DISPLACING WATER TO THE EARTH'S SURFACE BY INJECTING GAS INTO A WATER SUPPLY DOME

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Abstract: The article discusses the issue of pushing water to the surface by injecting gas into the dome of the water pressure system. The bed is completely filled with liquid. This requires the creation of underground gas storages in the central upper part of the water pressure system. For this purpose, the water must be pressurized from the drilled and unloaded wells. In solving the problem, a sequential approximation method is used, and the formation of the reservoir occurs due to the compression of the fluid through the operating wells. Fluids and gases that enrich the water pressure system, field system and parameters are known. The boundaries of the latter are the contours of the press and the flow. According to the time, the water pressure in the reservoir has been determined by changing the sum of the volume of the cavity at the edge of the reservoir, the capacity of the created gas and the amount of injected gas. Under the conditions considered, the movement of water in the areas bounded by the contour of the discharge and flow can be considered as radial. Since this area is not very large, the elasticity of the water and the porosity of the environment can be ignored. This issue can be considered as the filtration of incompressible fluid in a non-deformable bed. With a relatively small change in flow rate due to the constant pressure in the discharge circuit, the Water compressed by the gas flows freely through the mouth of the discharge well.

Keywords: injection wells, dome, water pressure, flow contour, operating well, water trap, underground gas storage, pressure loss, gas-water contour

Introdustion:

The article examines the schematic field water pressure system. The bed is completely filled with liquid. An underground gas storage is required in the central upper part of the dome-shaped water pressure field. To do this, the gas must be pumped into the central part of the dome, and from there the water is pumped out by special wells drilled and unloaded for this purpose. These wells are located in the form of a circular battery along the radius . The liquid is compressed until the gas-water contact surface takes an AB state. Subsequent compression is not profitable, because in this case the gas exceeds the water trap and spreads across the bed.

Objective:

Liquids and gases that enrich the water pressure system, field system and parameters are known. The boundaries of the latter are the contours of the press and the flow. It is necessary to determine the pressure in the reservoir over time, the volume of the void at the vacuum of the reservoir, the strength of the g

as created and the change in the sum of the amount of gas injected.

Let’s call the injection well around the disc harge and the flow contours wells circular.

Under the conditions considered, the movement of water in the areas bounded by the contour of the discharge and flow can be considered as radial. Since this area is not very large, the elasticity of water and the porosity of the environment can be ignored, and this issue can be considered as the infiltration of incompressible fluid in a non-deformable bed [2,3].

Let's indicate the volume of the cavity in the gaseous part of the edge of the field by; gas-water contact area; in this case the pressure of the gaseous part of the field – by; the period since the gas injection –; the decrease in the water level calculated from the highest point of the cover – Z; porosity of the gaseous part of the field – by m; when gas-water contact area – by; In the AB case, the average radius of water withdrawal – by; dynamic viscosity coefficient of water – we; Ro and of the bed; the power of the gaseous part between the radii and the contours – by h; conductivity – K; water pressure in the flow circuit – by; specific gravity of water – ; the height of the water trap - H; the radius of the discharge well - (Figure 1).

Performance of work: Let's use a sequential approach to solve the problem. We accept the calculation as follows. We use a small time interval at Δt = $t_e - t_b$ (where t_e and t_b are the end and beginning of the section) and the t_e time near the end of the section with the volume of space outside the gaseous part of the file Ω_w [7,8].

$$\bar{p}_g = \frac{\int_{t_n}^{s} q_g P_{at} dt + p_w \Omega_w}{\Omega_w} \qquad (1)$$

$$P_{at} = \frac{P_w \Omega_0 \neg P' \Omega_w}{Q}$$

$$P' = P_w \neg \gamma_w Z \neg \Delta P$$

We find the formula p - pressure p_o in the gaseous part of the field at the time of the final cut, t_e - pressure and volume Ω_o - in the gaseous part of the field at the time of the initial cut, k = Ω (Z) μ_w

