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# Optimization of the Technological Operation of USTYURT Gas Production Wells

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**ABSTRACT:** Increasing the final gas recovery of developed fields is an important task, the solution of which determines the savings of significant financial resources for geological exploration work to discover new fields. Extending the service life of water producing wells in the Ustyurt fields is one of the solutions to the problem of increasing their gas recovery, which also leads to savings in capital costs for drilling new wells instead of those abandoned due to watering.
In this regard, research is relevant to find the optimal parameters of the technological operating mode of the Ustyurt wells, aimed at minimizing the water cut of their products, which will extend the period of their operation. These studies are based on a detailed systematic analysis of geological and field characteristics and materials from gas-hydrodynamic studies of wells in the Ustyurt fields.

**KEY WORDS:** multi-layer field, natural gas, optimal process parameters, well, gas recovery reservoir, water influx, gas-hydrodynamic well testing, production of gas production wells, bottomhole pressure, reservoir pressure, well flow rate, bottomhole temperature.

## I. INTRODUCTION

Favourable prospects for the increase in hydrocarbon reserves of the fields of the Ustyurt region in Uzbekistan, the specifics of their geological structure: multi-layered productive section; the high initial water saturation of gas deposits producing an increased water content in the produced gas from the very beginning of well operation, led to research on optimizing the parameters of the technological operating mode of gas production wells. This optimization is aimed at minimizing the water content of the produced gas and, thereby, extending the life of wells with a corresponding increase in the final gas recovery of the formation.
Prospecting and geological exploration work to identify hydrocarbon deposits is very expensive, so increasing gas recovery from already developed fields is an important task, the solution of which helps to save significant financial costs in the oil and gas industry.
Since drilling new wells in the Ustyurt fields, instead of those being retired, mostly due to watering, is not always economically justified, extending the life of existing wells, which increases the gas recovery of the deposit, also helps to save financial costs for additional drilling.
The above has led to research to optimize the parameters of the technological operating mode of gas production wells, minimizing water content of their products. These studies are based on a detailed system analysis of the geological and field characteristics of the Ustyurt fields and materials from gas-hydrodynamic studies of their wells.

## II. METHODOLOGY

Gas-hydrodynamic studies (GHS) of wells can be primary, current and special [1].
Primary hydrodynamic testing is carried out on exploration and production wells in order to determine formation parameters, productive characteristics of wells and production capabilities of the field, as well as the relationship between formation flow rate, bottomhole and wellhead pressures and temperature, establishing the operating mode of wells and the presence of liquid and solid particles in their products, degree and quality of formation opening, etc.
Current hydrodynamic testing is carried out during the operation of wells in order to obtain the necessary information for analysis and control over development. At the beginning of development, hydrodynamic testing is carried out at least once a quarter, covering 25% of the existing well stock. After the field has entered the main stage of development, its

reserves are assessed based on well operation data (gas extraction, reservoir pressure dynamics), the frequency of hydrodynamic testing with reservoir pressure measurements is 1-2 times a year, covering at least 50% of the well stock [2].

Special studies are carried out to determine specific parameters in specially selected wells: intervals of formation fluid inflow; control over the position of the gas-water contact; studying the degree of corrosion of downhole equipment in various operating modes; determining the degree of depletion of individual layers during development and the possible flow of gas from one horizon to another when they are opened with a single filter; studying the influence of carried-out fluid and rock (in the event of destruction of the bottom-hole zone of the formation) on well productivity; carrying out intensification work - additional perforation, hydrochloric acid treatment, hydraulic fracturing or strengthening of the bottomhole formation zone, installation of cement bridges, etc.

During the hydrodynamic testing process, the following well parameters are determined:

- static pressure at the wellhead and formation pressure determined on its basis;
- bottomhole pressure in various operating modes and formation pressure according to measurements with a downhole pressure gauge;
- the process of pressure recovery and stabilization, recorded at certain intervals with a depth or standard pressure gauge;
- flow rate determined from the data of a puck or diaphragm critical flow meter (DICT);
- quantitative and qualitative characteristics of liquid and solid impurities carried out with its products;
- temperature at the bottom, along the trunk and at the mouth.

to carry out gas-hydrodynamic studies of a well in five direct and one reverse modes of its operation with mandatory measurement of pressure and temperature with an electronic pressure gauge-thermometer [3].

