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RESEARCH ARTICLE

JUSTIFICATION OF THE CHOICE OF RECOMMENDED METHODS OF OPERATION, DOWNHOLE EQUIPMENT AND CALCULATION OF GAS LIFT LIFTS FOR DUAL COMPLETION WELLS

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ABSTRACT

Based on laboratory studies, the article substantiates the scope of application, 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. Calculations are given for a periodic gas lift, in relation to the operating conditions of the Altyguyi field, where it is recommended to equip wells with a single-row replacement chamber with a packer and a check valve installed in the lower part of the tubing. The methodology of designing gas lift lifts, including the arrangement of starting and working valves, in accordance with the standard ones, taking into account the properties of reservoir fluids and projected well flow rates, is also presented. Based on the results of the conducted research, the justification of the choice of down hole equipment was carried out, taking into account the need for dual completion (DC) operation.

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INTRODUCTION

A number of geological and commercial, climatic and technological factors are manifested at the Altyguyi field, 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]. The Altyguyi field 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.

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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 [2,3], 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 field 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 field, 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 [4]. 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 [5]. *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 dual completion operation of oil and gas facilities by one well. At the same time, it is also advisable to partially use the technology of the down hole gas lift, the most efficient method of operation that does not require additional capital investments. The calculation of continuous gas lift lifts is reduced to determining the length, diameter of lifting pipes and specific gas consumption. The choice of the diameter of the lift pipes of the gas lift well is carried out in accordance with the volume of the filtered liquid in the area of the optimal operating mode of the lift. Practice shows that, depending on the flow rate of wells, the optimal sizes of lifts correspond to the data given in Table 1.

Table 1. Optimal sizes of lifts

Well flow rate, t/day	20-40	40-60	60-200	200-300
Lift diameter, mm	40,3	50,3	62	76

In field conditions, from the point of view of technological and mechanical characteristics, pipes of the "M" brand with a bore diameter of 62 mm have an unlimited scope of application. It is recommended to use a universal lift scheme that provides both periodic and continuous lifting of liquid (Fig. 1.). The above scheme is used in wells with a gas inlet depth of up to 3000 m. In wells with a depth of up to 4000 m or more, the lift layout shown in Figure 2 is used. For maximum fluid extraction, it is necessary to create minimum pressures at the bottom. Therefore, the depth of the descent of the lifting pipes should be maximum, i.e.

$$L = H - (20:30)m$$

where H is the distance to the upper filter holes, m.

For an annular system (the working agent - gas is injected into the annular space), the required specific gas consumption during continuous lifting is determined from the expression:

$$R = \frac{0,388\left[Lpg - (P_1 - P_2)\right]}{d^{0,5}(P_1 - P_2)Lg\,\frac{P_1}{P_2}}, m^3/t$$

where: P_1 is the working pressure, Pa (the working pressure is 8.5; 10.0; and 12 MPa);

P_2 is the wellhead pressure (the minimum allowable under operating conditions), we take it to be equal to $P_2 = 1.2x10^6$; $1.5x10^6$ Mpa;
ρ -the density of oil is assumed to be equal to 861 kg/m^3;
g-acceleration of gravity (9.81 m/sec^2);
d - diameter of lifting pipes, m;
L is the lifting height of the liquid, m.

The specific flow rate of the injected gas , taking into account the solubility of the gas , is determined from the expression:

$$R_{inj.} = R_{req} - \left[G_0 - \alpha\left(\frac{P_1 + P_2}{2}\right)\right](1 - \frac{n_w}{100}), m^3/t$$

where: G_0 is the gas factor (for oil), m^3/t;
α is the solubility coefficient of gas in oil, α = 0.4031 m^3/t. atm.
n_w is the water content of products, %.

The optimal specific flow rate of the injected gas calculated at an input depth of 2700, 3000m and 3500m (P_{work}= 8.5; 15.0 MPa) is, respectively, 200, 300 and 500 m^3/t and at a gas input depth of 3000 - 3500m (P_{work} = 10; 15 MPa) is, respectively, 150 ÷ 400 m^3/t.

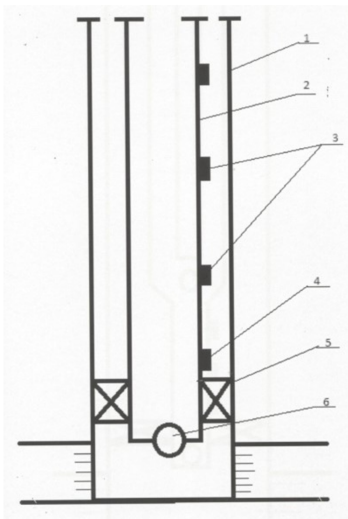

Fig. 1. Diagram of a universal gas lift

1- operational column; 2- elevator pipes; 3- starting valves; 4- working valve; 5- packer; 6- check valve.

