*UDC 532.546*

**Study of well pressure at pulsatıng values of ınıtıal pressure**

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Abstract. Pulsations are generated by the generator at the values of the initial pressure applied to the well. Depending on these pulsations, the well pressure and the resulting oil production also change. In this issue, changes in well pressure and oil production are studied.

Keywords: reservoir-wells, Laplace transform, fluid movement, gas movement, continuity equation, initial pressure values

## 1. Introduction

In order to increase the permeability and productivity of oil production, pulsations are created in the values of wellhead pressure and initial pressure. The elastic waves generated by the generator help to clean the pores of the formation from blockages and gas bags, while increasing the permeability of the formation and oil refining. When penetrating to the depth of the formation, it can release the energy stored under the influence of the rocks inside, and activates the previously located parts of the oil, thereby increasing the extraction of oil from the formation. In addition, by moving in the pores of the rock, elastic waves change the nature of the pressure distribution in the layer and increase its permeability [1,2-6,7].

## 2. Statement and solution of the problem

The pulsations in the pressure values of the well vary with the following regularities. [8]

By generating pulsations through the generator, the value of the initial pressure of the well changes with the following regularities.

$$P_0(t) = \Delta P_{01} + \frac{\Delta P_0}{2} - \frac{4\Delta P_0}{\pi^2}\sum_{m=1}^{n}\frac{\cos\left((2m-1)\frac{\pi t}{T}\right)}{(2m-1)^2}, \quad (1)$$

$$P_0(t) = \Delta P_{01} + \frac{2\Delta P_0}{3} - 3\Delta P_0\sum_{m=1}^{n}\frac{\cos\left(2\pi m\frac{t}{T}\right)}{\pi^2 m^2} + \frac{\Delta P_0}{\pi}\sum_{m=1}^{n}\frac{3\cos\left(2\pi m\frac{t}{T}\right)\left(\cos\left(\frac{2\pi m}{3}\right)+\cos\left(\frac{4\pi m}{3}\right)\right)}{2\pi m^2}, \quad (2)$$

$$P_0(t) = \Delta P_{01} + \frac{2\Delta P_0}{\pi} - \frac{4\Delta P_0}{\pi}\sum_{m=1}^{n}\frac{\cos\left(2\pi m\frac{t}{T}\right)}{4m^2-1}, \quad (3)$$

$$P_0(t) = \Delta P_{01} + \frac{\Delta P_0}{2} - \frac{\Delta P_0}{\pi}\sum_{m=1}^{n}\frac{\sin\left(2\pi m\frac{t}{T}\right)}{m} \quad (4)$$

$r_T = 3\cdot 10^{-2}\,м$; $a = 10^{-1}c^{-1}$; $\mu = 10^{-3}\,Pa\cdot c$; $h = 10\,м$; $k = 10^{-13}\,м^2$; $\rho_{liq} = 4\cdot 10^2\ кг/м^3$;

$l = 2000\ м$; $\chi = 0.17\frac{m^2}{c}$; $P_c(0) = 1{,}2\cdot 10^7\ Па$ ;

$\Delta P_{01} = 11\cdot 10^6$ Па ; $P_{wellhead}(0) = 1\cdot 10^6\ Па$ ; $P_k = 1{,}4\cdot 10^7\ Па$ ; $P_{атм} = 10^5\ Па$; $R_k = 100\ м$;

$\pi = 3{,}14$; $C = 1000\ м/c$ ; $g = 10\,m/c^2$

$r_c = 7.5\cdot 10^{-2}\ м$ , $B(x_\nu) = 0.114$ ; $b_\nu = 0{,}0002048$ ; $Q_{gaz}(0) = 1407{,}724120\ kg/see$ ;

$Q_{mix}(0) = 1407{,}72571\ kg/\sec$ ; $Q_{fil}(0) = 0{,}0015921741\ 0kg/\sec$ .

