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GENERAL PROVISIONS OF THE FEASIBILITY STUDY OF THE APPLICATION OF THE METHOD OF DUAL COMPLETION OPERATION IN THE DESIGN OF WELLS

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ABSTRACT

Introdução: The article discusses the general provisions of the feasibility study for the use of dual completion operation on the example of the experience of Turkmenistan, where an experimental test was conducted on four wells of the Northern Goturdepe field located in the coastal zones of the coastal waters of the Caspian Sea. Geological materials and materials of previously drilled wells were used for the design, as well as analysis of hydrodiamic and thermodynamic indicators from the existing well stock. Oil samples were also taken from wells in order to conduct laboratory analyses to fully determine their characteristics. The calculation of the economic efficiency of these four wells was carried out, according to the results of which the economic effect was determined by reducing capital expenditures for drilling and development of a multi-layer field. This work can be used and useful to fulfill the tasks set for the accelerated development of multi-layer deposits, which will eventually lead to a significant reduction in the volume of drilling wells, respectively, and funds.

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INTRODUCTION

On behalf of the national leader of Turkmenistan Gurbanguly Berdimuhammedov, in 2008, the development of shallow waters of the coastal part of the Caspian Sea, the Northern Goturdepe square, began. In 2012, the 4th wells were drilled (2nd exploration, 2nd production) using the method of dual completion exploitation of several oil reservoirs. A large inflow of oil was obtained from these four wells during development, and the leader of the nation of Turkmenistan Arkadag personally thanked the oilmen for this result. After that, at the next elections in 2012, the President of Turkmenistan visited the Northern Goturdepe field, namely directional well No. 204, and familiarized himself with the progress of drilling operations and the achievements of oil workers in the use and improvement of new advanced technologies. The interest of the President of Turkmenistan with new equipped technologies in the oil and gas industry inspired Turkmen oilmen and scientists of the oil and gas complex to new discoveries and achievements in this direction. The use of the dual completion (DC) method in multi-layer deposits in order to increase the technical and economic efficiency of development is achieved by combining operational facilities and is carried out using equipment for monitoring and regulating the process of product selection separately for each operational facility. In this regard, when developing multi-layer deposits with independent grids of wells for each formation, it often requires huge capital expenditures, thereby it is not economically and technologically justified. In this regard, when developing multi-layer deposits, several productive layers are isolated and combined into one operational object, which makes it possible to shorten the development time of the field, reducing capital investments for drilling wells and field development. When deciding on the application of the DC method, the degree of watering of productive horizons, the presence of resins and paraffin in the composition of products, the thickness of productive horizons and impenetrable clay layers separating them, the condition of operational columns, etc. are taken into account. The use of DC makes it possible to reduce the metal consumption of oilfield equipment, the cost of production of hydrocarbon products, reduce the time of field development, and increase the oil and gas recovery of reservoirs. Experience in the development of multi-layer deposits shows that during the development of deposits, 50 percent of capital investments are spent on drilling wells, and not all formations contain the necessary volume of oil and gas that is profitable for independent grid production. Justification of the need for dual completion operation and water injection at new multi-layer deposits should be given when drawing up a technological scheme or a development project. One of the main ways to reduce capital investments in the development of multi-layer oil and gas fields is the scientifically-based allocation of production facilities in the productive section, which can be represented by one or more layers developed by an independent grid of wells. The allocation of operational facilities is a complex problem due to the difficulties associated with the practical implementation of control and regulation of the development process of a multi-layer facility. One of the means largely contributing to the elimination of these difficulties is dual completion operation [2, 3]. The allocation of operational facilities is carried out during the design of the field development system. At the same time, possible options for combining layers into objects for their joint operation with the use of dual completion operation are considered. In the variants with the use of DC, tasks involving the intensification of field development, an increase in oil recovery, a reduction in metal consumption and capital intensity are solved. Methods of dual completion operation and water injection were provided for in the development projects of a number of deposits of the USSR: Dolina, Ust-Badykskoye, Uzen, etc. These methods are also widely used in the development of multilayer deposits abroad: USA, Mexico, etc. The experience of using the DC equipment in the fields shows that the effectiveness of the DC development system depends on the correct choice of the operational facility.

