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MANAGEMENT OF THE PRODUCTION PHASE IN ULTRA-LOW PRESSURE GAS CONDENSATE WELLS

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Abstract. Ultra-low pressure gas condensate wells are becoming increasingly relevant to the oil industry due to the growing economic and environmental importance of gas condensate. In gas condensate reservoirs with low permeability, the development of new production strategies aimed at maximizing output is becoming ever more critical.This study presents efforts directed at developing an optimization model designed to determine rational switching times for ultra-low pressure gas condensate wells, taking into account changes in bottom-hole pressure and gas flow rates during production processes.To enhance the adaptability of production strategies, key parameters such as erosional flow velocity, critical liquid loading flow rate, and optimal differential pressure in reservoirs were considered.

Keywords:erosional flow velocity; ultra-low pressure gas condensate wells; optimization model; gas condensate production phase; gas condensate well shut-in period.

Introduction

Gas condensate, as a vital source of energy and chemical feedstock, offers the potential to reduce carbon dioxide (CO_2) emissions by serving as an alternative to coal and oil. In recent years, due to the growing economic and environmental importance of gas condensate, ultra-low pressure gas wells—despite their relatively low condensate production volumes—have become a focal point of attention in the oil industry. Nevertheless, in recent years, recoverable condensate reserves have declined significantly, and many low-pressure gas wells—though not entirely depleted—have become economically unviable, forcing operators to cease production. Numerous researchers have conducted scientific studies focused on investigating the problem of liquid accumulation in low-pressure gas wells. In their research, Turner and Coleman identified the minimum gas flow rate required for the continuous removal of liquids from gas wells (Turner et al., 1969; Coleman et al., 1991). Lea and colleagues analyzed various liquid lifting technologies, such as gas lift, former injection methods, small-diameter tubing, flow regulators, and downhole pumps (Lea & Nickens, 2004; William, 2010).

Odiljon Hayitov and Azamat Umirzoqov conducted an analysis of reservoir bedding conditions and developed recommendations for applying innovative methods in field development (Hayitov & Umirzoqov, 2021).

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However, scientific publications addressing methods for determining the production phase in low-pressure gas wells remain scarce. Yet, such methods may be critical in maximizing recoverable reserves in low-permeability gas reservoirs. The objective of this study is to develop and analyze a method for determining optimal production periods in low-pressure gas wells.

Researchers have presented empirical correlations widely used in analyzing the performance of gas reservoirs (Boogar & Masihi, 2010; Brage & Bjarne, 2013). In low-pressure gas reservoirs, this correlation is commonly expressed in the form of a pressure-squared relationship, mathematically represented as follows:

$$Q=c(P_r^2-P_w^2)^n \quad (1)$$

Where:

- Q – Gas flow rate,
- P_r – Average reservoir pressure,
- P – Bottom-hole pressure,

c and n – Numerical coefficient and characteristic exponent specific to the gas well.

In this equation, if the values of c and n are known, the gas flow rate (Q) can be calculated at any bottom-hole pressure, allowing for the construction of the well's flow performance curve.

Pressure and Production Capacity in Low-Pressure Gas Condensate Wells

During production in gas condensate wells, both pressure and production capacity decline over time. Although the pressure depletion process may be prolonged, this method has not been widely used for evaluating gas condensate reservoirs, primarily because it requires a constant flow rate.

According to the analysis conducted by Wattenbarger (1968), reasonable results can be obtained by expressing the gradual pressure decline in terms of pressure squared. Furthermore, Darcy flow (nonlinear flow) is frequently observed in gas reservoirs with low permeability. Therefore, in low-pressure gas condensate wells, the bottom-hole flow pressure is typically simplified based on standard assumptions as follows:

$$p_{wf}=\sqrt{p_r^2-\frac{Q_{sc}p_{sc}T_i\mu_i Z_i}{2\pi K h T_{sc} Z_{sc}}\log\frac{4\eta T_o}{\gamma r_w^2}} \quad (2)$$

Where:

P_w – Bottom-hole flow pressure,
P_r – Average reservoir pressure,
Q – Gas flow rate,
T_i – Reservoir temperature,
T_s – emperature at standard conditions,
μ_i – Gas viscosity under reservoir conditions
Z_i – Gas compressibility factor under reservoir conditions,

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γ – Relative gas density,
$Z_{s.c.}$– Gas compressibility factor at standard conditions,
K – Reservoir permeability, r_o – Wellbore radius,
h – Reservoir thickness, r – Gas well radius.
T_o – Gas well production time

If reservoir permeability deteriorates or improves (for example, in cases of formation damage or stimulation near the wellbore), additional parameters must be incorporated into Equation 2 to account for these effects.

$$p_{wf} = \sqrt{p_r^2 - \frac{Q_{sc} p_{sc} T_i \mu_i Z_i}{2\pi K h T_{sc} Z_{sc}} \left(\ln \frac{4\eta T_o}{\gamma r_w^2} + 2S_a \right)} \quad (3)$$

Governing Equations for Low-Pressure Gas Wells:
Here, S_a represents the skin factor, which is determined based on the well test plot. By substituting the pressure decline over time (T_o) into Equation (3), the gas flow rate (Q) can be expressed as follows:

$$Q_{sc1} = c^{\frac{1}{1-n}} \left[\frac{p_{sc} T_i \mu_i Z_i}{2\pi K h T_{sc} Z_{sc}} \left(\ln \frac{4\eta T_o}{\gamma r_w^2} + 2S_a \right) \right]^{\frac{n}{1-n}} \quad (4)$$

Where:

Q_{s1} – Gas Flow Rate During Pressure Decline,
S_a – Skin factor, representing the condition of the filtration zone around the gas well.

