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Issue Article

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THE CHOICE OF THE METHOD OF OPERATION OF WELLS AND EQUIPMENT FOR DUAL COMPLETION EXTRACTION OF GAS AND OIL

Abstract: *The article, based on laboratory studies, substantiates the scope, efficiency, reliability and the possibility of maximum extraction of oil reserves from multi-layer oil and gas horizons with a large depth of occurrence, composed of weakly cemented rocks. The article also considers the possibility of using various methods of mechanized oil production in relation to the conditions of the Altyguyi field.*

The use of the latest technologies helps to increase the production potential both by extracting hard-to-reach oil from long-exploited fields, and by putting into development previously inaccessible deep-lying oil horizons.

Currently, the oil industry of Turkmenistan is facing the issue of involvement in the active development of hard-to-recover oil reserves, the bulk of which is located in low-permeability reservoirs. The importance of solving this problem is determined by the depletion of reserves in long-exploited areas with a sharp decrease in well productivity.

Based on the results of the conducted research, the justification of the choice of downhole equipment was carried out, taking into account the need for for dual completion (DC) operation.

Key words: *curvature, injection, defect, overflow, packer, sandstone, siltstone, pressure gauge, elevator, filter zone, ejector, working agent, geothermal gradient, thermal equivalent.*

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Introduction

A number of geological and commercial, climatic and technological factors are manifested at the Altyguyi deposit, which characterize the operation of wells as operation in complicated conditions.

As of 01.01.2014, the operation of the NK-9 oil horizon is carried out by 24 wells, of which oil is taken in 23 by the fountain method, in 1 by the gas lift method.

The main features that complicate the operation of oil wells of this field are:

- large depths of productive formations in the range of 3603 - 3740 meters;
- over the years, the daily flow rate of liquid varies from 60 to 43 tons.
- high initial pressures drop sharply, respectively, the liquid level in the wells decreases;
- initial reservoir pressure (652 kgf/cm^2);
- operation of wells at pressures below saturation pressure;
- high values of the gas factor (540-220 m^3/t);
- curvature and curvature of well pillars;
- oil formations have a sharp degree of cementation from dense sandstones and siltstones to loose sands and siltstones, which leads to sand formation;
- the extracted oil is highly paraffinic;
- productivity coefficients vary widely;
- the estimated depth of gas input into the lift of gas lift wells from the mouth is currently 2000m, this depth will grow and reach up to 3500m.

The choice of mechanized methods of oil production at the Altyguyi field is carried out taking into account the above factors. In addition to them, relief climatic conditions, inter-repair periods, the presence of paraffin and mechanical impurities in the extracted liquid, the reliability of equipment, the need for maintenance personnel and repair equipment, ease of maintenance in the process of mechanized oil production, production capabilities, the need for energy resources are also taken into account [1, 2].

The Altyguyi deposit is a multi-layer one. By the nature of saturation, the presence of pure oil deposits, pure gas deposits and gas deposits with oil rims is noted. For most deposits, the mixed regime is characterized by the predominance of the energy of gas released from oil and the manifestation of the activity of contour waters at a later stage of development. Under conditions when liquid is extracted from oil reservoirs, gas extraction is required, which serves as a working agent.

The development project does not provide for the maintenance of reservoir pressure, and therefore the exploitation of deposits will be carried out with a continuous drop in reservoir pressure, a decrease in static fluid levels in wells and an increase in the height of its rise.

In [3, 4], on the basis of laboratory research, the substantiation of the scope, efficiency, reliability and the possibility of maximum extraction of oil reserves from multi-layer oil and gas horizons with a large depth of occurrence, composed of weakly cemented rocks, is given. In these works, the criteria for choosing rational methods of mechanized oil production are given. The article also considers the possibility of using various methods of mechanized oil production in relation to the conditions of the Altyguyi field.

Analysis of the conditions of application of the ejector pump. The inexpediency of using ejector pumps is explained by the fact that the interval of occurrence of productive layers is very deep. The depth of descent of ejector pumps is 1000-2000 meters, at the places of reception of products, the volume of free gas should be above 50-70%. The wells of the Altyguyi deposit do not meet these requirements.