MATERIALS AND METHODS

The scientifically-based allocation of operational facilities, including in variants with the use of DC, should be carried out in a comprehensive way - on the basis of geological, hydrodynamic and economic studies. In geological studies of the issue, which are carried out first of all, the factors determining the geological and commercial characteristics of the field section and the properties of reservoir fluids are considered. It turns out the consistency of layers and clay impermeable interlayers by area, the ratio of average power values, discontinuity and lenticularity of layers. Reservoir properties of reservoirs (permeability, porosity, piezo conductivity, hydroconductivity, etc.) and properties of oils and gases in reservoir conditions (viscosity, saturation pressure, solubility, paraffin content, etc.) are determined and analyzed. These data are subsequently used in hydrodynamic calculations to determine the nature of reservoir production (promotion of oil-bearing contours, etc.). The methods of separate injection and separate operation with the help of technical means (DC) allow for the coordinated promotion of oil-bearing contours in formations with different permeability. However, a multiple difference in the permeability of the layers may lead to the conclusion that it is impractical to combine them into one object, even with the use of DC. The properties of oils and gases have a decisive influence on the combination of layers. They affect not only the nature of filtration, but also the possibility of obtaining optimal operating conditions for each reservoir during joint operation.

Technological indicators of operation are evaluated by hydrodynamic calculations and are used to determine the need for the use of the DC method in order to create optimal working conditions for each of the combined layers separately. It does not take into account the possibility of mixing oils of different formations. Of particular importance in the allocation of operational facilities is the location of the OWC (oil-water contact) along the layers, especially in fields with a thin-layered section and steep occurrence of layers. Under these conditions, the different position of the OWC can significantly reduce the possibility of enlarging the operational facility. The energy resources of reservoirs and possible changes in their operating modes as a result of exposure to them are considered. At the same time, the possibility of joint long-term operation of reservoirs in depletion mode or pressure mode is evaluated. It should be borne in mind that the best result is achieved by combining reservoirs with the same operating modes, since in this case, work with the well stock is greatly facilitated when transferring them from one operating mode to another and when monitoring and regulating developments. When forming operational facilities, the amount of oil reserves in the combined formations is also taken into account. The selected object must contain oil reserves, the processing of which by an independent grid of wells ensures the improvement of technical and economic indicators of oil production. As a result of the analysis of the geological parameters of the layers, a preliminary conclusion is made about the possibility and expediency of combining them into one operational object. Then hydrodynamic studies are carried out to establish the technological indicators of the selected operational facility during joint operation of the layers and during separate operation. The following main technological parameters are determined for analysis: a) the productivity of each reservoir and its share in joint operation; b) the dynamics of waterlogging across the layers; c) optimal values of depressions at the bottom; d) oil recovery; e) uniformity of production; f) the possibility of regulating the operation of each reservoir.

The values of technological parameters are determined by the method taking into account the heterogeneity and discontinuity of the formation, the viscosity ratios and other fluid parameters, as well as the non-piston displacement of oil by working agents (water, gas, steam, etc.) under various boundary operating conditions and deposit forms. According to the experience of Turkmenistan, an industrial experiment was conducted for the first time at the Northern Goturdepe multi-layer field using the DC of nine layers from three large horizons. No seismic survey was carried out in this field. One of the four wells was drilled obliquely in the shallow waters of the Caspian Sea. An analysis of all existing DC schemes shows that it is possible to achieve the planning of this method in the design process, which will lead to a significant reduction in the volume of drilling wells and funds. The experience of drilling such wells for a number of years in various countries has shown that for successful and economically justified drilling, the following is necessary:

- High engineering qualification of the staff;
- Availability of reliable geological data that are necessary for the design and wiring of a particular well;
- Creation, development, production and application of special devices and equipment;
- Latest software;
- The use of special drilling fluids in some cases;
- New technologies and devices for well completion.

The interest of mining enterprises in drilling directional wells and dual completion operation is associated with the following factors:

- increase in production rates in order to accelerate the development of the field without increasing the oil extraction coefficient;
- increase in flow rates without shortening the service life of wells due to the breakthrough of gas or water through the depression funnels;
- loosening of the grid for the placement of wells in a new field and, accordingly, the number of required producing wells;
- wiring of directional shafts from old wells in depleted fields in order to avoid compaction of the grid with new wells.