Optimization Model for the Production Cycle.

According to studies conducted on low-pressure gas wells that have been producing gas condensate in Uzbekistan for several decades, the reservoir pressure in such wells drops rapidly within a few hours during production and recovers within a few hours once the well is shut in.

Additionally, these gas condensate wells are typically opened and closed manually, and most are located more than 30 minutes away from the collection station.

Taking into account the pressure fluctuations and the operational control of low-pressure gas wells, the following fundamental assumptions are made:

• The reservoirs under consideration are closed-loop gas reservoirs, and pressure disturbances can propagate to the reservoir boundaries.

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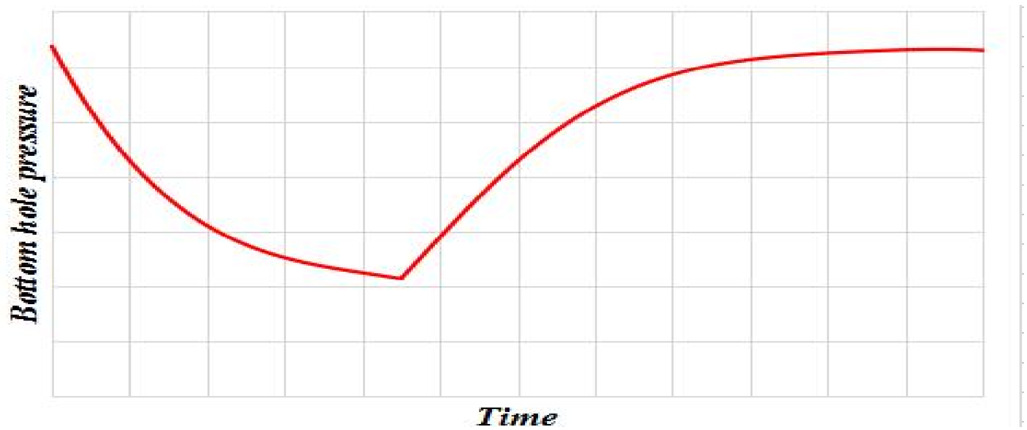
- Flow within the reservoir is assumed to be unsteady (transient).
- The gas retention effect within the wellbore is neglected.
- For operational convenience, the minimum production time for gas wells is limited to 6 hours.

As noted above, the overall gas condensate production process in low-pressure gas wells consists of two stages: a **pressure drawdown phase** and a **pressure buildup phase**. The changes in bottom-hole pressure and flow rate during these two phases are illustrated in the figure below.



Variation of Bottom-Hole Pressure and Flow Rate in Low-Pressure Gas Wells.

In order to determine the optimal production cycle for each low-pressure gas condensate well, the initial production time (**T_0**) (or the shut-in time – **T_γ**) is assumed to vary from 0 to **T** in 0.5-hour increments. Then, the required parameters are calculated within the optimization model described above, and the process continues until the model conditions are satisfied.

According to the optimization method proposed in this article, the gas condensate production period is 4.5 hours, while the pressure buildup period lasts 7.5 hours. Thus, the gas well produces gas condensate twice per day, with each full production cycle lasting 12 hours.

Moreover, the exact production times for gas condensate can be scheduled in accordance with the operational routines of different companies. In this practical example, the gas well operates as follows:

- From **6:00 AM to 10:30 AM**
- From **6:00 PM to 10:30 PM**

During the remaining time, the well remains shut in for pressure recovery.

During the application of this method, fluids within the well are discharged, and compared to continuous production cycles, the product output volume is estimated to increase by 13.4%. The solution and optimal control method proposed in this study will assist engineers in developing a more reliable gas condensate production strategy, ultimately ensuring the stable and long-term production of low-pressure gas condensate wells.

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Conclusion

Scientific ideas were proposed for developing an optimization model to determine the production cycle for ultra-low-pressure gas condensate wells. This model incorporates both the pressure drawdown during gas condensate production and the pressure buildup process when the well is shut in. Based on the work conducted in this paper, the following results and conclusions can be drawn:

- The primary goal of this approach is to determine the optimal switching times for ultra-low-pressure gas condensate wells (for both the gas condensate production cycle and the well shut-in period).
- The research considers erosion flow rate, the critical flow rate for liquid loading, and the pressure differential in the reservoir.
- The method proposed in this study, when applied to the selected gas well, resulted in a smooth variation of pressure inside the wellbore, and a significant increase in gas condensate production volume is expected.

References:

1. B. Akramov, B.Z. Adizov "Oil and Gas Technologies" Tashkent – 2019.
2. B.Sh. Akramov, R.K. Sidiqxo‘jayev, Sh.X. Umedov "A Handbook on Gas Production" Tashkent – 2012.
3. O.G. Hayitov, Sh.X. Baxronov, A.A. Umirzoqov, Sh.O. G‘afurov "Efficiency of Operating Kulbeshkak Gas Condensate Field" Scientific Progress – 2021.
4. A.B. Eshmuratov, Gulnara Abatbay qizi, K.A. Uzakbaev "Designing Systems for Gas Condensate Field Development" Science and Education – 2023.
5. Uzakbaev, K.A. O.G. L. "Requirements for Well Products in Gas and Gas Condensate Fields" Science and Education – 2022.