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Analyses and studies for the selection of the method of dual completion operation of wells in multi-layer fields

Annaguly Deryaev
Candidate of Technical Sciences, Senior Researcher,
Scientific Research Institute of Natural Gas of the State Concern „Turkmengas",
Ashgabat, Turkmenistan

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Abstract: Mandatory research and measurement complexes for monitoring development should cover evenly the entire area of the development object, the entire fund of observation wells. They should contain measurements of reservoir pressure for control and piezometric wells, measurements of reservoir and bottom-hole pressures, well flow rates for liquid, gas factors and water content of products for producing wells, measurements of wellhead injection pressures and injection volumes for injection wells, hydrodynamic studies of producing and injection wells in stationary and non-stationary modes, studies on the control of the oil and water contact, gas and oil contact, oil and gas saturation, technical condition of the wellbore by field-geophysical methods, selection and research of deep oil samples, surface rock products of wells (oil, gas, water).

The paper considers in detail proposals to improve the system of collection, preparation and transport of natural, associated gas and condensate. The topic of operation of gas wells, the state and proposals for improving the system of gas and condensate collection and treatment, requirements for structures, drilling technology, the method of reservoir opening and well development on the example of the Altyguyi gas condensate field is touched upon. The choice and justification of the well design in accordance with the intervals of compatibility of the well section according to mining and geological drilling conditions based on the forecast curves of reservoir pressures and rock rupture pressures (combined pressure graph), as well as methods of primary and secondary opening of productive formations and their development are considered in detail.

Key words: condensate degassing, aggregate, group measuring unit, combined graph, gutter system, bottomhole zone.

1. Introduction

The operational and technical characteristics of productive oil wells of the Altyguyi field are given in Tables 1 and 2.

The flow rate of 24 fountain wells is 82-6 t/day, the water content is 1-30%, only the water content of 3 wells (№№ 7, 16, 18) is 73; 71; 77%. The gas factor is 205-1129 m^3/t and the oil solidification temperature is 36-37 ºC.

In 2011, 2 wells (№№. 3 and 51) were transferred to gas lift operation. In 2014, due to the transition of these two wells to a semi-spontaneous mode of operation, the supply of a working agent was stopped [1]. And now these wells are working in a fountain way. During the operation of wells by the gas lift method, over time, there was a decrease in annular pressure, oil degassing and an increase in dissolved gas in the composition of the extracted products. As a result, this condition led to the transition of wells from the gas lift to the fountain method of operation

In the future, as the reservoir pressure on the productive formations decreases over time, it will be necessary to restore the gas supply and switch to the gas lift method of operation.

Table 1. Operational and technical characteristics of productive oil wells of the Altyguyi field

№ wells	Method of operation	Horizon	Down-hole (m)	Interval Perforations (m)	Output (t/day)		Water cut, %	Gas factor m^3/t
					Q_{fluid}	Q_{oil}		
21	fountain	NK-8	4007	4001-4004 3993-3998 3994-4000	17	16	6	401
3	fountain/ gas lift	NK -9	3757	3732-3778	19	17	13	309
4	fountain	NK -9	3770	3728-3740	40	39	3	289
7	fountain	NK -9	3758	3746-3750	26	7	73	461
10	fountain	NK -9	3674	3653-3662	24	22	8	513
11	fountain	NK -9	3868	3833-3839	53	37	30	349
12	fountain	NK -9	3740	3720-3726	60	58	3	501
16	fountain/ gas lift	NK -9	3875	3850-3857 3800-3806 3769-3775	7	2	71	1129
17	fountain	NK -9	3860	3842-3848	79	78	1	331
18	fountain	NK -9	3905	3890-3896	35	8	77	403
19	fountain	NK -9	3910	3891-3897	84	82	2	401
24	fountain	NK -9	3751	3691-2302	56	52	7	205
51	fountain/ gas lift	NK -9	3685	3652-3662	13	12	8	403
52	gas lift	NK -9	3685	3672-3679	16	15	6	290
102	fountain	NK -9	3727	3695-3704	37	36	3	332
104	fountain	NK -9	3760	3714-3723	17	16	4	612
105	fountain	NK -9	3860	3838-3844	56	55	2	250
106	fountain	NK -9	3810	3783-3792	43	33	23	283
107	fountain	NK -9	3885	3864-3869	40	39	3	318
108	fountain	NK -9	3829	3790-3796	35	33	6	303
110	fountain	NK -9	3820	3789-3791	12	11	8	513
111	fountain	NK -9	3880	3834-3842	71	70	1	283
112	fountain	NK -9	3771	3763-3769	55	53	4	374
113	fountain	NK -9	3705	3686-3695	7	6	8	726
114	fountain	NK -9	3700	3682-3691	44	36	18	403

2. Object and subject of research

Currently, 52 wells are being operated at the field. According to the calculations of the field development, the transition of all fountain wells to operation by the gas lift method is being considered.