Analysis of the conditions of application of the installation of an electric centrifugal pump (ESP). The main criterion that determines the inexpediency and impossibility of application is the large depth of wells - from 3600 to 3700m. The maximum depth of the ESP descent does not exceed 1600m. In addition to this limiting factor, there is also the presence of a high gas content in the pumped liquid and the planned flow rates, which are significantly lower than the minimum performance of the ESP. These factors are opposed to the possibility of using ESP in limited quantities at this field.

Analysis of the conditions of application of the installation of a rod depth pump (IRDP). In the conditions of the Altyguyi deposit, the use of IRDP has a very limited area. However, IRDP is distinguished by the perfection of its design, a wide range of manufactured equipment of the normal range, as well as ease of maintenance. Installations of rod depth pumps can be used up to a depth of 2300 meters and when pumping liquid from relatively shallow depths. They are inferior in developed pressure only to hydraulic piston installations, can be effectively used in low-flow wells up to 10 tons with high water content of products. Limiting factors of their application are: high gas factors, large depths, curvature of boreholes less than 7 degrees. With an increase in the depth of the pump descent, the reliability of its operation decreases, the degree of leakage through the gaps increases, and the repair period is also shortened [5].

The modern normal range of drives of the deep pump of the rocking machine (RM) and downhole pumps of the plug-in type allow theoretically lifting liquid from depths of 3500m.

However, with such a large pump descent, due to the insufficient operational reliability of the pumping pipes and rods, problems arise related to the provision of the repair base of the fields.

In the conditions of the fields of Turkmenistan, oil production by IRDP installations is provided from a maximum depth equal to 2300m. Due to the influence of various negative factors, the actual feed from a depth of 2300 m does not exceed 5.3 m / day with a feed ratio of no more than 0.17.

Thus, the use of IRDP installations at this field cannot be considered as promising. In addition to low productivity, when using the IRDP, irrational expenditure of material and energy resources is expected due to a significant decrease in the reliability of the IRDP equipment when pumping liquid from wells with sand, the formation of paraffin and salt deposits, rod breaks and other malfunctions. According to the existing experience of IRDP operation in such conditions, the operating coefficient is significantly reduced, which does not exceed 0.7 for similar fields in Turkmenistan. Based on the above, the use of the method of oil extraction by IRDP installations is not recommended at this field.

Analysis of the conditions for the use of ISHP (submersible piston pump with hydraulic drive). Block automated installations of hydraulic piston pumps (ISHP) are designed for the operation of 2-8 cluster directional and deep wells (over 4000m) with low dynamic levels (3000m) and with debits up to 100 m^3 /day. The small dimensions of these pumps allow them to be lowered into wells with an internal diameter of the production column of 117.7-155.3 mm.

The principle of operation of the installation is based on the use of hydraulic energy of a liquid pumped under high pressure through a special channel into a hydraulic downhole reciprocating piston engine, which converts this energy into reciprocating motion of a piston pump rigidly connected to the engine.

These pumps have a high efficiency (0.65), which decreases slightly with a decrease in the dynamic level in the wells. The distinctive ability of hydraulic piston pumps is the possibility of using the same unit to work with different pressures, i.e. to operate wells with different depths and to take liquid in the right quantities.

As hydraulic piston installations, IHP 25-150-25, IHP 40-25 0-20, IHP 100-200-18 are recommended.

Hydraulic piston units of the discharged type HP are recommended for pumping reservoir fluid from wells- 59-89-10-118 , HP-59-89-25-25 , HP-59-89-40-20 .

According to their production characteristics, ease of operation, they fully meet the operating conditions of the Altyguyi deposit. However, at this stage, we do not envisage the use of these installations. For their use, it is necessary to carry out special work from the point of view of choosing rational technological schemes in relation to the conditions of this deposit. It is also necessary to study the energy technical and economic indicators, without which the choice of a rational method cannot be carried out. We consider it expedient to use them at the final stage, when wells will be operated with a water content of more than 90% and there is a need to transfer them from mechanized methods of oil production to ISHP [6].

Analysis of the conditions for the use of installations of submersible screw electric pumps. Installations of submersible screw electric pumps are designed for pumping reservoir fluid of increased viscosity from oil wells.