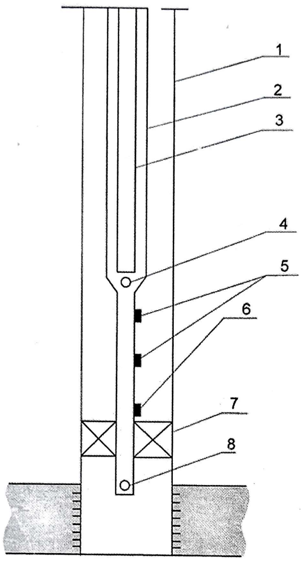

Fig. 2. Diagram of a stepped gas lift

1- operational column; 2- intermediate column; 3- upper stage of the elevator; 4, 8 – check valves; 5- starting valves; 6- working valve; 7- packer.

Calculation of the installation of a periodic gas lift with a replacement chamber

For periodic gas lift, in relation to the operating conditions of the Altyguyi field, it is recommended to equip wells with a single-row replacement chamber with a packer and a check valve installed in the lower part of the tubing (Fig. 3). In this case, the annular space between the tubing and the casing acts as a replacement chamber [6, 7].

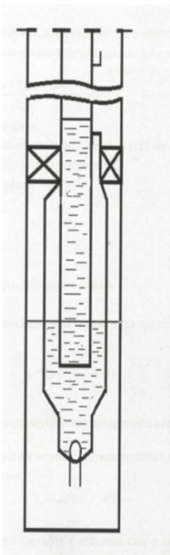

Fig. 3. Diagram of a lift for periodic lifting of a liquid with a replacement chamber

Reducing the pressure of the injected gas for purging the liquid is provided by installing starting valves on the tubing string, and the lower (working) valve acts as a shut-off device that reduces the specific gas consumption [8].

The working pressure of the injected gas is determined from the expression:

$$P_{work} = \frac{h\gamma_{oil}}{10} - P_{pip} + P_{w.h}, kgf/sm^2$$

The height of the column of liquid that can be forced into the lifting pipes with full use of the working pressure will be:

$$h = \frac{(P_{work} - P_{pip} - P_{w.h})10}{\gamma_{oil}} = \frac{(P_{work} - \frac{0,0064L}{d^{0,5}} - P_{w.h})10}{\gamma_{oil}}, m$$

where: L is the length of the lift, m; d is the inner diameter of the lifting pipes, d = 62 mm (2.5") P_{work}, $P_{w.h.}$ - working and wellhead pressure, at; γ_{oil} - the specific gravity of oil.
Camera Length:

$$\ell_c = \frac{d^2}{d_{1c}^2} h$$

where dc is the diameter of the camera, we take it equal to 4".

The volume of liquid raised in one cycle at the optimal flow rate of the injected gas:

$$q_{cyc.} = \left(h \; \frac{0,5\sqrt[3]{L^2}}{d^{0,5}\gamma} \right) f\, \gamma, t$$

where d = 0.003 m is the area of the inner cross-section of 2.5" pipes. The gas consumption during the injection period corresponding to the minimum specific consumption will be:

$$V_0 = 1,1d^2\sqrt[3]{L^2}, m^3/h$$

For a periodic gas lift with a gas cut-off at the chamber, the amount of gas required for one cycle, reduced to normal conditions, is determined from the expression:

$$V_c = f(L + h - \ell_c)\frac{P_{work}}{P_o}, m^3$$

Duration of the gas injection period:

$$T_1 = \frac{60V_c}{P_o}, m^3$$

Duration of the full cycle:

$$T = \frac{q_{cyc.}1440V}{Q}, min$$

where: Q is the flow rate of the liquid, t/day

$$T_2 = T - T_1 \ , min$$

Duration of the liquid accumulation period:

$$n = \frac{1440}{T}$$

Number of cycles per day:

Specific gas consumption per 1 ton of liquid:

$$R_0 = \frac{V_c}{q_{cyc.}}, m^3/t$$

Table 2. Calculated parameters of the periodic gas lift

L, m	d, mm	Ppip, MPa	P_{work}, MPa	$P_{w.h}$, MPa	h, m	l_c, m	q_{cyc}, t	V_0, m^3/h	Vc m^3	T_1 min	T min	n_{cyc}, cycle	Q, t/day	R_o, m^3/t	V, m/day
2500	62	1,01	8,4	1,5	695	271,7	1,62	1266	884	41,89	116,6	12,35	20	546	10920
3000	62	1,21	10,0	1,5	898	350,7	2,12	1430	1064	44,65	152,6	9,4	20	501	10022
3000	62	1,42	12	1,5	1115	435,7	2,66	1584	1504	57,0	191,5	7,52	20	565	11314

The calculated values of the parameters of the periodic gas lift for wells with a lifting height from depths of 2500, 3000, 3500 m are given in Table 2. The design of gas lift lifts, including the arrangement of starting and working valves, should be carried out in accordance with standard methods [9,10], taking into account the properties of reservoir fluids and projected well flow rates. Bellows valves of the G-38 and G-38R, G-25 and G-25R types, installed in the pockets of downhole chambers KT 73-25 and KT 73-38, K60-25 and K60-38, are recommended as gas lift valves. The minimum required number of valves per well is 5÷6 [11, 12].

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