Table 2. Operational and technical characteristics of productive oil wells of the Altyguyi field

№ wells	Method of operation	Horizon	Down hole (m)	Interval Perforations (m)	P_b/P_{ann}	Fitting diameter (mm)	Gas inlet depth (m)	Note
21	fountain	NK -8	4007	4001-4004 3993-3998 3994-4000	34/118	5	2200	
3	fountain/ gas lift	NK -9	3757	3732-3778	60/105	4		
4	fountain	NK -9	3770	3728-3740	44/106	8		
7	fountain	NK -9	3758	3746-3750	24/153	5		
10	fountain	NK -9	3674	3653-3662	76/154	6		
11	fountain	NK -9	3868	3833-3839	27/136	6		
12	fountain	NK -9	3740	3720-3726	153/248	8		
16	fountain/ gas lift	NK -9	3875	3850-3857 3800-3806 3769-3775	152/155	5		Puncher 2000 m
17	fountain	NK -9	3860	3842-3848	57/143	8		
18	fountain	NK -9	3905	3890-3896	15/116	4		
19	fountain	NK -9	3910	3891-3897	114/122	8		
24	fountain	NK -9	3751	3691-2302	118/144	8		
51	fountain/ gas lift	NK -9	3685	3652-3662	31/94	5		Puncher 2000 m
52	gas lift	NK -9	3685	3672-3679	46/76	6	2200	Puncher 2000 m
102	fountain	NK -9	3727	3695-3704	100/114	6		
104	fountain	NK -9	3760	3714-3723	63/154	4		
105	fountain	NK -9	3860	3838-3844	81/152	8		
106	fountain	NK -9	3810	3783-3792	122/136	5		
107	fountain	NK -9	3885	3864-3869	78/110	5		
108	fountain	NK -9	3829	3790-3796	63/115	6		
110	fountain	NK -9	3820	3789-3791	52/137	4		
111	fountain	NK -9	3880	3834-3842	57/148	8		
112	fountain	NK -9	3771	3763-3769	13/167	4		
113	fountain	NK -9	3705	3686-3695	70/112	8		
114	fountain	NK -9	3700	3682-3691	102/136	6		

Table 3 shows the proposed options for the development of the transition of fountain wells to the gas lift method of operation.

In the gas lift mode, the supply of the working agent in the range of 2000-2200 meters lifts is carried out at 38 0C with heated gas through the holes of the gas lift valves temporarily installed in place [2, 3].

At the field, gas is supplied to gas lift wells with operating pressures of 70-85 kgf/cm2 by special gas compression lines. The gas consumption for each well currently averages 15 thousand m^3/day.

To operate the lift with the greatest efficiency, i.e. with the minimum specific consumption, it is necessary that the lift operates at the optimal flow rate, which requires the greatest immersion under the dynamic level, i.e. the length of the lift must be equal to the depth of the well. The minimum specific flow rate in the maximum feed mode is provided if the relative immersion is ξ = 0.5, and for the optimal mode the relative maximum flow rate is ξ = 0.6 [4].

Operated gas lift wells need to be optimized according to existing methods. According to calculations, in gas lift wells with a gas inlet point of 2300 - 2500, we accept a working pressure of P_{work} = 6.4; 7.4; 8.4 MPa, and in wells with a gas inlet depth of 3000 - 3500 m - 10-12 MPa. At gas condensate fields, it is necessary to implement a closed-cycle compressor gas lift with high-quality gas preparation for the needs of the gas lift and with further gas supply to the export gas pipeline.