The most effective operation of these installations is wells with a low coefficient of productivity, high gas content, high viscosity of oil in reservoir conditions.

Installations of submersible screw electric pumps is produced for reservoir fluid with a temperature of up to 70 °C, the maximum viscosity of which is 1-10 m/s, the content of mechanical impurities is not more than 0.8 g/l, the volume content of free gas at the pump intake is not more than 50%, hydrogen sulfide is not more than 0.01 g/l.

When operating installations in conditions other than those indicated (increased content of mechanical impurities, gas content, temperature of the pumped liquid, curvature of the borehole more than 17 degrees), the pump resource is reduced due to wear of the working elements, which leads to premature failure of it.

Pilot-industrial introduction of German-made electric screw pumps of the NTZ-240.DT16 brand is underway in the fields of Turkmenistan. Their theoretical supply is 15-30 m^3 / day, the maximum depth of descent is 1900 m, the volume content of free gas at the pump intake is not higher than 50%.

Practice has shown the possibility of their use only in vertical wells and unreliability, impossibility of application in curved wells. The actual pump supply is not higher than 15 m^3/day, the content of mechanical impurities is undesirable, due to the poor quality of plastic, the elastomer quickly fails (within 1-1.5 months).

Thus, electric screw pumps, taking into account the above, have a very limited scope of application and can be used at the Altyguyi field in vertical, low-yield wells with a dynamic level of at least 1700m, at a reservoir temperature of the pumped liquid not higher than 70 °C and the volume content of free gas at the pump intake is not more than 50%.

Analysis of the conditions of application of the gas lift method of oil production

The gas lift method of oil production has been widely used in the fields of Turkmenistan, including Altyguyi.

The extraction capabilities, as well as the reliability of the use of gas lift operation, have shown that it is more efficient than other methods of mechanized extraction.

The conditions for lifting the liquid in a gas lift well mainly depend on the parameters of the lift itself, the pressure of the working agent and the parameters of the reservoir. The greatest role is played by the height of the liquid rise. At the Altyguyi field, specific factors are: a high lifting height, low flow rates, an increase in the water content of products over time, the availability of working agent (gas) resources.

The practice of gas lift operation at this field proves the expediency of its use both in continuous and periodic lifting of liquid. For the purpose of the most efficient operation, wells with debits above 30 t/day are recommended to be operated with a continuous gas lift. Wells operating with debits below 30t/day should be operated with a periodic gas lift. In the conditions of this field, a periodic gas lift is the most realistic, ensuring the design production volumes until the end of the field development.

When studying the geological and operational characteristics of the field, it was revealed that oil and gas layers alternating in productive horizons are isolated from each other by impermeable layers having relatively large thicknesses. To a large extent, gas formations overlap oil formations by area, which creates favorable conditions for the implementation of methods simultaneously-separate operation of oil and gas facilities by one well. At the same time, it is also advisable to partially use the technology of the downhole gas lift, the most efficient method of operation that does not require additional capital investments.

The use of the latest technologies helps to increase the production potential both by extracting hard-to-reach oil from long-exploited fields, and by putting into development previously inaccessible deep-lying oil horizons. The technology with multipacker-sectional layouts makes it possible to refine the basic highly watered, depleted oil formations with good profitability until the planned oil recovery is achieved, together with the connection of new anhydrous oil deposits into dual completion (DC) development under certain conditions.

Currently, the oil industry of Turkmenistan is facing the issue of involvement in the active development of hard-to-recover oil reserves, the bulk of which is located in low-permeability reservoirs. The importance of solving this problem is determined by the depletion of reserves in long-exploited areas with a sharp decrease in well productivity.

Let's consider the technology of dual completion extraction of oil and gas from the well of the Altyguyi field, which should open the productive layers of the red-colored deposits NK_7, HK_8 and NK_9, and the layers NK_7 and HK_8 are gas, and NK_9 are oil.

As follows from the above, the rise of gas from two layers of NK_7, HK_8 in the well along one tubing column leads to a significant pressure drop between the filter zone and the wellhead, which required special calculations of the temperature regime of wells to identify the conditions of hydrate formation in the wellhead zone of the tubing.