## 3. Calculation of well pressure

According to reports in the literature, the well pressure was found as follows [9-15].

$$\overline{P}_c = 2\pi h\rho_{liq}\frac{k}{\mu}\frac{1}{\ln\left(\frac{R_k}{r_c}\right)}\cdot\frac{\Delta P_{cy}^2}{\Delta P_{c1}}(s+2a)(s+b_v)((s+a)^2+\omega_i^2)\cdot\frac{1}{s\psi(s)}-$$

$$-4\pi h\frac{k}{\mu}\rho_{liq}B_v\left(x_v\frac{r_c}{R_k}\right)\cdot\Delta P_{cy}\frac{(s+2a)((s+a)^2+\omega_i^2)}{\psi(s)}+$$

$$+2\pi h\rho_{liq}\frac{k}{\mu}P_c(0)\cdot\frac{1}{\ln\left(\frac{R_k}{r_c}\right)}\cdot\frac{\Delta P_{cy}}{\Delta P_{c1}}(s+2a)(s+b_v)((s+a)^2+\omega_i^2)\cdot\frac{1}{s\psi(s)}-$$

$$-4\pi h\frac{k}{\mu}\rho_{liq}B_v\left(x_v\frac{R_k}{r_c}\right)\cdot P_c(0)\frac{(s+2a)((s+a)^2+\omega_i^2)}{\psi(s)}+$$

$$+\frac{f_k}{l}\cdot(s+b_v)\cdot((s+a)^2+\omega_i^2)\cdot\frac{\overline{P_0}}{s\psi(s)}+\frac{f_k}{l}\cdot i\pi\cdot(s+b_v)\frac{1}{\psi(s)}\cdot\left[s\varphi_i(0)+\dot{\varphi}_i(0)+\right.$$

$$\left.+2a\varphi_i(0)-\frac{2}{\pi}(sP_c(0)+\dot{P}_c(0))+\frac{4}{\pi}P_c(0)-\frac{2}{\pi}\overline{\ddot{P}_0}-\frac{4a}{\pi}\overline{\dot{P}_0}\right]+$$

$$+\frac{f_kQ_{qaz}(0)(s+b_v)((s+a)^2+\omega_i^2)}{\psi(s)}+\frac{f_t\overline{P}_{wealhead}(t)(s+b_v)((s+a)^2+\omega_i^2)}{l\cdot\psi(s)}+$$

$$+\frac{f_t\pi(s+b_v)}{l\cdot\psi(s)}\cdot\left[s\varphi_{i1}(0)+\dot{\varphi}_{1i}(0)+2a\varphi_{1i}(0)-\frac{2}{\pi}\overline{\ddot{P}}_{yct}-\right.$$

$$\left.-\frac{4}{i\pi}\overline{\dot{P}}_{wealhead}+\frac{2}{\pi}(sP_c(0)+\dot{P}_c(0)+\frac{4a}{\pi}P_c(0)\right]-\frac{f_tQ_{mix}(0)(s+b_v)((s+a)^2+\omega_i^2)}{\psi(s)} \quad (5)$$

Where

$$\psi(s)=F(s)\cdot\left[(s+a)^2+\omega_i^2\right]+2\frac{f_k}{l}(s+b_v)+4a\frac{f_k}{l}(s+b_v)s+$$

$$+2\frac{f_t}{l}(s+b_v)s^2+4a\frac{f_t}{l}(s+b_v)s$$

,

$$F(s)=2\pi h\rho_{liq}\frac{k}{\mu}\frac{1}{\ln\left(\frac{R_k}{r_c}\right)}\cdot\frac{\Delta P_{cy}}{\Delta P_{c1}}(s+2a)(s+b_v)-4\pi h\frac{k}{\mu}\rho_{liq}B_v\left(x_v\frac{R_k}{r_c}\right)\cdot s\cdot(s+2a)+$$