The program of dual completion operation has strong support for manufacturing enterprises that produce devices for working in wells [4]. Considering the proposals of world manufacturers of downhole equipment for dual completion operation, the specialists focused their attention on the equipment of the Weatherford company. The scheme of simultaneous oil production with the use of technological equipment using a combination of the fountain method with the subsequent transition to the gas lift method was chosen. The main purpose of the presented pilot work is to develop less costly and more effective methods of increasing oil and gas production [1]. Analysis in the scientific context of dual completion exploitation of several reservoirs in increasing oil and gas production indicates the importance of the topic of scientific and industrial experience. In this regard, the following tasks arise [5]:

- study of the work carried out on dual completion jointly development of several layers in a directional well, for accelerated development of a multi-layer field, as well as increasing the volume of oil and gas production;

Table 1. Well design at the Northern Goturdepe field

Column name	Well numbers							
	147		37		200		201	
	project	fact	project	fact	project	fact	project	fact
Direction	30	30	30	30	30	30	30	30
Conductor	600	597	600	595	600	594	600	594
The first intermediate column	2700	2697	2800	2780	2000	1996	2800	2798
Second intermediate column	4148*	4140	4800	4762	4500	4180	4800	-
Operational column	-	4249	5200	4687 - 4902	4900	4180 - 4330	4700 - 5100	-