Using the methodology described in [7], calculations were performed according to the formula:[13]

$$T_x = T_{b.} - G_x \frac{1-e^{-a_m x}}{a_m}\left[G_m - \frac{D_i(P_{b.} - H_x}{x} - \frac{A}{C_r}\right]\beta \qquad (1)$$

where T_x is the temperature of the gas at a depth of x, ° C; [13]

G - average geothermal gradient, °C/m;

D_i is the Joule-Thomson differential coefficient in the borehole. [13]

°C/kgf/cm^2;

P_x - pressure at depth x, kgf/cm^2;

A - thermal equivalent of mechanical work, 1/427, kcal/kg*m; (P + P) [13]

C_r is the average heat capacity of the gas at $P_{av.} = \frac{(P_b + P_x)}{2}$ kcal/kgf;

α is the coefficient, $\alpha = \frac{2\pi\lambda}{GC_r f(\tau)}$;[13]

here λ is the thermal conductivity of rocks, kcal/m *hour*°C;

$f(\tau)$ is a dimensionless function of time [13]

$$f(\tau) = Ln(1 + \sqrt{\frac{\pi\lambda_g \tau}{C_n R_c^2}});$$

The calculation was made for the projected (conditional) well intended for DC. [13]

In accordance with the calculation method, given the final temperature corresponding to the equilibrium conditions of hydrate formation (T at P_m) after determining the reduced values of pressure and temperature: [13]

$$P_{giv} = \frac{P_{aver.}}{P_{cr.}}$$

where P_{cr} is the critical pressure,

$$T_{giv.} = \frac{T_{aver.}}{T_{cr.}}$$

where $T_{cr.}$ is the critical temperature according to the corresponding functional dependencies, the following are defined: [13]

- the heat capacity of the mixture $C_p = C^0{}_p + \Delta C_p$

where ΔC_r = f (T_{giv}, $P_{giv.}$) is the function of d (Di) = 0.4 (according to the values of of P_{giv} and T_{giv}), the value of the Joule-Thomson coefficient is further determined [13]

$$D_i = \frac{T_{cr} f(D_i)}{P_{cr} C_r}$$

The calculation result in terms of determining the Joule-Thomson coefficient was also checked using the analytical formula of I.A. Charny, derived on the basis of thermodynamic calculations in accordance with the Vander-Waals real gas model [8, 9]. [13]

The average throttle effect according to I.A. Charny is calculated by the formula: [13]

$$T_o - T = \frac{(k-1)T_{cr.}(P_o - P)(7.12\, T_{cr.} - T_o)}{8kT_o P_{cr}} \qquad (2)$$

Pressure losses in downhole equipment are taken into account in cases when the formations are high-flow and the flow rate strongly depends on a slight change in depression on the formation.

The most characteristic elements of underground complexes in determining "additional" pressure losses (in relation to the total pressure drop in the tubing column) are packers and valves. Practical methods for determining pressure losses in downhole equipment have been developed, for example, described in [9]. The design features of packers and shut-off valves used in the CIS countries and by foreign firms make it possible to determine the losses arising in them as pressure losses when gas passes through a pipe segment or diaphragm. [13]

Productive layers of the lower red-color (NK) are located on average at depths: NK_7 - 3450; HK_8-3500; NK_9 -3600 meters and have reservoir pressures: NK_7 - 53.0 MPa; HK_8- 57.0 MPa, NK_9 - 65.0 MPa.

For the practical implementation of the method, a well is first drilled to a precisely selected depth under the 244.5 mm production column, so that it overlaps the upper gas layers NK_7 and NK_8, then the production column is lowered and cemented to the mouth. After that, the well is deepened to the design depth under 177.8 mm of the operational shank with the expansion packers, so that it overlaps the lower oil reservoir NK_9.

First, the lower oil reservoir is perforated, covered with a shank with a diameter of 177.8 mm on a polymer-lime solution (without clay particles) according to the temporary patent of Turkmenistan №. 380, a temporary elevator is lowered into the well, on the shoe of which a perforated pipe with a fitting is installed, the well is mastered, the operation of the well is investigated and the parameters of the lowest reservoir are removed, in our case, NK_9.