$$+\frac{f_k}{l}(s+b_v)+\frac{f_t}{l}(s+b_v)$$

$Q_{mix}(0)$ and $Q_{gaz}(0)$ found in the following expressions

$$Q_{mix}(0)=Q_{gaz}(0)+\frac{\rho_{liq}Q_{fil}(0)}{2\pi r_c h}, \quad Q_{fil}(0)=2\pi h\frac{k}{\mu}\frac{P_k-P_c(0)}{\ln\frac{R_k}{r_c}}$$

$$Q_{gaz}(0)=\frac{P_0(0)\cdot\exp(g\frac{\rho_{am}}{P_{am}}l)-P_c(0)}{\exp(g\frac{\rho_{am}}{P_{am}}l)-1}\frac{\rho_{am}g}{2aP_{am}}$$

We return the original by writing the given parameters and the (1) value of $P_0$ in the expression of $\overline{P}_c$.

Then we get the mathematical expression for the well pressure.

$$\begin{aligned}P_c&=1{,}20000095\cdot10^{7}-0{,}101659082\sin(0{,}5233333333\,t)-1{,}20287618\cos(0{,}5233333333\,t)+\\&+6{,}564371819\cdot10^{-86}(-4{,}288471004\cdot10^{83}-1{,}571997176\cdot10^{80}\cos(0{,}5233333333\,t))\cdot\\&e^{-0{,}000204537607t}+1{,}471082102\cdot10^{-134}(1{,}814216776\cdot10^{11}(-9{,}806749185\cdot10^{123}+\\&+7{,}73937399\cdot10^{122}\cos(0{,}5233333333\,t))\cos(0{,}9071083878\,t)+(2{,}649328293\cdot10^{135}-\\&-1{,}618013171\cdot10^{135}\cos(0{,}5233333333\,t))\sin(0{,}9071083878\,t))e^{-0{,}0376446970t}+\\&+5{,}923393961\cdot10^{-63}(1{,}122404995\cdot10^{65}-6{,}629550319\cdot10^{64}\cos(0{,}5233333333\,t))e^{-29{,}69372812t}\end{aligned} \quad (6)$$

The time dependence graph of the mathematical expression of pressure (6) is given in Figure 1.

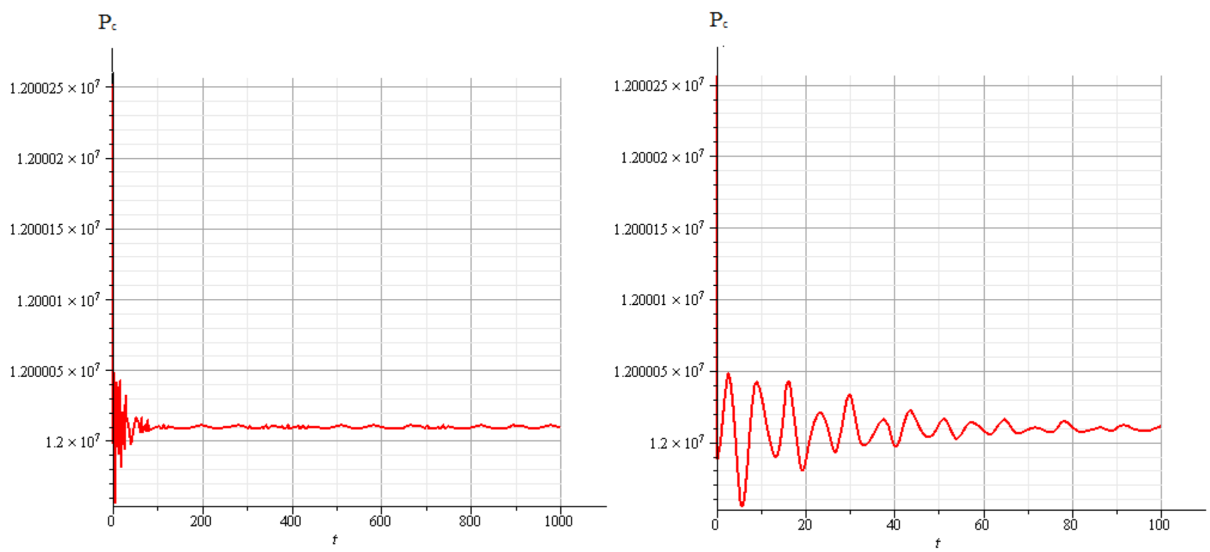


Figure.1. Time dependence graph of well pressure at pulsating value given by formula (1) of initial pressure at large and small moments of time