(H –Z), $p_{v.s.}$ we define

$$q_k = \frac{2\pi k h \Delta p n}{\mu_w \ln \dfrac{R_{sa}^{2n} \neg R_b^{2n}}{n R_{s.a}^{n} R_b^{n\neg 1} R_e}} \qquad (2)$$

According to the formula t_e we find the debit sum of the compressed water at the end of the cutoff time. Then we determine the change in the volume ΔΩ of the cavity at the edge of the gaseous part of the field over time. However, it should be noted that the average consumption of the liquid Δt in a small period of time is equal to the arithmetic mean of the initial and final sections

$$\Delta\Omega = \frac{q_w + q_k}{2} \Delta t \qquad (3)$$

The new value of the outer space volume is $\Omega'_w = \Omega_0 + \Delta\Omega$ We repeat the calculation as described above until the values of accepted Ω_w and Ω'_w obtained are not equal or the calculation that can be accepted differs in accuracy. Then we work with the following values of Δt and Ω_w and accept the initial Ω_0 and p_w values of $\bar{p}_0$ and Ω_w in the same way in the report. By squeezing the liquid from water trap of the operating wells with gas it is possible to create underground reservoirs under different boundary conditions in the press contours [1,4]. In the general case $q_w = q_w(t)$. This shows that the consumption of gas injected into the water trap is well known. Boundary conditions in the flow contour are $p_{v.s.} = const$. The presence of a constant pressure in the discharge circuit results in the gas flowing freely through the wellhead of the discharge well at a relatively small change in flow rate [9].

In the following case, gas reservoirs are created by squeezing the liquid from the working wells in the water pressure system of the field, and in this case the injected gas consumption is known. It is required to calculate the creation of the reservoir. In this case, let's carry out the calculation. The scheme of the field water pressure system is given in Figure 1.

We accept the following data for the calculation. The porosity of the field is 0,2 m, the coefficient of permeability is 1,5 darsi, the dynamic coefficient of water viscosity, μ_w, centipoise 1, field capacity 20 m, pressure in the discharge contour, $R_{d.c.}$ 6 MPa, pressure in the contour of the feeding area $P_{f.c.}$ 6 MPa, radius of the discharge contour, $R_{d.c.}$, 3000 m, specific gravity of water γ_w 1000 Q/m^3, water trap height – 55m, radius of the emptied well, R_w, 0,1 m, average radius of fixed water intake, $R_a = R_b$ 500m, constant consumption of injected gas q_g 10^6 m^3/day, radius of contour of feeding area R_c, 19,47 km, number of operating wells, 40, number of pressure wells, 20. Let's calculate the value of: $q_s = \Delta P \bullet A_0$

$$A_0 = \frac{2\pi khn''}{\mu_w \ln \dfrac{R^{2n'}_{c.a} \neg R_b^{2n'}.}{n' R^{n'}_{c.a.} R_b^{n''-1} \; R_c}} = \frac{2 \bullet 3{,}14 \bullet 1{,}5 \bullet 2000 \bullet 40 \bullet 0{,}864 \bullet 10}{2{,}3 \bullet 33{,}5 \bullet 10} = 845 m^3/day$$

The results of the above calculations are given in Table 1.

Table 1. Basic data characterizing gas storage facilities created by displacement of water from operating wells

$t_e \neg t_b = \Delta t$, days	Ω_w, $10^6 m^3$	$\overline{p}_w$, MP_a	Z, m	$\Delta p, at$	A_0, m^3/day, at	$q_c, 10^6$ m^3/day	$\Delta\Omega$, $10^6 m^3$	Ω''_w, $10^6 m^3$
60-0=60	0,84	7,15	5,35	16,56	845	13,900	0,84	0,84
120-60=60	1,675	7,165	7,45	16,41	845	13,60	0,834	1,674
180- 120=60	2,507	7,18	9,05	16,39	845	13,830	0,831	2,505
240-180=60	3,336	7,192	10,5	16,37	845	13,820	0,830	3,335
300-240=60	4,16	7,202	11,7	16,35	845	13,810	0,828	4,163
360-300=60	4,99	7,212	12,9	16,33	845	13,800	0,827	4,99