At the same time, gas-hydrodynamic studies must be carried out with a full (sufficient) set of downhole fittings and instrumental measurements of downhole and wellhead pressures, as well as measurements of oil, water and gas flow rates at each mode of the downhole fitting.

After that, the created well filter is temporarily blocked (with a clay-sand plug or an extractable packer plug) and the lower gas layer NK_8 is perforated with a casing with a diameter of 245 mm, similar to the previous one, on a polymer-lime solution (without clay particles). A temporary elevator is lowered into the well, on the shoe of which a perforated pipe with a fitting is installed, the well is mastered, the operation of the well is examined and the parameters of the second layer are removed from below, in our case NK_8. Then, the created NK_8 reservoir filter is temporarily blocked and these works are carried out with the overlying NK_7 gas reservoir.

After carrying out the above-mentioned works related to the perforation of all productive formations, conducting all gas-hydrodynamic studies on each formation separately and establishing the parameters of their operation, the well is washed to artificial bottom (if clay-sand plugs were used during temporary overlap), if temporary packer plugs were used during temporary overlap, then they are removed from the well with the help of cable cars. The process of flushing the well before the face is completed in such a way that the perforated intervals are blocked on a polymer-lime solution (without clay particles) according to the temporary patent of Turkmenistan № 380.

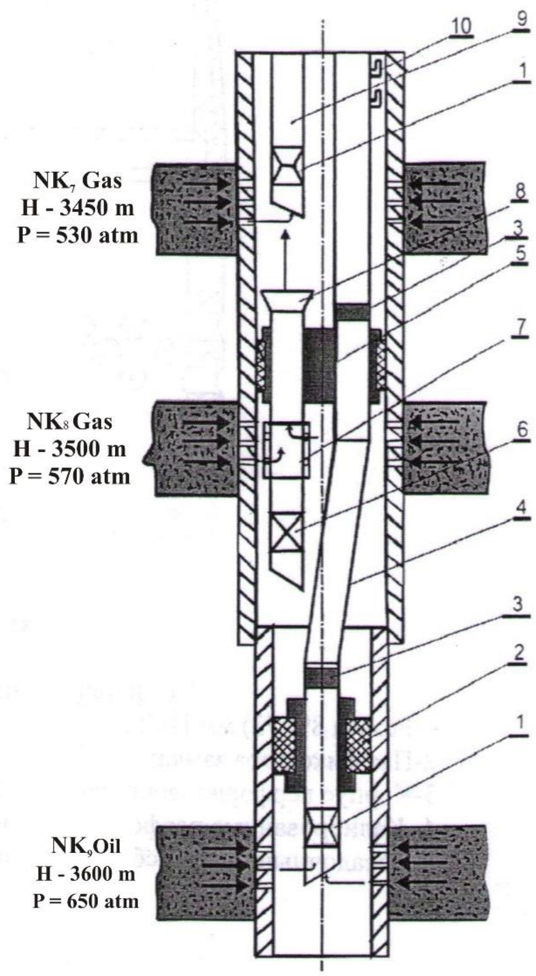

Figure 1. Diagram of downhole equipment for DC of oil and gas horizons

The installation sites of packers are being worked out with pear-shaped cutters, scrapers and templates of appropriate sizes [10].

A long row of tubing is lowered into the well according to Fig. 1., a long row of tubing is assembled (from bottom to top) from equipment: a landing nipple (1), a well repair device, a single-barrel lower packer

(2) for a 177.8 mm operational shank placed between the NK_9 and NK_8 layers on the tail (3); a double-barreled packer (4) for a 244.5 mm production column, the muffled trunk (5) of which is additionally equipped with a perforated branch pipe (6), inside which an extractable nozzle is placed a guide funnel (7) on a column of 89 mm non-coupling tubing with underground equipment (Fig.2) according to the patent of Turkmenistan №. 603 [11]. Adjust the locations of the packers according to the indications of the magnetic locator of the couplings, then reset the crimping device and create the appropriate hydraulic pressure inside the tubing and press all the packers that separate the productive layers from each other. A crimping device is removed from inside a long row of tubing.