In the next step, we replace the given parameters and the (2) value of $P_0$ in the expression of $\overline{P}_c$ and return to the original. By making calculations, we can get the mathematical expression for the well pressure.

$$\begin{aligned} P_c &= 1{,}20000998\cdot 10^{7} - 0{,}4307094\sin(1{,}04666666\,t) + 1{,}601099781\cos(1{,}04666666\,t) + \\ &+ 8{,}205465704\cdot 10^{-87}(-3{,}488663038\cdot 10^{84} - 1{,}415230277\cdot 10^{81}\cos(1{,}04666666\,t))e^{-0{,}000204537607t} + \\ &+ 2{,}806956989\cdot 10^{-134}(1{,}81426776\cdot 10^{11}(-5{,}912989613\cdot 10^{123} + \\ &+ 4{,}564491463\cdot 10^{122}\cos(1{,}04666666\,t))\cdot\cos(0{,}9071083878\,t) + (1{,}747116929\cdot 10^{135} - \\ &- 9{,}542641716\cdot 10^{134}\cos(1{,}04666666\,t))\sin(0{,}9071083878\,t))e^{-0{,}0376446970t} + \\ &+ 2{,}689945938\cdot 10^{-64}(3{,}071000901\cdot 10^{66} - 1{,}642844847\cdot 10^{66}\cos(1{,}04666666\,t))e^{-29{,}69372812} \end{aligned} \quad (7)$$

The time dependence graph of the mathematical expression of pressure (7) is given in Figure 2.

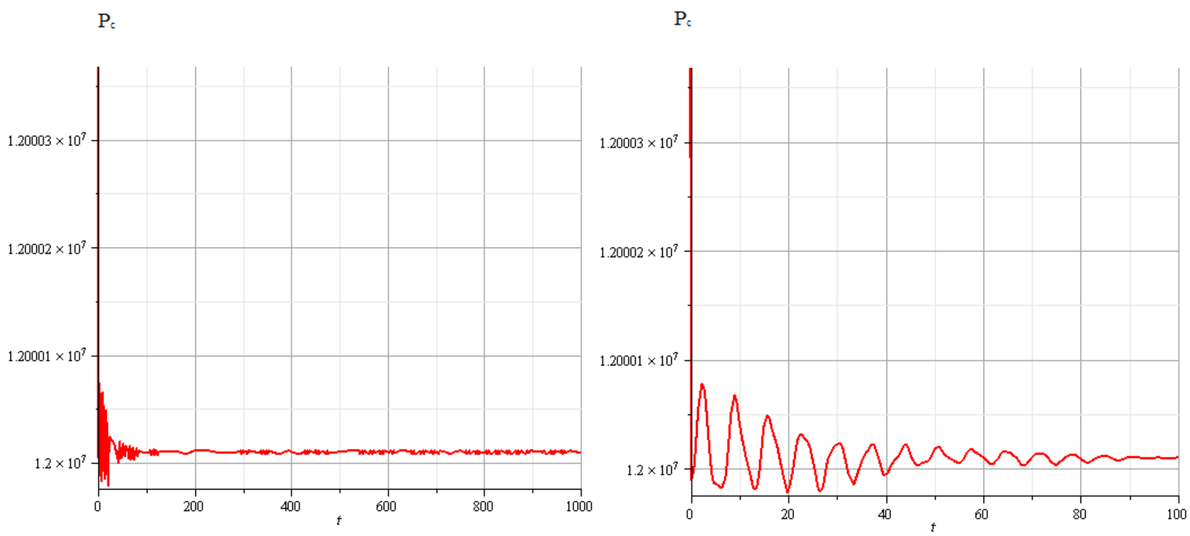


Figure 2. Time dependence graph of well pressure at pulsating value given by formula (2) of initial pressure at large and small moments of time