When using DICT for hydrodynamic testing, a prerequisite is a critical outflow of gas through the washer or diaphragm in this device [3]. If this condition is met, hydrodynamic testing of the well is carried out in a plume, that is, without releasing gas into the atmosphere. In this case, if the critical exhaust is not observed in any mode, the hydrodynamic data processing is performed taking into account the back pressure in the loop according to the formula [1]:

$$Q = 1700\,\alpha\,\varepsilon\,K_1\;K_2 d^2\sqrt{\frac{1}{\gamma\,T\,Z}}\,\sqrt{PH_{\text{рт}}},\ (1)$$

where P is the absolute pressure in front of the diaphragm; $H_{Hg}$ – measured pressure difference in mm Hg; d – diameter of the diaphragm opening, cm; z – compressibility coefficient; T – gas temperature in front of the diaphragm; $\bar{\gamma}$ – relative gas density; α – flow coefficient; ε – correction factor for jet expansion; $K_1$ – correction factor for the non-sharpness of the entrance edge of the diaphragm; $K_2$ – correction factor.

The flow coefficient (α) is determined depending on the diaphragm module $m = d^2 / D^2$ according to the graph in [1], the correction factor for the jet expansion (ε) is determined from this graph depending on the ratio $\frac{H_{\text{рт}}}{P_{\text{рт}}}$ and module of the diaphragm, where D is the diameter of the pipeline.

The correction factor for the bluntness of the entrance edge of the diaphragm ($K_1$) is determined in cases where the edge of the diaphragm hole has a bluntness noticeable to the naked eye (rounding). Then, depending on the ratio d/D tabulated in [1], the value ($K_1$) is determined. At small gas flow rates and a large value of the $d^2/D^2$ ratio, the coefficient (α) depends on the Reynolds number (Re). In this case, the coefficient α is multiplied by the correction factor ( K2 ), depending on the Re value and the $d^2/D^2$ ratio [1].

Critical parameters (Pcr and Tcr) and relative gas density are calculated based on its component composition during hydrodynamic testing [3].

Based on the research performed in [4], approaches were developed to determine the optimal parameters of the technological operating mode of a gas production well, minimizing the presence of water in its production. Let's look at the example of well 77 GCF Sharkiy Berdak determines the optimal parameters of the technological mode of its operation according to the approaches to their determination in [4].

Well data:
production casing – 122 mm - 2724 m;
slaughter – 2698 m;
artificial face – 2698 m;
perforation intervals – 2367-2360; 2354-2348 m (horizon $J_2^{3a}$);
Tubing –73 mm – 2340 m.

When processing the results of gas-hydrodynamic studies of wells 77 (Table 1), the critical parameters and relative gas density obtained from the composition of the reservoir gas were used: $P_{cr}$=46.66 kgf/cm$^2$; $T_{cr}$=203.89 K; $\bar{\rho}$ =0.6410.

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GDI well 77 were carried out in three modes - on washers with a diameter of 16, 14 and 12 mm, installed alternately in the DICT.

According to the methodological instructions of [1], gas flow and liquid yield were determined, incl. condensate and water presented in Table 1. As follows from this table, the specific content of water carried out by the produced gas varies from 4.96 $cm^3/m^3$ - with a washer diameter of 16.0 mm to its complete absence in the produced gas - with washer diameter 12.0 mm.

According to the instructions in [3], the moisture content of the formation and separation gas is determined under the conditions of hydrodynamic testing (Table 2).

