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DETERMINATION OF THE LIFT DIAMETER FOR MINIMUM PRESSURE LOSS IN GAS AND GAS-CONDENSATE WELLS

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ABSTRACT

Oil, gas, and gas-condensate extracted from offshore fields play a crucial role in Azerbaijan's economy, making the enhancement of oil and gas production efficiency highly important. Therefore, increasing oil and gas recovery from fields is one of the key issues in field development. This article focuses on the determination of the optimal regime for gas and gas-condensate wells to effectively manage production.
First, the technological regime selection methods used in practice are analyzed, and based on the field characteristics, the most suitable approach is identified. The results of studies conducted on production wells in the field are refined using computational methods to propose optimal parameters. Based on the known well parameters, an optimal technological regime is selected for each well individually. Additionally, based on the average values of the parameters, a generalized technological regime is proposed. Wells with similar and interconnected characteristics are grouped together. A new optimal regime is then determined for each group.
The removal of liquid and solid particles from the lower zone of gas-condensate wells depends primarily on the upward gas flow rate within the wellbore and the production regime of the well. Additionally, the physical properties of gas, liquid, and solid particles, as well as the well's structural characteristics and the lift diameter, are determining factors for these parameters.
To ensure the effective removal of liquid and solid particles from the lower zone of a gas-condensate well, it is necessary to consider the minimum gas flow rates and the lowest production levels at which the lift ceases to function. Thus, obtaining prior information about the operational wells is crucial. To effectively remove liquid and solid particles from the wellbore, the required minimum production rate and gas flow must be adjusted to the well's determined bottom-hole pressure.
Keywords: gas-condensate wells, liquid particles, flow rate, lift diameter, bottomhole pressure, optimal regime, critical velocity, liquid blockage.

Introduction

In gas and gas-condensate wells, the lift diameter is determined based on the given production rate to ensure minimal pressure loss in the wellbore and efficient lifting of liquid and rock particles from the bottomhole. Therefore, application of various impact methods on wellbottom zone is being investigated.

Objective

In gas and gas condensate fiejds the aim is to eliminate complications in the wells and increase production by controlling both the length and diameter of the riser in the wells, as well as the speed of the gas flow in the shoe.

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Methods

1. Field experience shows that the removal of liquid and rock particles from the bottom of the well mainly depends on the gas flow velocity (V) and the critical falling velocity of the particle in the medium (V_{cr}) [1,2].

If $V > V_{cr}$ liquid and rock particles are lifted to the surface. Typically, the velocity is taken as $V = 1{,}2V_{cr}$:

Here is

$$V_{cr} = \sqrt{\frac{2}{3} \cdot \frac{g \cdot d_{par}(\rho_{par} - \rho_{gas})}{\varphi \cdot \rho_{gas}}} \quad (1)$$

here is D_{par} - particle diameter, cm ; ρ_{gas}- gas density, g/cm ^{3}; ρ_{par}- particle density, g/cm^3; φ- shape coefficient of the particle (for spherical liquid particles, φ = 0.45; for spherical rock particles, φ = 0.25; for prismatic rock particles, φ = 0.73)

2. The gas flow velocity (V) is minimal at the shoe of the lift and is given by:

$$V = \frac{4 \cdot 10^6 Q \cdot z}{\pi d^2 \cdot P_{sh} \cdot 86400} = 14{,}74 \frac{Q \cdot z}{d^2 \cdot P_{sh}} \quad (2)$$

Considering the above equations for V and V_{cr}, the maximum lift diameter that ensures the removal of liquid and rock particles from the bottomhole can be determined as:

$$d_{\max} = \sqrt{\frac{14{,}74 Q \cdot z}{1{,}2 V_{cr} \cdot P_{sh}}} = \sqrt{\frac{12{,}3 Q \cdot z}{V_{cr} P_{sh}}} \quad (3)$$

Here is d_{max} - the maximum diameter of the lift, m; Q- gas production rate, m ^{3} /day; P_{sh}- shoe pressure, kg/cm ^{2} ; z- gas compressibility factor.