We replace the given parameters and the (3) value of $P_0$ in the expression of $\overline{P}_c$ and return to the original. Now we get the following mathematical expression for the well pressure

$$P_c = 1{,}20000981 \cdot 10^{7} + 1{,}489160058 \cos(1{,}046666667\ t) - 0{,}4005966715 \sin(1{,}046666667\ t) +$$
$$+ 8{,}205465704 \cdot 10^{-87}(-3{,}478339312 \cdot 10^{84} - 1{,}316285485 \cdot 10^{81}\cos(1{,}046666667\ t))e^{-0{,}000204537607t} +$$
$$+ 2{,}806956989 \cdot 10^{-134}(1{,}814216776 \cdot 10^{11}(-5{,}847890011 \cdot 10^{123} +$$
$$+ 4{,}245368375 \cdot 10^{122}\cos(1{,}046666667\ t)) \cdot \cos(0{,}9071083878\ t) + (1{,}684044749 \cdot 10^{135} -$$
$$- 8{,}87574889 \cdot 10^{134}\cos(1{,}046666667\ t)) \cdot \sin(0{,}9071083878\ t)e^{-0{,}0376446970t} +$$
$$+ 2{,}689945938 \cdot 10^{-64}(2{,}964035811 \cdot 10^{66} - 1{,}5279866549 \cdot 10^{66}\cos(1{,}046666667\ t))e^{-29{,}69372812t} \qquad (8)$$

The time dependence graph of the mathematical expression of pressure (8) is given in Figure 3.

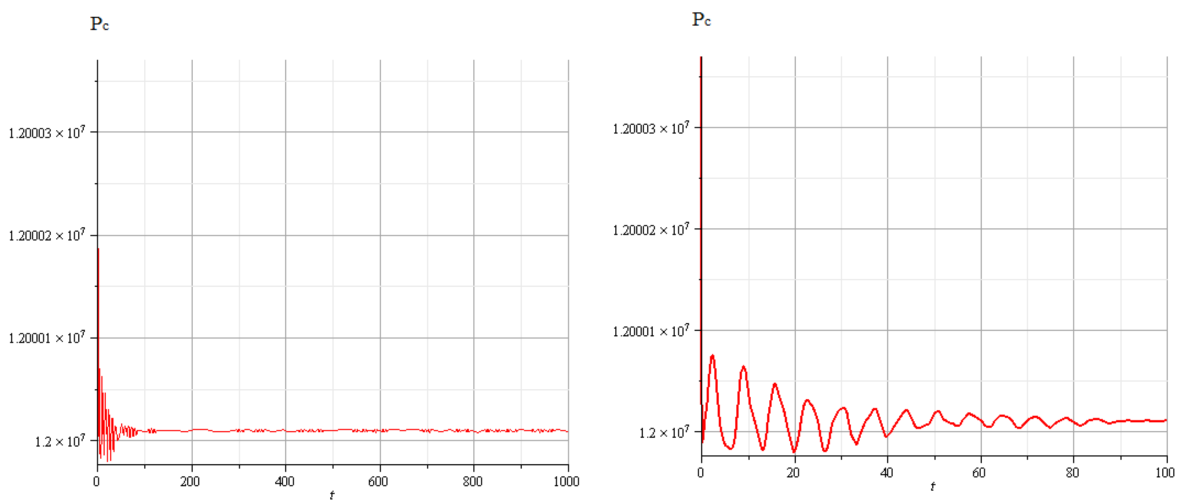


Figure 3. Time dependence graph of well pressure at pulsating value given by formula (3) of initial pressure at large and small moments of time

In the next step, we replace the given parameters and the (4) value of $P_0$ in the expression of $\overline{P}_c$ and return to the original. We can get the mathematical expression for the well pressure.