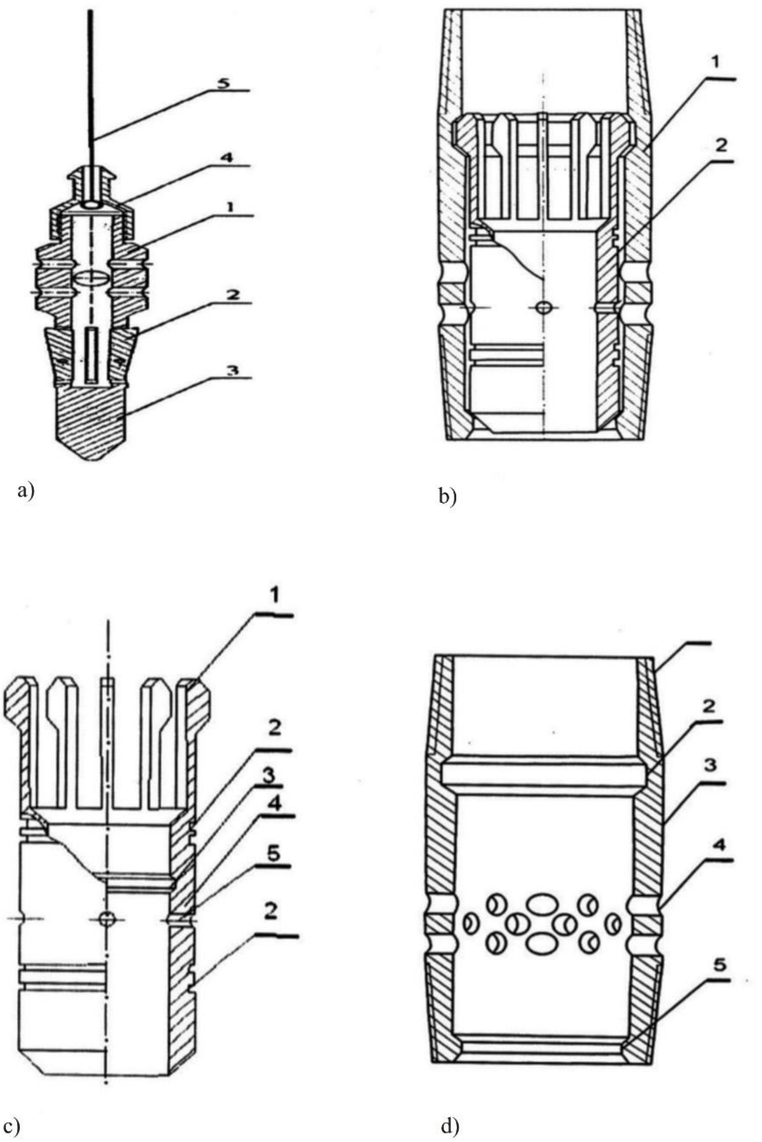

Figure 2. Layout of downhole equipment for DC

a) a perforated pipe (improved), b) a removable downhole fitting (additionally introduced), c) a perforated pipe with a downhole fitting, d) a catcher of the extracted downhole fitting (additionally used).

Then, a short row of tubing (8) assembled according to the patent of Turkmenistan № 603 is lowered into the well in parallel and the wellhead equipment is assembled, the well is mastered and put into operation. At the same time, the NK_9 formation works with oil in a long row separately, and the NK_8. NK_7 formations work with gas in a short row together, but separately from the NK_8 formation.

The technological effects of using the proposed method are due to: high technological efficiency; the possibility of studying and regulating the production of hydrocarbons from each operational facility; optimization of the technological mode of operation of the well as a whole for the well and the operating modes of each of the operational facilities, both by changing their characteristics and by changing the parameters of the well installation: independently affect each formation and process the bottom-hole zone of each object separately [12].

The economic effect of this technology is expressed in additional oil and gas production and reduction of capital investments for drilling and construction of additional wells. According to the current field development projects, the operation of each reservoir is provided for by a separate grid of production wells, i.e. for the operation of productive horizons NK_7, NK_8, NK_9, it is necessary to lay 3 wells, and according to the claimed method, this work is carried out by one well. Consequently, the total economic effect of using the claimed method will be from additional oil and gas production, as well as from a reduction in capital investments for drilling 2 additional wells.

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