Table 3. The proposed variant of the development of the transition of fountain wells to the gas lift method of operation for the Altyguyi field

(basic option I)

Indicators	Unit of measurement	2022	2023	2024	2025	2026	2027
Oil production	thousand tons						
Liquid extraction	thousand tons						
Associated gas resources	miln m^3						
Transfer of wells to the gas lift method	well		5	6	7		
Fund of gas lift wells operating until the end of the year	well	1	6	12	19	19	19
Average oil flow rate of operating wells	t/day						
by liquid	t/day						
Water cut	%						
Required gas resource for gas lift	miln m^3	1,9	5,9	30,2	32,3	43,1	41,7

(Option II)

Indicators	Unit of meas.	2022	2023	2024	2025	2026	2027
Oil production	thousand tons						
Liquid extraction	thousand tons						
Associated gas resources	miln m^3						
Transfer of wells to the gas lift method	well		7	12	12	12	12
Fund of gas lift wells operating until the end of the year	well	1	8	20	32	44	56
Average oil flow rate of operating wells	t/day						
by liquid	t/day						
Water cut	%						
Required gas resource for gas lift	miln m^3	1,9	19,7	68,8	141	188	209

(Option III)

Indicators	Unit of meas.	2022	2023	2024	2025	2026	2027
Oil production	thousand tons						
Liquid extraction	thousand tons						
Associated gas resources	miln m^3						
Transfer of wells to the gas lift method	well		11	24	13	7	6
Fund of gas lift wells operating until the end of the year	well	1	12	36	49	56	62
Average oil flow rate of operating wells	t/day						
by liquid	t/day						
Water cut	%						
Required gas resource for gas lift	miln m^3	1,9	11,0	45,4	88,7	120	120

3. Target of research

At the Altyguyi field, when choosing the gushing mode (the diameter of the fitting), it is necessary that the well has an optimal flow rate with a small gas factor, gives less water and sand, gushes calmly, without large pulsations. Only when these conditions are met, it is possible to ensure the most rational use of reservoir energy and long-term, uninterrupted gushing of the well.

When choosing the mode of operation of a fountain well, reservoir conditions are also taken into account - the proximity of contour water, the possibility of a plug in the well, the mode of the field itself, etc.

The main reasons for the disruption of the normal operation of fountain wells are the waxing of fountain pipes, the formation of a sand plug, corroding of the fitting, clogging of the fitting or ejection of paraffin complications, etc. [5].

Measures to restore the operation mode of wells are carried out depending on the reason that caused its violation.

When a sand plug is formed in the fountain pipes, which caused the buffer pressure to drop to zero and the supply is stopped, a liquid (oil) pump is flushed into the annular space to restore circulation and eliminate the plug.

A significant decrease in pressure in the annular space indicates the formation of a plug at the bottom and the appearance of water, the latter is detected by taking a sample from the jet. When water appears, it is necessary to increase the pressure on the face by reducing the diameter of the fitting. To eliminate the downhole plug, the well is allowed to work without a fitting or oil is pumped into the annular space.

The pressure drop on the buffer while increasing the flow rate of the well indicates that the nozzle is corroded by sand, in this case it is necessary to transfer the fountain jet to another outlet and immediately change the nozzle.

If the specified method fails to eliminate sand jams in the lifting pipes or at the bottom, then the well is stopped for repair work, after which it is put into normal operation.

Dewaxing of the elevator is the main way to ensure the normal operation of fountain wells. The largest amount of paraffin is deposited in the upper part of the lifting pipes, at a length of 400 - 1000 m from the wellhead and in the field oil collection system, in which paraffin deposition increases during the cold season. Several methods are used against waxing of lifting pipes. First of all, these are regime measures: reduction of pulsation and frequency of gushing, regulation of the gas factor in order to reduce it as much as possible.

If these measures do not give results, it is necessary to clean the lifting pipes from paraffin.

There are 3 types of cleaning from paraffin: mechanical, thermal, chemical [6, 7].

Mechanical cleaning of pipes from paraffin is carried out during the operation of wells without stopping them with scrapers of various designs.

When exposed to heat, the lifting pipes are heated with steam, hot oil pumped into the annulus of the well without stopping it. The melted paraffin is carried out by a jet of oil to the surface, while the paraffin melts in the switch line. The thermal method does not prevent the deposition of paraffin in pipes, it is used sporadically, under favorable conditions and when for some reason it is not possible to use other more effective methods.

As a solvent of paraffin, it is envisaged to use condensate (gasoline), which is extracted at the Altyguyi deposit in sufficient quantities.

The most characteristic complications in gas lift mining are the appearance of sand and cork formation, the deposition of paraffin in lifting pipes and discharge lines.

Measures against sand entering the well are of a regime nature and are reduced to limiting depression, i.e. limiting oil extraction. The amount of liquid extraction from gas lift wells is regulated by changing the amount of injected working agent, the depth of immersion of lifting pipes or their diameter. To prevent the settling of sand during the periods of its greatest inflow from the reservoir, without interrupting operation, oil is pumped into the annulus in small portions by a mobile pump.