During the operation of gas-condensate wells, changes in pressure and temperature cause the separation of liquid hydrocarbons from the gas. As a result, a two-phase system moves through the wellbore. At low flow rates, only small-diameter particles are lifted from the bottom of the well, while larger-diameter particles accumulate in the wellbore, forming liquid plugs. Consequently, well production decreases and eventually stops completely. In this case, the gas-condensate well must operate at a minimum production rate that ensures the lifting of particles. This minimum production rate is determined by the following empirical formula:

$$Q_{\min} = 115{,}5 d^{2{,}5} \sqrt{\frac{P_{sh}}{M \cdot T \cdot z^2}} \quad (4)$$

here is Q_{min} - minimum allowable production rate, m ^{3} /day; d - lift diameter, mm; P_{sh} - shoe pressure, atm; T - bottomhole temperature, K; M - molecular weight of the natural gas, kg/mol.

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Now, let's consider the lift's role in minimizing pressure loss in the wellbore. Here, the lift acts as a transport object. Every object in this system experiences pressure loss.
Let's assume that hydrodynamic studies have determined the maximum allowable production rate ($Q_{a.max}$). At this production rate, factors such as rock collapse in the near-wellbore zone, water encroachment into the wells, and other factors limiting well production do not occur [3]. It is known that the bottomhole pressure ($P_{w.b}$) can be determined using the following formula:

$$P_{wb.} = \sqrt{P_{w.h}^2 \cdot e^{2s} +,377\lambda \frac{T_{av}^2 \cdot z_{av}^2}{d^5} (e^{2s} - 1) Q^2} \quad (5)$$

here is $P_{w.h}$ - wellhead pressure, atm; λ- hydraulic resistance coefficient; $T_{av} = (T_{w.b} + T_{w.h})/2$- average temperature in the wellbore, K; Z_{av} - gas compressibility factor.

$$S = 0{,}03415 \frac{\bar{\rho} H}{z_{av} \cdot T_{av}} \quad (6)$$

here is H - well depth, m; $\bar{\rho}$- relative density of gas; Q- well production rate, thousand m ^{3}/day; d- diameter of the lift, mm
If $\Delta P = P_{w.b} - P_{w.h} = P_{w.h} + P_{fr}$ is given, then the lift diameter is determined using the following formula:

$$d = \sqrt[5]{\frac{1{,}3777\lambda T_{av}^2 z_{av}^2 (e^{2s} - 1) Q_{a\max}^2}{P_{w.b.}^2 - P_{w.h.}^2 e^{2s}}} \quad (7)$$

If the lift diameter determined by the first condition is d_1, and the lift diameter determined by the second condition is d_2, then the diameter is selected as follows:
If $d_1 > d_2$ the larger diameter is chosen (i.e., d_2).
If $d_2 < d_1$, then d_2 is selected.
This is explained by the fact that an increase in diameter reduces energy losses due to friction[4,5].
If it is required to determine the pressure loss for a given diameter, the same formula is used:

$$\Delta P = P_{w,b} - \frac{\sqrt{P_{w.b.}^2 - \frac{1{,}377\lambda T_{av}^2 z_{av}^2 (e^{2s} - 1) Q_{a.\max}^2}{d^5}}}{e^{2s}} \quad (8)$$

If the calculated ΔP is greater than the given ΔP, then $Q_{a.max}$ needs to be reduced.
Now, let's determine the minimum gas velocity required to lift liquid and rock particles from the bottom of the well, as well as determined gas production based on the given well operation parameters. The calculation is performed based on the following provided data:
- reservoir pressure P_r =92 atm=9.2 Mpa;

- reservoir temperature T_r =380 K;
- hydrodynamic resistance coefficients:

$$a = 1{,}8 \cdot 10^{-2} \frac{MPa \cdot day}{thm^3}$$

$$b = 6{,}4 \cdot 10^{-5} (\frac{MPa \cdot day}{thm^3})^2$$

- lifting pipe diameter d = 2.5 ”= 0.0625 m;
- condensate density ρ = 0.78 g/cm^3;
- as compressibility factor under reservoir pressure and temperature conditions z_{init} =0.92;
- well productivity coefficient $c_{well} = 6{,}5 \frac{\text{thm}^3}{\text{MPa} \cdot \text{day}}$;
- gas production $q_{gas} = 170 \frac{\text{thm}^3}{\text{day}}$;
- condensate production $q_{wat} = 6 \frac{\text{ton}}{\text{day}}$;
- water extraction $q_{wat} = 3 \frac{\text{ton}}{\text{day}}$.