Analyzing the results of calculations presented in tables 2, 3, we come to the conclusion that the smallest removal (lack of water) of water in well products 77 is noted in the third operating mode of the well 77 – with a washer with a diameter of 12 mm. From a comparison of the moisture content with this indicator in reservoir conditions (5.5 $g/m^3$), we come to the conclusion that the water carried out by the gas is standard (relict). This conclusion is also confirmed by the results of a chemical analysis of the composition of the water carried out, presented in Table 3. From this table it follows that the concentration of chloride ions in the water carried away by gas during well hydrodynamic testing 77 is 6162.4 – 4910.8 mg/l (regimes 1, 2). The concentration of these ions in the formation water of the Sharkiy Berdakh gas condensate field is 88,000-115,000 mg/l [5], which is an order of magnitude higher than the analyzed water (Table 3). At the same time, in [4] it is noted that the indicator of the beginning of the appearance of formation water in the production of gas production wells of the Sharkiy Berdakh gas condensate field is the concentration of chloride ions in the water carried out above 2900 mg/l. That is, in the water carried out in modes 1, 2 there are already signs of the presence of formation water attributed to the calcium chloride type [5]. In mode 3 (washer diameter 12 mm), no water removal was noted, although this mode is characterized by a gas velocity at the bottom of 5.91 m/s (Table 2), which is higher than the limit - 5.0 m/s, which determines the complete removal of liquid from slaughter [3].

Analyzing the results of hydrodynamic data processing obtained above, we come to the conclusion that the optimal operating mode of well 77, when the removal of formation water is minimal or completely absent, occurs when installing a 12 mm fitting, causing a gas flow rate of 70.22 thousand $m^3$/day.

## III. CONCLUSION

The proposed approaches to establishing optimal parameters for technological operating modes of gas production wells are based on a systematic analysis of the results of hydrodynamic testing of Ustyurt wells under stationary filtration modes in the presence of formation water in the produced gas in any operating mode. These approaches make it possible to establish optimal parameters for the technological operating mode of a water-producing gas well, minimizing water content of its products during the development of Ustyurt multi-layer gas condensate fields, which have a very complex geological structure. The established optimal parameters of the technological operating mode determine the extension of the life of gas production wells and, thereby, contribute to an increase in the final gas recovery of the field.

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Table 1 – Well hydrodynamic testing results . 77 GKM Sharkiy Berdakh

| Washer diameter, mm | Pressure on the head, kgf/cm² | Gas consumption, thousand m³/day | Reservoir | | Depression on the formation, kgf/cm² | Gas speed at the bottom, m/s | Separation conditions | | Liquid output | | Sod. C5+in ext. gas, g/m3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | pressure, kgf/cm² | temperature, °C | | | pressure, kgf/cm² | temperature, °C | condensate, g/m³ | water, cm³/m³ | |
| 16.0 | 24.10 | 84.86 | 71.7 | 81.9 | 34.80 | 8.99 | 20 | thirty | 19.23 | 4.96 | 34.38 |
| 14.0 | 29.10 | 79.25 | | | 30.72 | 7.51 | 18 | 28 | 24.46 | 2.97 | 41.58 |
| 12.0 | 34.71 | 70.22 | | | 25.89 | 5.91 | 16 | 26 | 26.59 | | 45.39 |

Note: the well was examined after workover.

Table 2 – Results of determining the moisture content of gas during well hydrodynamic testing . 77

| Washer diameter, mm | Pressure kgf/cm² | Temperature, °C | Moisture content of gas, g/m³ |
|---|---|---|---|
| In the reservoir | 71.7 | 81.9 | 5.50 |
| 16.0 | 20.0 | 30.0 | 2.00 |
| 14.0 | 18.0 | 28.0 | 1.90 |
| 12.0 | 16.0 | 26.0 | 1.80 |

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Table 3 - Chemical composition of water (mg/l) carried out with gas during well hydrodynamic testing . 77 GKM Sharkiy Berdakh

| Mode | $Na^{++}$ $K^{+}$ | $Ca^{2+}$ | $Mg^{2+}$ | $Cl^{-}$ | $HCO_3^{-}$ | $CO_3^{2-}$ | $SO_4^{2-}$ | Total mineralization | $CO_2$ | $Fe^{2+}$ | $Fe^{3+}$ | Specific gravity at 20°C | pH | Type of water according to Sulin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | 890.1 | 1891.8 | 544.8 | 6162.4 | 134.2 | 0 | 91.3 | 9714.6 | 2.2 | 0 | 4.7 | 1.006 | 7.9 | Calcium chloride |
| II | 413.2 | 1396.8 | 666.4 | 4910.8 | 146.4 | 0 | 96.1 | 7639.7 | 2.2 | 0 | 5.6 | 1.004 | 8.1 | Calcium chloride |

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