Sometimes the pressure of the gas injected into the well increases sharply when the liquid supply is stopped at the same time. This may occur due to the formation of a so-called cartridge sand plug in the lifting pipes, which blocks the section of the lifting pipes, preventing the mixture of oil and injected gas from reaching the surface. To destroy such a plug, gas is pumped not into the annular space, but into lifting pipes. If in this way it is not possible to push the plug from the pipes to the bottom of the well, then it is necessary to remove the pipes [8].

When wells are equipped with a single-row lift, it is finished with a shank of a smaller diameter than the main tubing string. The descent of the lifting pipes with a shank to the filter facilitates the conditions for the removal of sand by the liquid to the surface and prevents the formation of sand jams.

Measures to prevent paraffin deposits in lifting pipes during gas lift operation of wells, and methods for cleaning pipes from paraffin are similar to those used in fountain operation.

With the drop in reservoir pressures and the flooding of reservoirs at some stages of development in the gas condensate fields of the western part of Turkmenistan, it is planned to improve the gas lift. It is proposed to install a column of lifting pipes equipped with borehole chambers with gas lift valves (starting and working) located in them in the production column on the packer. This eliminates the influence of the injected gas on the flow of liquid into the well. It is planned to conduct research on optimizing the operating modes of gas lift wells according to known methods to determine the optimal flow rate.

It is also necessary to equip the gas lift gas distribution system with regulating and measuring equipment.

All the measures mentioned above are aimed at increasing and stabilizing gas lift production and reducing the volume of injected gas.

At the Altyguyi gas condensate field under development, the number of gas lift wells will increase with the expiration of the operating time, since with the cessation of well gushing, it becomes necessary to transfer them to a mechanized method [9].

Under the existing modes of gas lift lifts, the depth of the input of the working agent (gas) is in the range of 1400 - 3000 m, the gas input into the lift is carried out through holes (punchers) temporarily replacing the working valves.

Gas supply to gas lift wells is carried out from the gas pipeline via separate gas injection lines at operating pressures of 6.2 - 11 MPa.

Operated gas lift wells need to be optimized according to existing methods. According to calculations, in gas lift wells with a gas inlet point of 2300 - 2500, we accept a working pressure of P_{work} = 6.4; 7.4; 8.4 MPa, and in wells with a gas inlet depth of 3000 - 3500 m - 10-12 MPa. At the Altyguyi gas condensate field, it is necessary to implement a closed-cycle compressor gas lift with high-quality gas preparation for the needs of the gas lift and further gas supply to the export gas pipeline.

The issues of ecology and nature protection include restrictions on the external impact on the environment, preventing the loss of hydrocarbon resources during the extraction, carrying out technical and control measures.

Oil and gas enterprises occupy one of the first places among other sectors of the national economy in terms of the degree of environmental impact. Exploration and development of oil fields includes such technologies as exploration drilling, oil production, collection and preparation of hydrocarbons, transportation and processing.

The enterprises of the oil and gas industry have a harmful effect on all objects of nature, the atmosphere, the hydrosphere and underground and surface waters, the geological environment, drilled wells at all depths, on the land where they are located.

The cycle of oil and gas works consists of two main groups:

1. New construction sites (search and exploration, drilling, installation of equipment)

2. Working processes of the enterprise (collection, processing, shipment and processing of oil and gas)

When carrying out construction work, a report is made on technogenic pollution of the earth and the environment for technical reasons.

A report on the measures taken to protect the environment should be prepared by oil and gas producing organizations [10].

It should be noted that the time spent on exploration, drilling and preparation of oil and gas fields, the production time of the enterprise cause pollution due to technical reasons.

The performance of these works causes high harm to the environment. Ecological catastrophes that occur are physical and mechanical impacts on soil, land, flora, fauna, soil, lowering of hydrogeological conditions, strengthening of soil erosion conditions, deterioration of living conditions of fauna and flora and local residents, and others.

Currently, geological studies have been completed at the Altyguyi gas condensate field and a field test plan has been prepared based on the data obtained.

When drilling wells in the fields, the environment is polluted mainly by some chemical elements used in the preparation of drilling fluids.

Currently, normal limit values, chemical elements indicating aggressiveness used in the preparation of drilling fluids have not been established.

During drilling operations, the source of atmospheric air pollution is diesel-fueled equipment that emits 2 tons of hydrocarbons and soot, 30 tons of nitrogen oxides, 8 tons of carbon monoxide and 5 tons of sulfur anhydrite into the atmosphere during the year. When drilling wells, drilling mud is mixed with soil layers, surface and groundwater, forming 30 m^3/day of water used [11].