According to Table 1, the dependencies $p_w = \overline{p}_w(t)$ and $Z = Z(t)$ are set up (Fig. 2). As it can be seen from the calculation, if the formation of the reservoir is due to the displacement of the fluid through the operating wells, then the storage of the reservoir in a stable gas injection the rate of formation is almost constant

$$(\frac{d\Omega_w}{at}) \;.\; 1 \neg \overline{p}_w = \overline{p}_w(t); \qquad 2 \neg Z = Z(t)$$

Based on the above (Table 1), the calculation of the gas storage can be done using formula (1), [5,6]:

$$\Delta\overline{\Omega} = \Delta\tau \frac{[\neg 1 + \alpha(1 \neg \overline{Z}_0) + \dfrac{\overline{Q}_0 + \overline{Q}_1}{2 \;\; \overline{\Omega}_0}]}{1 + \dfrac{1}{2}\Delta\tau(\dfrac{\alpha\beta_1}{F_0} + \dfrac{\overline{Q}_1}{\overline{\Omega}_0^2})} \qquad (4)$$

Here

$$\beta_1 = \frac{\Omega_k}{HF_k m}, \Omega_k = \int_0^n FmdZ, \Omega_q = \int_0^z FmdZ, \overline{\Omega} = \frac{\Omega_q}{\Omega_k}, \overline{Z} = \frac{Z}{H}$$

$$\overline{F} = \frac{F}{F_k}, \quad \alpha = \frac{\gamma_w H}{\rho_{d.c/}}, \quad q_0 = \frac{2\pi kh\rho_{d.c.}n}{\mu_w \ln \dfrac{R_{d.c.}^{2n} - R_b^{2n}}{nR_{d.c.}^{n} R_b^{n-1} R_q}}$$

$n-$ number of working wells, $\dfrac{\Omega_k}{q_0} = T$, $\tau = \dfrac{t}{T}$, $Q = \int_0^t q_g p_{at}$, $Q = q_g p_{at} t$,

at -constant the initial data for the calculation has been carried out according to the formula (4) in the previous example t = 60 days; $\Omega_n = 0{,}84 \cdot 10^6 m^3$; $p_n = 7{,}15 MPa$; $Z_n = 5{,}35m$, $F_m = 32 \cdot 10^4 m^2$; $\Omega_k = 56{,}5 \cdot 10^6 m^3$; $F_k = 616 \cdot 10^6 m^2$ was carried out according to the initial data.

To perform the calculations, it is necessary to compile an auxiliary table (2).

$$\alpha = \frac{1000 \cdot 55}{60 \cdot 10^4} = 0{,}092, \quad \beta_1 = \frac{56{,}5 \cdot 10^6}{55 \cdot 6{,}16 \cdot 10^6 \cdot 0{,}2} = 0{,}833$$

$$\overline{Z_0} = \frac{5{,}35}{55} = 0{,}00975, \quad q_0 = \frac{2 \cdot 3{,}14 \cdot 1{,}5 \cdot 2000 \cdot 60 \cdot 40 \cdot 0{,}864 \cdot 10^5}{2{,}3 \cdot 33{,}5 \cdot 10^6} = 50700 m^3/day$$

$$\overline{\Omega_0} = \frac{0{,}84 \cdot 10^6}{56{,}5 \cdot 10^6} = 0{,}01487, \quad \overline{F_0} = \frac{32 \cdot 10^6}{0{,}2 \cdot 6{,}16 \cdot 10^6} = 0{,}257, \quad T = \frac{56{,}5 \cdot 10^6}{5{,}07 \cdot 10^4} = 1113 day$$

