{(k-1)} \cdot t + \alpha_{(k-1)} - 240^0\right) + \Phi_{(\kappa)_m} \cdot sin\left(\omega_{(k)} \cdot t + \alpha_{(k)} - 240^0\right) \\ + \Phi_{(\kappa+1)_m} \cdot sin\left(\omega_{(k+1)} \cdot t + \alpha_{(k+1)} - 240^0\right) \end{bmatrix}^2$$

On the basis of these:

$$\frac{1}{h}F_{\Sigma}(t) = \frac{3}{2}\Phi^2_{(k-1)_m} + \frac{3}{2}\Phi^2_{(k)_m} + \frac{3}{2}\Phi^2_{(k+1)_m} +$$

$$+3\Phi_{(\kappa)_m} \cdot \Phi_{(\kappa-1)_m} \cdot cos\left[\left(\omega_{(k)} - \omega_{(k-1)}\right)t + \left(\alpha_{(k)} - \alpha_{(k-1)}\right)\right] +$$

$$+3\Phi_{(\kappa+1)_m} \cdot \Phi_{(\kappa)_m} \cdot cos\left[\left(\omega_{(k+1)} - \omega_{(k)}\right)t + \left(\alpha_{(k+1)} - \alpha_{(k)}\right)\right] +$$

$$+3\Phi_{(\kappa+1)_m} \cdot \Phi_{(\kappa-1)_m} \cdot cos\left[\left(\omega_{(k+1)} - \omega_{(k-1)}\right)t + \left(\alpha_{(k+1)} - \alpha_{(k-1)}\right)\right] \quad (4)$$

From the obtained equation (4), we see that the traction force created at the anchor of the electromagnetic exciter for the purpose of creating waves acting on the productive layer space is expressed in the form of an algebraic sum of constant and variable quantities [5]. This parameter is the traction force that stimulates mechanical waves, being polyharmonic, consisting of harmonics with different frequencies and amplitudes, and these harmonics give rise to a set of nonlinear mechanical resonances with different frequencies [10].

Conclusion

- The emergence of these processes on the productive layer spase serves to change the permeability of the layer and increase production.
- The creation of mechanical resonance phenomena in several wells located at a certain distance at the same time leads to an increase in oil production (10-15%) in most of the produchive wells located in this area.
- The developed method is used for the first time, being considered as a method of physical impact on the productive layer space. Unlike other methods, the physical impact in this case is carried out in a short period of time (2-3 days) and is technically efficient, since the lift pipes do not need to be lifted to the surface of the earth.

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