During the development of wells, hydrocarbon mainly causes pollution. In most cases, oil-based circulating solutions with serious environmental consequences produce used wastewater, suspension and colloidal solution.

When preparing environmental protection measures during installation work in wells, it is necessary to avoid work that negatively affects natural objects. Since the sources of pollution are closely related to the technology used by the enterprise, it is necessary to establish the technology that has the least impact on the environment.

In case of geochemical soil decay, the following must be done:

- When preparing plots, it is necessary to prevent contamination of the topsoil from the products obtained;
- To collect sedimentary rocks of drilled rocks on slurry barns;
- It is necessary to cover the slurry barn;
- Restore the soil area of the extracted products;
- Road construction.

As a result of drilling operations, there is a negative impact on the hydrogeological change in the soils of the earth, and as a result, drilling fluids penetrate into aquifers, which leads to the formation of a complex of waters.

The waters used in drilling fluids are divided into three groups:

1. Water formed during the production of works;
2. Water for household work;
3. Atmospheric, rainwater.

Circulating waters are used to carry drilled rocks to the surface. In world practice, 95% of clay elements are mixed into the composition of circulating waters for the preparation of drilling fluids.

The quality of the flushing solutions used contributes to the speed of drilling operations, the prevention of complications with colmatation and water occurrence [12].

During the operation of producing wells and oil and gas collection facilities, the integrated safety and environmental protection system includes:

- monitoring of the condition of borehole fittings;

- selection of equipment and pipelines that meet the specified operating conditions, taking into account current regulations;
- periodic testing of equipment for strength (crimping);
- corrosion protection;
- prevention of technological complications that create emergency situations (gas communications flooding, deposition of paraffin and salts in wells and collection systems), with the use of special inhibitor substances.

When collecting and storing oil, safety requirements and reducing hydrocarbon emissions into the environment are ensured at the stage of arranging collection points in accordance with building codes and regulations, with the necessary equipment of tanks with floating roofs or breathing valves, with mandatory bunding of tank farms to localize emergency oil spills [13].

When implementing the gas lift method of oil production, with a high manifestation of gas injected into the well to ensure safety and environmental protection, it is envisaged (in addition to the design and construction of the main facilities in full compliance with the required technological parameters of operation according to the current building codes and regulations) the construction and proper operation of additional technological equipment that provides a hydrate-free operation of gas distribution systems (furnaces for heating gas and inhibition unit). In the case of the construction of furnaces for heating hydrocarbons, it is necessary to make a preliminary calculation of atmospheric pollution by combustion products and assess the need to determine the MPC.

Storage and use of chemicals is planned to be carried out in accordance with their individual characteristics and in accordance with Safety Regulations (SR) in the oil industry, including providing employees with personal protective equipment (PPE), carrying out instructions and monitoring the condition of equipment used for the use of chemicals (surfactants, methanol, etc.).

The operation of electrical installations and heating equipment is provided in accordance with the current rules of SR and fire safety rules.

According to estimates, in oil fields with a similar technology of oil extraction and collection, the maximum concentrations of the above harmful substances at the border of the sanitary zone (within a radius of 1000 m from the source of emission) do not exceed the maximum permissible (MPC), which are set for each harmful substance individually according to the methodology of the State Committee for Hydrometeorology (OND-86).

In this regard, emissions of harmful substances into the atmosphere, subject to regular (accident-free) technological modes of operation of oil and gas field equipment, can be considered approximately corresponding to the maximum permissible emissions (MPI) [14].

A detailed assessment of emissions for all fishing facilities is taken into account when compiling an environmental passport.

The environmental passport is being developed in accordance with GOST 17.0.0.04-90 "System of standards in the field of nature protection and improvement of the use of natural resources", which already gives the full technological cycle of this production from the supply of raw products to the finished product. At the same time, the presence of emissions, discharges and solid waste is carefully checked and calculated at each production facility and their impact on the environment is analyzed. All this material is described and calculated in the relevant chapters of the environmental passport. It also concludes that it is necessary to calculate the norms of MPD, the results of which are issued in the form of a second volume, but in the future, in the event of an increase in oil production due to Miocene-Paleogene and Mesozoic underlying red-colored sediments, it will be necessary to adjust all calculations on emissions.

The drilling depth of production wells on the Altyguyi field along the NK_9 horizon, depending on the location of wells in the structure, varies on average in the intervals of the consolidated part of 3750 m, in the krill parts it is 4000 m.

Drilling of wells is planned by the rotary method. All project wells are vertical.