Table 2. Values of t, τ and $\bar{Q}$

t, days	τ	$\bar{Q}$	t, days	τ	$\bar{Q}$
0	0	0,0177	180	0,1617	0,0708
60	0,0539	0,0354	240	0,2156	0,0885
120	0,1078	0,0531	300	0,2695	0,1062

$$\Delta\overline{\Omega} = \frac{0{,}0539\ \left[-1 + 0{,}092(1 - 0{,}0975) + \dfrac{0{,}0177 + 0{,}0354}{2 \cdot 0{,}01487}\right]}{1 + \dfrac{1}{2} 0{,}0539(0{,}257 \dfrac{0{,}092 \cdot 0{,}833}{0{,}257} + \dfrac{0{,}0354}{(0{,}01487)^2}} = 0{,}0088$$

$$\overline{\Omega_1} = 0{,}01487 + 0{,}0088 = 0{,}02377$$

$$\overline{\Omega_1} = 56{,}5 \cdot 10^6 \cdot 0{,}02377 = 1{,}34 \cdot 10^6 m^3$$

$$Z_1 = 6{,}7m$$

$$\overline{Z_1} = \frac{6{,}7}{55} = 0{,}122, \quad \overline{F_1} = \frac{40{,}0 \cdot 10^4}{0{,}2 \cdot 616 \cdot 10^6} = 0{,}322, \quad p_g = 8{,}95 MPa$$

In the next calculation, let's take the values of Ω, Z, and F-1 as the initial values and follow the same procedure. The results of the calculations and comparison with the data obtained by the sequential approximation method (Table1), are given in Table 3.

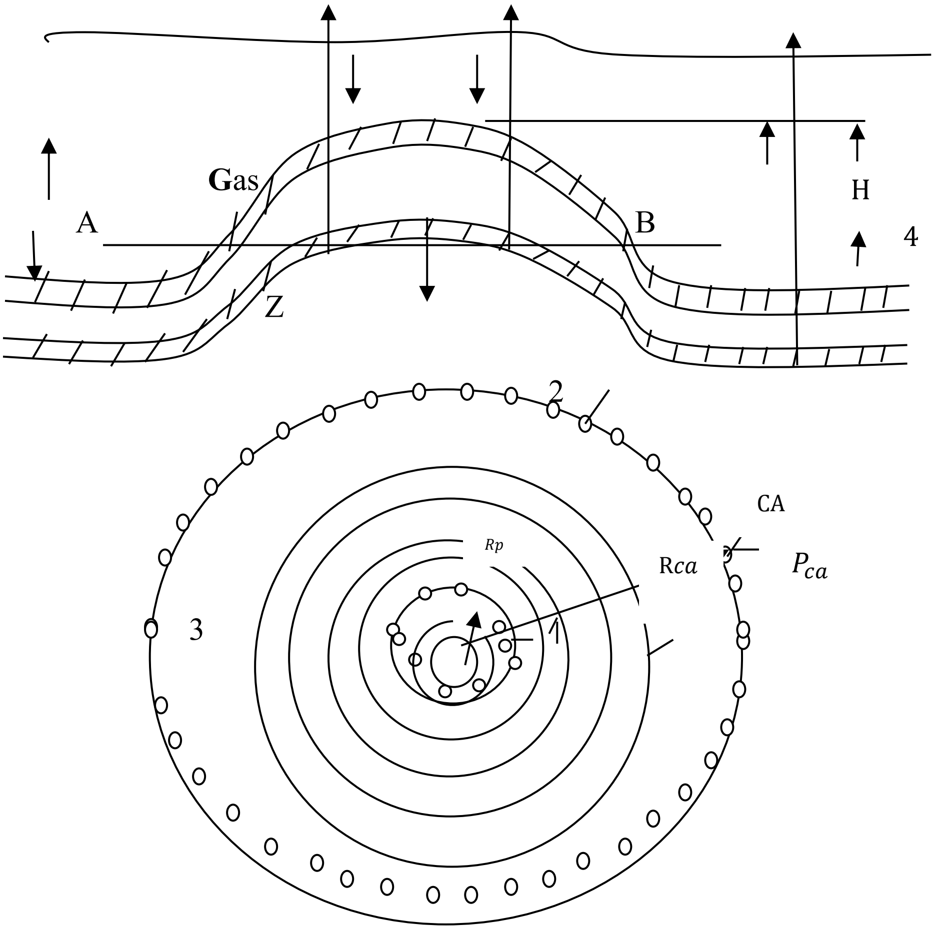

Figure 1. Scheme of the field water pressure system

1 - pressure wells; 2- operating wells; 3 - isogips; 4- waterproof bed cover;
FC- flow contour; PC – pressure contour; R_b – radius of pressure well battery ($R_b = R_0$);