$$P_c = 1{,}20000909 \cdot 10^{7} + 0{,}3004475035 \cos(1{,}046666667\ t) + 1{,}116870044 \sin(1{,}046666667\ t) +$$
$$+ 4{,}102732852 \cdot 10^{-86}(-6{,}7354995411\ 0^{83} - 1{,}974428229 \cdot 10^{80}\sin(1{,}046666667\ t))e^{-0{,}000204537607t} +$$
$$+ 1{,}403478495 \cdot 10^{-133}(1{,}814216776 \cdot 10^{11}(-1{,}02772708 \cdot 10^{123} +$$
$$+ 6{,}368052566 \cdot 10^{121}\sin(1{,}046666667\ t))\cos(0{,}9071083878\ t) + (1{,}898457944 \cdot 10^{134} -$$
$$- 1{,}331321234 \cdot 10^{134}\sin(1{,}046666667\ t))\sin(0{,}9071083878\ t))e^{-0{,}0376446970t} +$$
$$+ 1{,}344972969 \cdot 10^{-63}(3{,}635438265 \cdot 10^{65} - 2{,}291979824 \cdot 10^{65}\sin(1{,}046666667\ t))e^{-29{,}69372812t} \qquad (9)$$

The time dependence graph of the mathematical expression of pressure (9) is given in Figure 4.

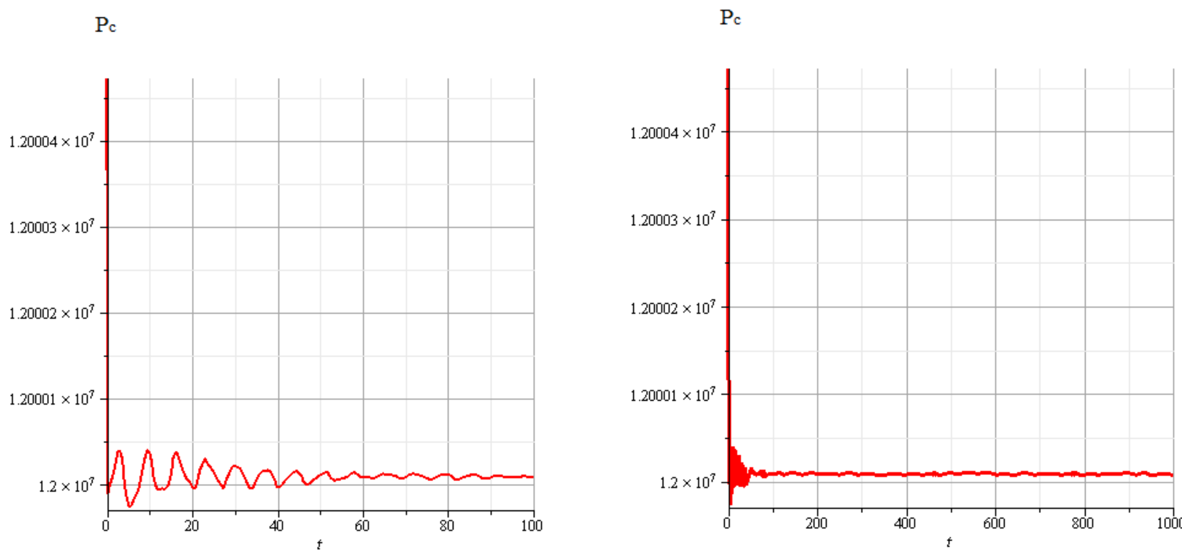


Figure 4. Time dependence graph of well pressure at pulsating value given by formula (4) of initial pressure at large and small moments of time

In the same way, we can study the dynamics of the increase in oil production in the case of pulsating prices of initial pressure.

## 4. Conclusion

It can also be seen from the graphs and calculations that when the value of the initial pressure fluctuates, so do the values of the well pressure. This affects the amount of oil extracted from the well. Studies show that there is an increase in the price of oil production obtained when the initial pressure creates pulsations in the price.

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