The selection and justification of the well design is carried out in accordance with the intervals of compatibility of the well section according to the mining and geological drilling conditions based on the forecast curves of reservoir pressures and rock rupture pressures (combined pressure graph). And also taking into account the requirements of the "Safety Rules in the oil and gas industry", "Regulations for calculating intermediate columns when drilling wells in the areas of Western Turkmenistan" and geological and technical information, based on proposals to improve technical and economic indicators for previously drilled wells in the field of Altyguyi [15,16].

The design of production wells with a depth of 3750 m on the productive horizon of NK-9 in the consolidated part has the following form:

- shaft direction of pipes Ø720mm and 10m in length to prevent the erosion of the wellhead and the binding of the wellhead with a trough system for the circulation of drilling mud;
- elongated direction of pipes Ø 530mm and 30m long to overlap the upper unstable part of the section and install anti-blowout equipment, for effective well management during further deepening under the conductor and possible gas occurrences at shallow depths;
- a conductor made of pipes Ø426mm and 400m long for overlapping unstable sandy-clay quaternary deposits and effective well management in case of possible fluid phenomena, using anti-blowout equipment during drilling for an intermediate column;
- the first intermediate column of pipes Ø324mm and 1600m long to reduce the interval of the open borehole when drilling for a technical column, to prevent hydraulic fracturing with an increase in the density of drilling mud.
- the second technical column made of pipes Ø324mm and 3460m long for overlapping formations with high reservoir pressures and in order to increase the density of drilling mud to 2.0 – 2.15 g /cm^3, as well as to reduce the risk of seizure of drilling tools and control of anti-blowout equipment in case of possible complications and during drilling for the production column. The casing shoe with adjustment descends to the lower part of the NK-6 horizon;
- an operational column of pipes with a diameter of Ø140 Mm descends to a design depth of 3750 m in order to operate the productive horizon.

The cement is lifted behind all the columns to the wellhead. The combined pressure graph is shown in the figure 1.

The design of production wells with a depth of 4000 m on the productive horizon of NK-9 in the krill part has the following form:

- the shaft direction of the pipes Ø 720mm descends to a depth of 10m to prevent the erosion of the wellhead and the binding of the wellhead with a trough system for the circulation of drilling mud;
- the elongated direction of the pipes Ø 530 mm descends to a depth of 30 m to overlap the upper unstable part of the section, consisting of loose, sandy-clay deposits, protecting the wellhead from erosion, as well as overlapping the zone of possible gas saturation at shallow depths;
- a conductor of Ø426mm pipes descends to a depth of 600 m into the water pressure horizons to cover the upper unstable part of the section of quaternary deposits, isolate the borehole from hydrostatically connected with the surface of water, secondary gas contamination of rocks due to drainage. As well as installation of anti-blowout equipment for effective well management in case of possible oil and gas occurrences during drilling for the first intermediate column;
- the first intermediate column of pipes Ø 324mm descends to a depth of 2000m to cover quaternary deposits, the Absheron and Akchagyl tiers, parts of the upper section of the red-colored strata, in which hole collapses and absorption of drilling fluid are possible during the well wiring, and also ensures successful well wiring to the depth of the descent of the second intermediate column and effective well management in case of possible gas and oil occurrences with the help of anti-discharge equipment;
- the second intermediate column of pipes Ø245mm descends to a depth of 3750m, ensures successful wiring of the well to the depth of the descent of the production column, as well as effective well management during manifestations, when opening high-pressure gas condensate horizons NK-7 and NK-8 with the help of anti-blowout equipment.

The shoe Ø245 mm of the second intermediate column is installed in a clay bundle, and the installation depth of the shoe is adjusted according to the logging data;

-an operational column of pipes with a diameter of Ø140 mm descends to a design depth of 4000 m, provides the necessary conditions for testing productive layers and carrying out repair and insulation work. The final depth of the descent of the production column is adjusted according to GDS (gas-dynamic studies) data.

The cement is lifted behind all the columns to the wellhead.

Drilling of wells for the conductor is planned to be carried out on an oil-emulsion humate-lignosulfonate drilling mud, for intermediate and operational columns - on a polymer, cement-inhibited drilling solution ALKAR-3 according to the recipe of the institute "Nebitgazylmytaslama" [17].