H is the height of the water trap; h – field water height; AB - the lowest possible level of gas-water condition

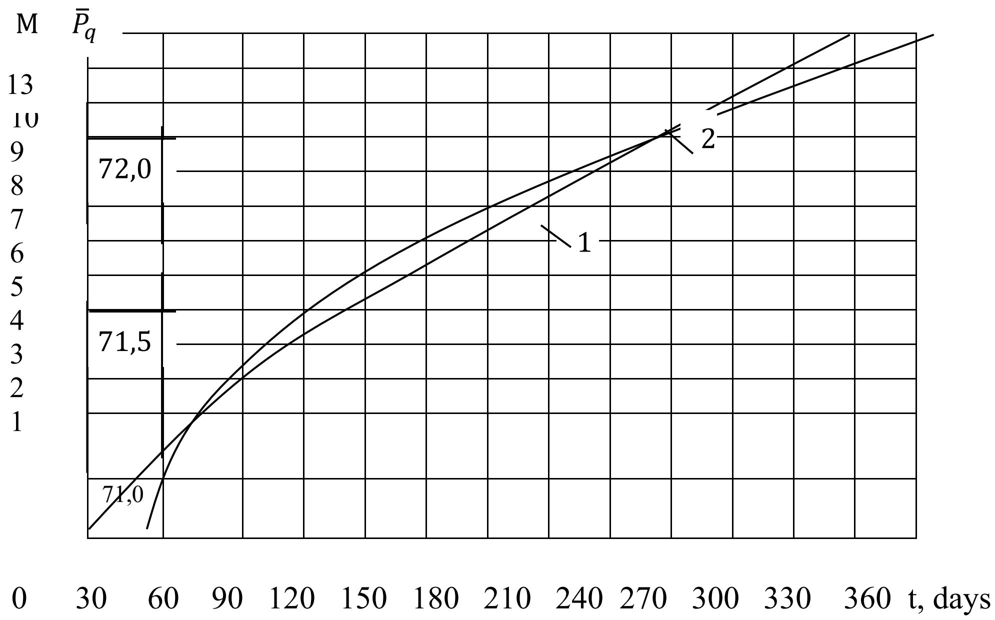

Figure 2. Dependence curves

Table 3. Ω **calculated by the formula (1) and the corresponding values** Z, F_m, p_g

t_c, days	Ω, $10^6 m^3$	Z, m	F, $10^4 m^2$	$\overline{p_g}$, MPa	$\frac{(\Omega_g - \Omega)\bullet 100}{\Omega_g}$, %	$\frac{(p_g - p)\bullet 100}{p_g}$, %
0	0,84	5,35	32,0	7,15	0	0
60	1,34	6,70	40,0	8,95	20	24,9
120	2,15	8,45	50,0	8,37	14,3	16,6
180	3,07	10,0	60,0	7,82	8,0	8,74
240	3,99	11,5	69,0	7,52	4,08	4,83
300	4,87	12,7	76,0	7,4	2,4	2,61

It can be seen from Table 3 that $\Delta\tau = 0{,}0539$ is obtained by the sequential approximation method.

The relative error in the accepted values Ω and p_g is too large at the beginning of the calculation and reaches 20 and 24,9%, respectively. Then these values decrease and when t = 300 days it is 2,4 and 2,61%, respectively.

To increase the accuracy of the report, it is necessary to reduce the value of Δτ to Δτ = 1,01 0,005, which in turn significantly increases the volume of calculations. However, in modern computing, all operations can be performed quickly and at a very low value of Δτ.

At the bottom of the pressure wells, the pressure at the calculated value of p_g is as high as the pres sure from the well to the gas-water contour during gas filtration.