The minimum production rate required to lift liquid and rock particles from the bottom of the well is determined by the following formula:

$$q_{\min} = \frac{\pi d^2}{4} \cdot V_{0\min} \cdot \frac{T_0 \cdot P_{q.d}}{T_L \cdot z_{init} \cdot P_0} \quad (9)$$

Here is - V_{0min} is the settling velocity of liquid and rock particles in the gas medium, determined as:

$$V_{0\min} = 10(45 - 0{,}0455 P_{w.b})^{1/4} P_{w.b,}^{-1/2}$$

$$Q_{\min} = \frac{3{,}14 \cdot 0{,}0625^2}{4} \cdot 10(45 - 0{,}0455 P_{w.b})^{1/4} P_{w.b}^{-1/2} \cdot \frac{273 \cdot 86{,}4 P_{w.b}}{380 \cdot 0{,}92 \cdot 0{,}1}$$

By substituting this minimum value into the flow equation, $P_{w.b}$ is determined using an iterative approximation method:

$$P_r - P_{w.b}^2 = a \cdot q_{\min} + b \cdot q_{\min}^2$$

$$9{,}2^2 - P_{w.b.}^2 = 18 \cdot 10^{-2} (45 - 0{,}0455 P_{w.b})^{1/4} \cdot P_{w.b.}^{-1/2} + 64 \cdot 10^{-5} \left[21 \cdot P_{w.b}^{1/2})45 - 0{,}0455 P_{w.,b})^{1/4} \cdot P_{w.b}^{1/2}\right]^2$$

To determine $P_{w.b}$ from this equation, we test the validity of the equality by giving different values to $P_{w.b.}$.

We determine that at the value of $P_{w.b}$=7.5 Mpa, the equality is satisfied: 28.39 ≈28.2

Now let's calculate $q_{\min}$: let's assume n=1.

$$q_{\min} = k_{well} (P_r^2 - P_{w.b}^2)^n$$

$$q_{\min} = 6{,}5 (9{,}2^2 - 7{,}5^2) = 184{,}54 \frac{\text{thm}^3}{\text{day}}$$

$$q_{\min} = 185\frac{\text{thm}^3}{\text{day}}$$

The actual production of well N is:

$$q_{fac} = 170\frac{\text{thm}^3}{\text{day}}$$

Since $d_{fac} < d_{min}$ (170<185), liquid accumulates at the bottom of the well, leading to liquid blockages.
In the field, the formation of sand and liquid blockages reduces well production. These blockages are eliminated by blowing out the well. This means the well is temporarily disconnected from the collection system and operates with atmospheric blowout. After atmospheric blowout, the well operates freely[6].
It is assumed that well N, after being blown out, operates at a 30% increased production rate. That is, the well's production after blowout is:
Blowing out the bottom of the well takes 15–20 minutes. During this time, there is gas loss:

$$q_{atm} = 170 + 0{,}3 - \cdot 170 = 221\frac{\text{thm}^3}{\text{day}}$$

$$q_{loss} = \frac{221000}{24 \cdot 60} \cdot (15 \div 20)\text{m}^3 = (2302 \div 3069)\text{m}^3$$

Thus, the average gas loss per blowout is approximately m³. If the well is blown out at least twice a month, the monthly gas loss is:

$$q_{month.loss} = 2685{,}5 \cdot 2 = 5371{,}0m^3$$

The annual gas loss will be:

$$q_{an..loss} = 5371 \cdot 12 = 64452\, m^3$$

Now let's determine the diameter and length of the lift. The calculation is carried out in the following sequence:

1) First, let's determine the falling speed of the particle:

$$V_0 = 10(45 - 0{,}455 \cdot P_{w.b.})^{1/4} \cdot \frac{1}{\sqrt{P_{w.b}}} = 10(45 - 0{,}0455 \cdot 7{,}5)^{1/4} \cdot \frac{1}{\sqrt{7{,}5}} = 9{,}3m/\sec$$

2) well production per second:

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$$q_{pr} = \frac{170000}{24 \cdot 60 \cdot 60} = 1{,}97 m^3/\sec$$

3) Production in wellbore conditions:

$$q_{w.b} = 1{,}97 \frac{0{,}1 \cdot 380 \cdot 0{,}78}{7{,}5 \cdot 293} = 0{,}025 m^3/\sec$$