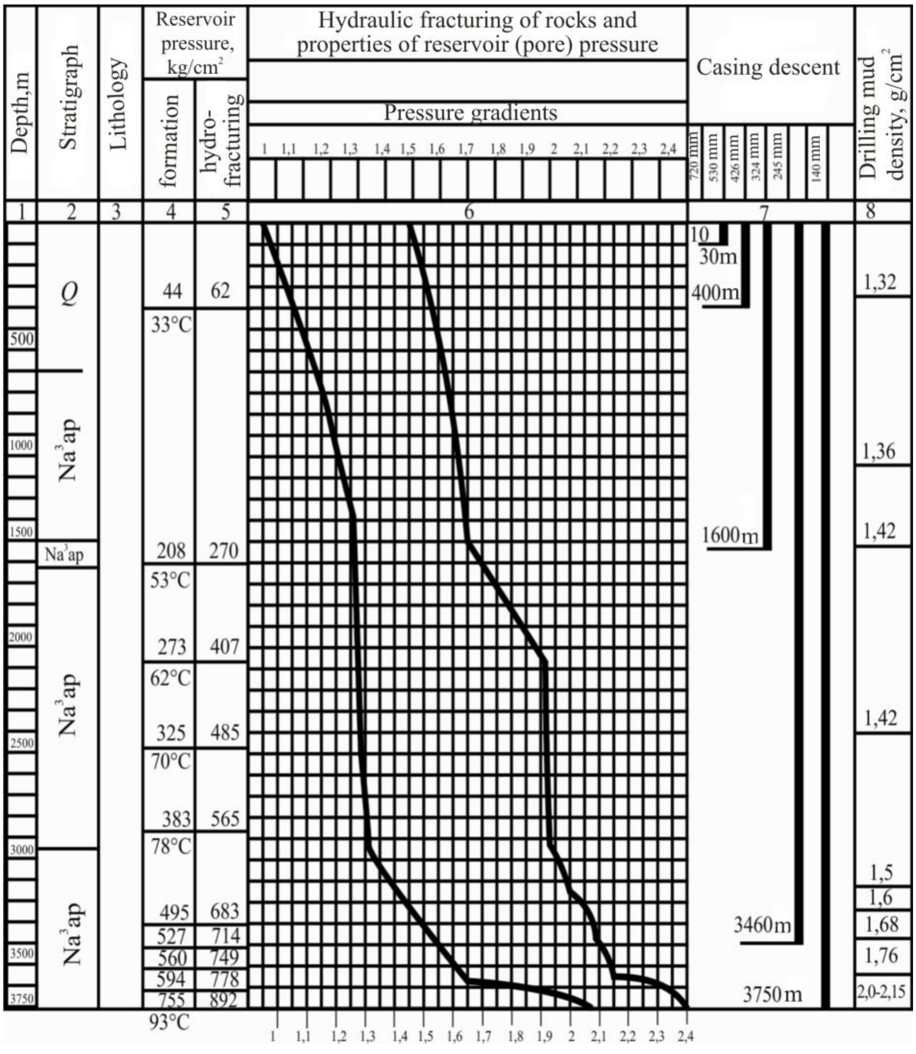

Figure 1. Combined pressure schedule at the Altyguyi field.

In the process of drilling production wells, core sampling, as a rule, is not designed. The selection of individual core samples can be planned in order to study their filtration properties and develop measures for their effective (pollution-free) opening.

Separate studies of formations during drilling and by other methods can be planned and performed in order to clarify reservoir pressures, hydraulic fracturing pressures and properties of reservoir (pore) pressure [18, 19].

It is planned to use water-based clay solutions weighted with barite and treated with chromlignosulfonate reagents and inhibited with cement for well wiring.

For the construction of wells, drilling rigs of the normal BU-5000 series are required on a diesel drive - Uralmash-ZD and diesel-electric -ZJ 70 DS.

Drilling rigs, in addition to the equipment included in the kit, must also be equipped with complete anti-blowout installations and additional equipment for the preparation, cleaning and storage of weighted drilling fluids in desert conditions.

When drilling, rigid layouts of the bottom of the drill strings are used according to the regulations developed by the drilling technology laboratory of the institute "Nebitgazylmytaslama". Recommended layouts prevent the curvature of the borehole. Their use does not require additional templating and drilling of the borehole before the descent of the casing strings.

For drilling boreholes, it is recommended to use high-performance 3- roller-bit of the MS-TSGAU, MS-TSGVU and S-TSGVU series. The adjustment of the operating parameters is carried out in accordance with the technical project or geological and technical order (GTO).

In the course of drilling, complex geophysical studies of wells are planned.

The research package includes: standard logging, cavernometer, profiler, side logging, gamma logging, neutron logging, acoustic logging, thermometry, inclinometer. Logging operations are carried out on a scale of 1:500 for all holes.