Conclusion

Thus, the presence of a constant pressure in the flow contour results in the gas flowing freely from the wellhead of the working well at a relatively small flow rate, and the formation of a reservoir occurs by compressing the fluid through the working wells.

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SU TƏCHIZATI QÜBBƏSINƏ QAZ VURULMASI VASITƏSILƏ SUYUN YER SƏTHINƏ ÇIXARILMASI

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Xülasə: Məqalədə, sutəzyiq sisteminin kümbəzinə qazın vurulması ilə suyun yer səthinə sıxışdırılması məsələsinə baxılmışdır. Yataq bütövlükdə maye ilə doldurulmuşdur. Bunun üçün sutəzyiq sisteminin mərkəzi yuxarı hissəsində yeraltı qaz anbarlarının yaradılması tələb olunur. Bu məqsədlə də həmin suyu qazılmış və yüksüzləşdirilmiş xüsusu quyulardan təzyiq altında sıxışdırmaq lazımdır. Məsələni həll edərkən ardıcıl yaxınlaşma üsulundan istifadə edillir və anbarın yaranması işləyən quyular vasitəsilə mayenin sıxışdırılması hesabına baş verir. Sutəzyiq sistemi, yatağın sistemi və parametrləri zənginləşdirən maye və qazlar məlumdurlar. Sonuncuların sərhədləri basma konturları və axmasıdır. Zamana görə anbarda su təzyiqi, anbarın qırağında boşluğun həcminin, yaradılmış qazın gücünün və vurulmuş qaz miqdarının cəminin dəyişməsi ilə təyin edilmişdir. Baxılan şərtlərdə sıxışdırılan və axma konturu ilə məhdudlaşan sahələrdə suyun hərəkətini radial кimi qəbul etmək olar. Qeyd olunan sahə çox da böyük sahə olmadığından suyun elastikliyi və mühitin məsaməliyini nəzərə almamaq olar. Bu maraqlandıran məsələyə deformasiya olmayan yataqda sıxılmayan mayenin süzülməsi kimi baxmaq olar. Axma konturunda sabit təzyiqin olması ilə debitin müqayisəli kiçik dəyişməsində qazla sıxışdırılan su, boşaltma quyusunun ağzından sərbəst axması ilə nəticələnir.
Açar sözlər: yeraltı qaz anbarı, kümbəz, su təzyiqi, axma konturu, işlyən quyulaır, vurucu quyulaı, təzyiq itkisi, qaz-su konturu

ВЫТЕСНЕНИЕ ВОДЫ НА ПОВЕРХНОСТЬ ЗЕМЛИ ПУТЕМ ЗАКАЧКИ ГАЗА В ВОДОНАПОРНЫЙ КУПОЛ

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Резюме: В статье рассмотрена проблема вытеснения воды на поверхность нагнетанием газа в купол водонапорной системы. Залежь полностью заполнена жидкостью. Требуется создание подземных газовых хранилищ на центральной верхней части водонапорной системы. Для этой цели необходимо вытеснение воды из пробуренных разгруженных скважин под давлением. При решении этой проблемы используется метод последовательного приближения и создание хранилища происходит за счет вытеснения жидкости с помощью действующих скважин. Известны жидкости и газы, которые обогащают водонапорную систему, систему и параметры месторождения. Границами последнего являются контуры и поток. В зависимости от времени необходимо определить давление в хранилище, объем пустоты на границе хранилища, силу повяленного газа и изменения количества нагнетённого газа.
В рассматриваемых условиях в зонах, ограничивающихся контурами нагнетания и потоки движение воды можно принять как радиальное. Так как отмеченная зона не является большой, то эластичность воды и пористость окружающей среды не принимается во внимание, и интересующая нас проблема может рассматриваться как фильтрация несжимаемой жидкости в недеформированном месторождении. В результате постоянного давления в контуре потока происходит свободный поток воды, сжимаемый газом при маленьком изменении дебита.
Ключевые слова: подземные газохранилища, напор воды, контур потока, действующие скважины, нагнетательные скважины, потеря давления, газо-водной контур, купол