4) gas flow velocity in the shoe will be:

$$V_{w,b} = \frac{0{,}025}{0{,}0785 \cdot 0{,}0625^2} = 8{,}33 m/\sec$$

So, since $V_0 > V_q$, liquid drops will not be lifted to the ground by a 2.5" diameter lift. Therefore, it is necessary to reduce the diameter of the lift in the shoe. Therefore, it is necessary to leave a 2" diameter pipe of 100 m length instead of 2.5", in the lower part of the first row lift. It is also necessary to increase the length of the first row lift by 1000 m. The first row lift is taken 4"-3000m; 2.5"-1194m; 2"-100m. In this case, the gas flow velocity in the shoe is:

$$V_{w,b} = \frac{0{,}025}{0{,}0785 \cdot 0{,}050^2} = 13{,}3 m/\sec$$

Therefore, since $V_{w.b}$>, $V_0$the liquid particle is lifted to the surface.

Conclusion

Depending on the characteristics of the deposits, the optimal technological regime is proposed for the wells. In order to select the optimal technological regime, the average values of the well parameters and its product are determined. New individual technological regimes are worked out for the exploitation wells. Average technological regimes are proposed based on the average parameters of the wells and their product. At the same time, the diameter of the lift is determined at the minimum value of the pressure loss in the wellbore of gas and gas-condensate wells. Thus, by controlling both the length and diameter of the lift in the well , as well as the velocity of the gas flow in the wellbore, it is possible to eliminate complications in the well and increase production [7-9].

Declarations

The manuscript has not been submitted to any other journal or conference.

Study Limitations

There are no limitations that could affect the results of the study.

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Competing Interests
No potential conflict of interest was reported by the authors.

REFERENCES

1. Murayev A.V. Optimization of Condensate Production Mode. Gas-Condensate Wells:Challenges of Sampling, Testing and Production Optimization.07.2022, page 6-8.
2. Zeynalov R.M., Kazimov E.A. Complication during drdlling of designed wells in the 8th horizon of the Bulla deniz field and measures to combat them. Azerbaijan Oil Industry 03.2020,pp 15-17.
3. Edgie Yuda Kaeshi, Mia Ferian Helmy. Gas-Condensate Systems, Gas-Condensate reservoirs. The summary of Gas Condensate and Gas reservoir Performance. 2021, page 18-21.
4. Suleymanov S.A. et al. / Geology, exploration and development issues of the Bulla-Deniz gas-condensate-oil field / Baku, 2000
5. Lapshin V.I., Volkov A.N., Konstanlinov A.A. Gas-condensate chasacteristics of hydrocarbon fliuds of oil-gas-condensate deposits. Scientific-Tecnical Collection. News of Gas Science. No 4(20)/2014.pp.119-120.
6. İsmayılov Sh.Z., Suleymanov A.A., Novruzova S.H. and eth Technology of oil and gas extraction by well.Baku-2022, pp. 56-57.
7. Mamedova G.G. Measures on the liquidation of a column of liquid collected on the drilling of gas-condensate wells during operation // 69th International Youth Scientific Conference (April 14-16, 2015) "Neft and Gas-2015" Russian State University of Oil and Gas. IM Gubkina, M., 2015, pp. 92-94.
8. Mamedova G.G., Aliyev T.G. Regulation of gas well production in offshore oil and gas fields. News of the Hıgher Technıcal Schools of Azerbaıjan // Baku, 2024, №1(147). -Vol.26, pp.10-16. https://zenodo.org/records/10709019
9. Mamedova G.G. On the determination of the diameter of the fountain pipe at the minimum value of pressure loss in the wellbore. // Rassohinskie readings, Materials of the International conference (February 1-2, 2024), Ukhta, UGTU, 2024 pp. 209-212