In order to achieve the greatest technological effect, the filtration and rheological properties of the solution are adjusted. To open a productive object, the drilling mud is subjected to special treatment in order to reduce its water output and give the filtrate properties that prevent contamination of the formation.

Protection of the formation from contamination during secondary opening is achieved by perforating the column under conditions of a given depression on the formation with the help of PKO-86 perforators (on drilling mud) or "Paurget", "Enerzhet" (on water), followed by smooth (in order to avoid destruction of the hole zone) launching the object into operation according to the technology of the institute "Nebitgazylmytaslama" [20].

4. Research methods and results

In order to study the nature of changes in the oil and gas value of formations and for the most complete recovery of reserves in the process of developing oil and gas deposits, it is necessary to carry out complex hydro-gas dynamic, field-geophysical and laboratory studies.

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 [21].

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. 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 [22, 23], 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 [24].

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 field. 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 [25].

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 are manufactured for reservoir fluid with temperatures 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 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 multi-packer-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 [26], calculations were performed according to the formula:

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

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

G - average geothermal gradient, °C/m;

D_i is the Joule-Thomson differential coefficient in the borehole.

°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)

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, $\alpha = \frac{2\pi\lambda}{GC_r f(\tau)}$;

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

$f(\tau)$ is a dimensionless function of time $f(\tau) = Ln(1 + \sqrt{\frac{\pi\lambda_g \tau}{C_n R_c^2}});$

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

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:

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

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:

- 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

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

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 [26, 27].

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

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

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 [28]. 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.

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 drilling is completed in such a way that the perforation intervals are blocked with a polymer-lime solution (without clay particles) according to the temporary patent of Turkmenistan № 380.

The installation sites of packers are being worked out with pear-shaped cutters, scrapers and templates of appropriate sizes [29].

A long row of tubing is lowered into the well according to Fig. 2., 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.3) according to the patent of Turkmenistan №. 603 [30]. 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.

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.

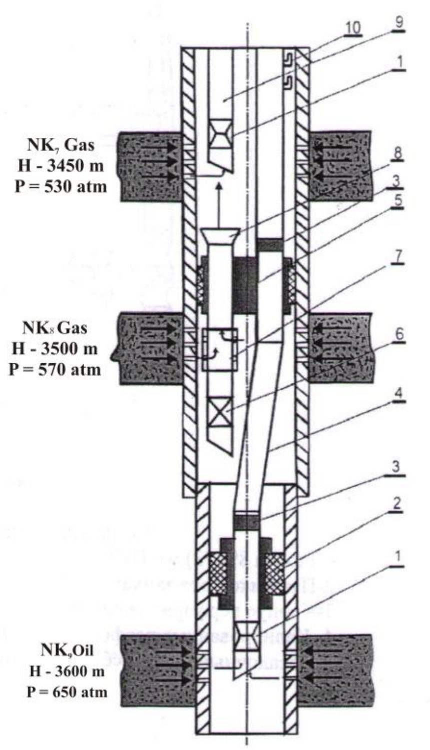

Figure 2. Diagram of downhole equipment for DC of oil and gas horizons.

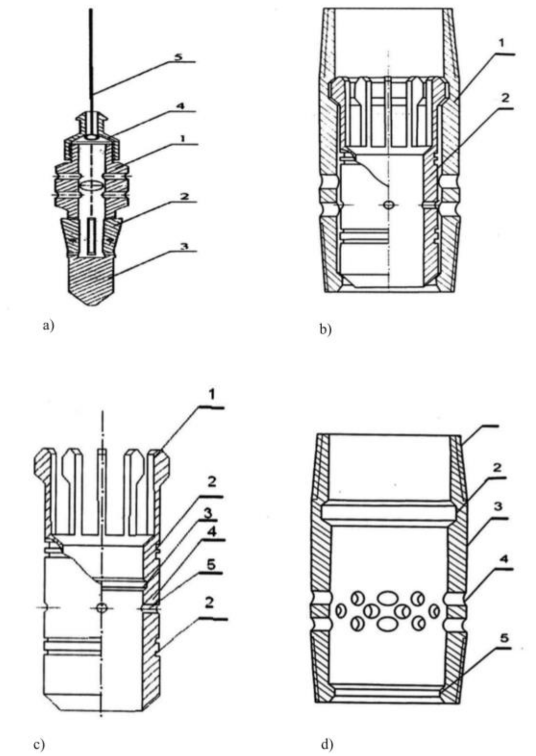

Figure 3. Layout of downhole equipment for DC.

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).

5. Conclusions

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.

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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