QAZ VƏ QAZ-KONDENSAT QUYULARINDA QUYU GÖVDƏSİNDƏ TƏZYİQ İTKİSİNİN MİNİMUM QİYMƏTİNDƏ QALDIRICININ DİAMETRİNİN TƏYİNİ

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Məqalə qaz və qaz-kondensat quyularının optimal rejiminin təyini ilə çıxarılan hasilatın idarə olunmasına həsr olunur. Əvvəlcə quyuların texnoloji rejiminin seçilməsində tətbiq olunan üsullar araşdırılır və yatağın xüsusiyyətlərindən asılı olaraq bu və ya digər üsulun qəbul olunması məqsədə uyğun sayılır. Mədən şəraitində aparılmış quyuların tədqiqat nəticələri ətraflı araşdırılır və həmin parametrlər hesabat yolu ilə dəqiqləşdirilərək optimal parametrlər təklif olunur. Məlum quyu parametrləri əsasında fərdi quyular üçün optimal texnoloji rejim seçilir. Eyni zamanda parametrlərin orta qiymətləri əsasında ümumiləşdirilmiş texnoloji rejim seçilir. Quyular arasında əlaqə tədqiq olunur və bir-birilə əlaqəsi olan quyular qrup şəklində seçilir. Sonra hər qrup üçün yeni optimal rejim müəyyən olunur. Qaz-kondensat quyularının aşağı zonasından maye və bərk hissəciklərin çıxarılması ilk növbədə quyu lüləsi daxilində yuxarıya doğru qaz debitindən və ya quyunun hasilat sürətindən asılıdır. Bundan əlavə, o, qazın, mayenin və bərk hissəciklərin fiziki xüsusiyyətlərindən, həmçinin quyunun strukturundan,qaldırıcının diametrindən və digər parametrlərdən asılıdır. Qaz kondensatı quyusunun aşağı zonasından səthə maye və bərk hissəciklərin qalxmasının, adətən, qazın minimal debiləri və ya quyunun minimum hasilat səviyyəsi zamanı qaldırıcının sonunda baş verdiyini nəzərə alaraq, istismar quyuları haqqında əvvəlcədən məlumat almaq vacibdir. Quyunun dib zonasından səthə maye və bərk hissəciklərin effektiv çıxarılması üçün tələb olunan minimum hasilat dərəcəsi və ya qaz axını quyunun müəyyən edilmiş quyudibi təzyiqinə uyğundur.

Açar sözlər: qaz-kondensat quyuları, maye hissəcikləri, axın sürəti, qaldırıcının diametri, quyudibi təzyiq, optimal rejim, böhran sürət, maye tıxacı.

ОПРЕДЕЛЕНИЕ ДИАМЕТРА ПОДЪЕМНИКА ПО МИНИМАЛЬНОМУ ЗНАЧЕНИЮ ПОТЕРЬ ДАВЛЕНИЯ В ТЕЛЕ СКВАЖИНЫ В ГАЗОВЫХ И ГАЗОКОНДЕНСАТНЫХ СКВАЖИНАХ

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РЕЗЮМЕ

В статье рассматриваются вопросы управления добычей путем определения оптимального режима работы газовых и газоконденсатных скважин. В первую очередь рассматриваются методы выбора технологического режима работы скважин и в зависимости от особенностей месторождения принимается решение о целесообразности применения того или иного метода. Результаты бурения скважин в горнодобывающих условиях подробно изучаются, эти параметры уточняются путем составления отчетов и предлагаются оптимальные параметры. На основании известных параметров скважин подбирается оптимальный технологический режим для каждой отдельной скважины. При этом обобщенный технологический режим выбирается на основе средних значений параметров. Изучаются связи между скважинами и скважины, которые связаны друг с другом, отбираются в группу. Затем для каждой группы определяется новый оптимальный режим. Удаление жидкостей и твердых веществ из нижней зоны газоконденсатных скважин

зависит в первую очередь от скорости восходящего потока газа в стволе скважины или дебита скважины. Кроме того, он зависит от физических свойств газа, жидкости и твердых частиц, а также конструкции скважины, диаметра стояка и других параметров. Важно получить предварительную информацию о добывающих скважинах, учитывая, что подъем жидких и твердых частиц из нижней зоны газоконденсатной скважины на поверхность обычно происходит в конце стояка при минимальных расходах газа или минимальных уровнях добычи скважины. Минимальный дебит или расход газа, необходимый для эффективного удаления жидкости и твердых частиц из призабойной зоны скважины на поверхность, соответствует заданному забойному давлению скважины.
Ключевые слова: газоконденсатные скважины, частицы жидкости, расход, диаметр стояка, забойное давление, оптимальный режим, критическая скорость, пробка жидкости.

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