Note: * - vertical depth

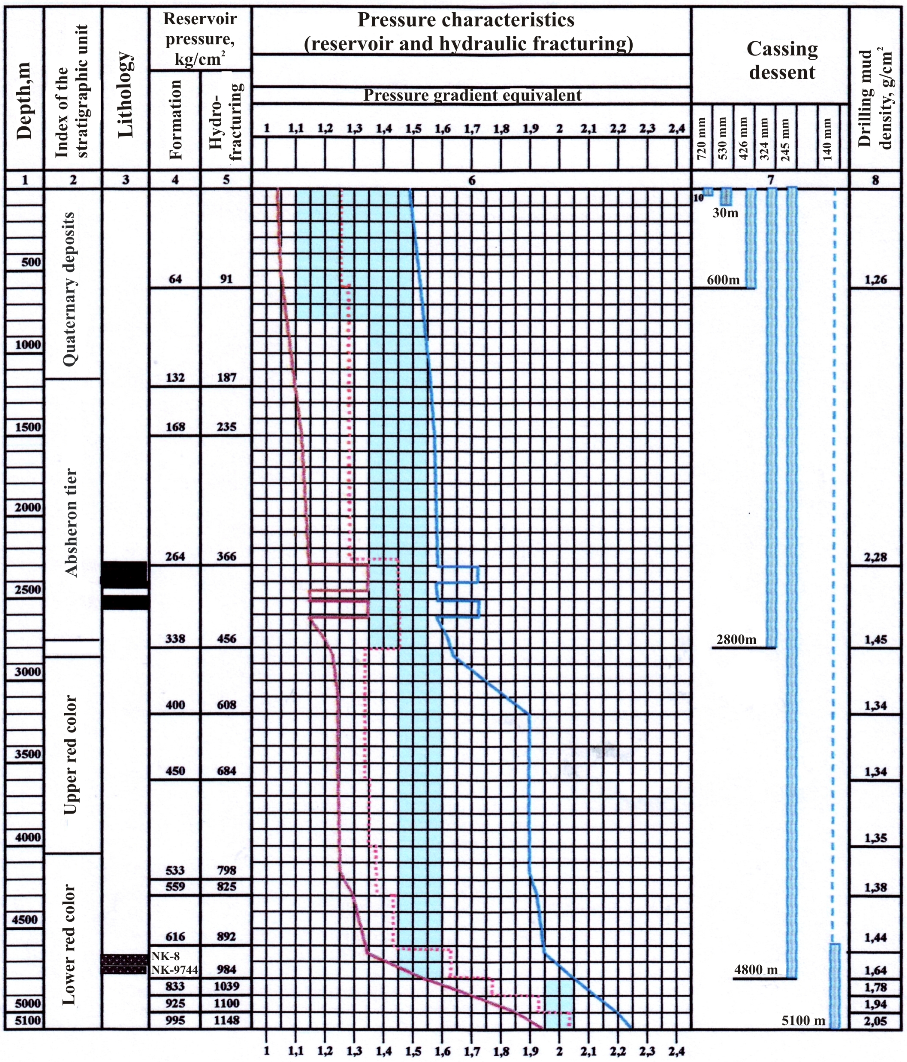

Figure 1. Combined pressure graph for borehole No. 201 North Goturdepe

- justification with geological and technical analyses when developing the correct design of drilled wells for dual completion jointly development of several layers at once in one directional well in order to increase oil and gas production;
- determination of the range of productive strata in oil and gas fields that are inaccessible or with various ground installations, and fields where seismic exploration has not been carried out (difficult to access and requiring high costs for seismic exploration), located in shallow offshore areas;
- substantiation of the structures of the complex of underground equipment and the design of the well, drilling of which is carried out by the directional method for dual completion jointly development of several open formations to increase the volume of oil and gas production;
- analysis of scientific research on the improvement of measures aimed at dual completion jointly development of several layers in directional wells, increasing the volume of oil and gas production carried out according to the results of scientific, theoretical and experimental studies;
- verification of the effectiveness of new technologies developed for dual completion development of several layers at once in one directional well to increase oil and gas production through scientific experiments;
- conducting an experimental study of the possibility of using the technology of dual completion jointly development of several layers at once in one directional well for all types of well development;
- determination of the optimality of the method of using dual completion jointly development of several layers in multi-layer deposits at the early and late stages of field development.

According to the design, a two-lift method was adopted dual completion operation of several oil reservoirs. The essence of this technology lies in the fact that two parallel tubing elevators are lowered into the operational column (mainly a 244.5 mm intermediate column), differing in suspension height - short and long. At the same time, productive horizons are separated by a packer device, which ensures their separate operation and accounting of production by the well for each operational object [8]. Wells No. 147, No. 37, No. 200 and No. 201 were laid at the field in the order of field tests, where technological equipment was supposed to be used dual completion operation. Upon completion of the construction of wells and the introduction of technological innovations in the development of fields by the technology of dual completion operation (DC) of several productive horizons, with two tubing elevators, large volumes of oil were received in all four wells, and the economic feasibility of using the selected downhole equipment was confirmed. During the development of the well, a short elevator was put into operation by the gas lift method, and a long elevator by the fountain method. Oil inflow of 800 tons/day was received at well No. 147, and oil inflow at well No. 37 was 730 tons/day. This is several times higher than the average values at the exploited fields, which in practice confirms the forecasts of the concern's specialists about the high prospects for the development of deep-lying deposits of the Goturdepe field [9]. Table 1 shows the design and actual designs of wells No. 147, No. 37, No. 200 and No. 201 of the Northern Goturdepe field.

Below is the justification of the well designs at the Northern Goturdepe field (using the example of well No. 201).

When choosing and justifying the design of the North Goturdepe exploration well No. 201, the requirements of the "Safety Rules in the Oil and Gas Industry", "Regulations for calculating intermediate columns when drilling wells in the areas of the Western Part of Turkmenistan were taken into account and geological and technical information on previously drilled wells in the North Goturdepe area was used. The choice of the well design is carried out in accordance with the intervals of compatibility of the well section according to the mining and geological conditions of drilling, based on the forecast curves of reservoir pressures and rock rupture pressures.

Based on the above, the following well design was adopted:

1. The elongated direction Ø 530mm descends to a depth of 30m in order to prevent erosion of unstable rocks in the wellhead when drilling a well for a conductor. The rise of cement to the wellhead. It is not pressed.
2. The conductor's descent Ø 426mm is projected to a depth of 600 m to overlap the upper unstable part of sandy-clay quaternary deposits. The wellhead is equipped with an OP1-425x210 blowout unit according to scheme 1 for effective well management in case of gas occurrences. The rise of cement to the wellhead. The pressure of crimping on water is 70 kg / cm^2.
3. The first intermediate column Ø 323.7mm is projected to be lowered to a depth of 2800 m, in order to overlap the "black clays" of the Absheron tier prone to collapses and to shorten the interval of the open hole when drilling for the second intermediate column Ø 244.5 mm. The wellhead is equipped with an OP2-350x350 anti-blowout installation according to scheme 2 for effective well management during gas occurrences using anti-blowout equipment. The rise of cement to the wellhead. The pressure of crimping on water is 350 kg / cm^2. The descent of the Ø 324mm technical column is designed to be carried out in two sections. The "head" of the I section is installed in a stable part of the open hole section, in the range of 1700-2300m with logging adjustment.
4. The second intermediate column Ø 244.5mm is designed to be lowered to a depth of 4800 m, in order to prevent the absorption of drilling mud with a density of 2.05 g / cm^3 and the tack of the drilling tool under the influence of a pressure drop. The wellhead is equipped with an OP2-280x700 blowout control unit according to scheme 2 for effective well management during manifestations using blowout equipment. The rise of cement to the wellhead. The pressure of crimping on water is 660 kg / cm^2. The descent of the Ø 245mm technical column is designed to be carried out in two sections. The "head" of the I section is installed with a 50-100m approach into the "shoe" Ø 323.7 mm into the intermediate column.
5. The operational "shank" Ø 139.7 mm descends to the design depth of 5100m (4600-5100m), provides the necessary conditions for testing productive layers and carrying out repair and insulation work. The height of the cement lift is 500m. The pressure of crimping on water is 504 kg / cm^2. The wellhead is equipped with a column head OKK3-700-140x245x324x426 and fountain fittings AFK6-80/65-700.

It should be noted that the Goturdepe field, which has been developed for more than 65 years, thanks to the introduction of new technologies, today not only continues to be successfully operated, but also increases its oil recovery. The success achieved is primarily due to the use of modern powerful drilling equipment and highly efficient technologies of advanced foreign companies, which are mastered by Turkmen specialists. Figure 1 shows a combined pressure graph for the North Goturdepe field (using the example of well No. 201). Schematic diagrams of two-lift tubing suspensions for some wells are shown in Fig.2. Thus, successfully implemented new technologies and equipment in the process of drilling and development of wells contributed not only to improving the quality and shortening the construction time of wells, but also to a significant increase in oil production.

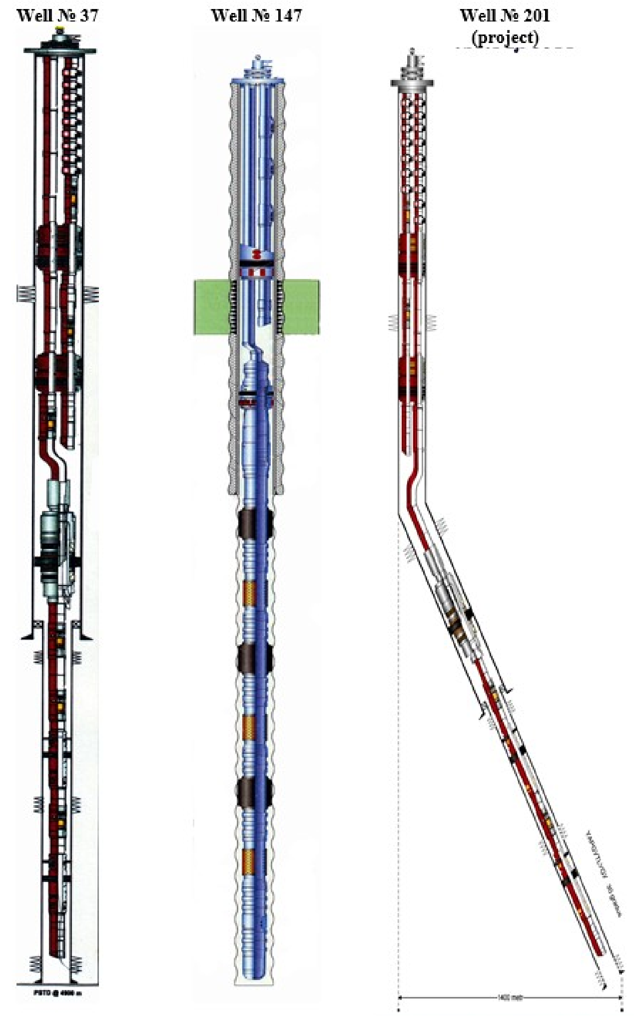

Figure 2. Schematic diagrams of two-lift tubing suspensions

The scientific novelty of the pilot industrial work is as follows:

- for the first time, dual completion jointly operation of several layers with attachment to the production column of packers (9 layers of 3 large horizons) was used by changing the design and configuration of the internal equipment of an exploratory directional well in shallow areas of the Northern Goturdepe field (difficult to access, requiring high costs for seismic exploration works) in which seismic exploration was not carried out;

- in an inaccessible shallow offshore area (due to the lack of seismic data from a depth of 3800m, a pilot vertical shaft was drilled to the design depth with a small diameter chisel, the presence of productive layers was determined, the field operation area was expanded due to directional drilling), the presence of productive layers at an inclined distance of 298 meters from the vertical position of the directional exploration wells, this eliminates the costs of seismic exploration on the 298-meter extended area of productive formations and allows drilling a number of new production wells.;
- for dual completion jointly operation of several oil and gas bearing formations at a multi-layer field, the design and internal equipment of directional wells are installed on double-row pumping and compressor pipes to ensure smooth operation of productive formations without mutual obstacles;
- a new drilling mud additive and buffer liquid has been created "Treatment of clay mud with inhibited complex additives "PACS", "PACS -T" and "Cementing of the casing of a well drilled with a hydrocarbon-based drilling fluid" (buffer solution "OBSF"), used to improve the quality of cementing and drilling of formations located at large depths in difficult mining and geological conditions with high temperature;
- a design has been developed for an obliquely directed well in order to fix without cementing the two lower large productive horizons in the open hole with packers swelling under the influence of drilling mud installed in the operational filter shank (to exclude the influence of cement mortar on the productive formation in order to increase their productivity);
- development of complex deposits in shallow offshore areas, reduction of the number of wells to be drilled (using one directional well instead of several vertical wells for each of the productive formations), and a significant reduction in investment costs for their drilling and operation;
- it has been established that the method of dual completion exploitation of several layers in multi-layer deposits can be used both at an early and at a late stage of development of deposits;
- the economic efficiency of the tested well, expressed in additional productivity and a reduction in the number of 2 wells to be drilled in each development grid, as well as in reducing the cost of major repairs during operation, and saving pipes for oil pipelines.

possible to shorten the payback period and reduce operating costs. However, the expediency of using DC at each specific field, block, horizon, deposit, etc. should be determined only on the basis of a deep economic analysis. The use of the DC technology also makes it possible to extract from one well not only from several productive horizons, but also by various methods - from the lower horizons by the fountain method, and from the upper ones, which have been in development for a long time and have low reservoir pressures, by gas lift. Despite the fact that the first experience of using the DC technology gave a positive result, not all technical problems have been completely solved and it is necessary to work out this technology and bring it to perfection [7]. As for the Northern Goturdepe field, an additional difficulty for the additional exploration and development of the area is the fact that some of the points on the exploration and development grid are located in the waters of the Balkhan Bay of the Caspian Sea and drilling of the area must be carried out from bulk islands. The construction of such islands, and they, due to technical requirements, have dimensions of 200x200 meters and a height of more than 3 meters, is very laborious and costly, even with high-performance construction equipment. It becomes obvious that it is necessary to change approaches to the methods of additional exploration of the field. One of the ways to solve this problem may be the drilling of advanced exploratory directional shafts from existing wells under the bottom of the Balkan Gulf with displacements of 1000-1500 meters. This will avoid possible unjustified costs for drilling additional wells when delineating the deposit. The resulting amount of profit for well No. 147 (DC) under the usual traditional scheme can reach 10 years. The allocation of operational facilities is completed by an economic analysis of the options. The analysis compares the technical, economic and technological indicators of the considered options and identifies the most economically effective [10]. When analyzing all existing schemes, the DC shows what can be achieved in planning this method in the design process, which will lead to a significant reduction in the volume of drilling wells and funds.

Systems of dual completion operation from several productive horizons can reduce the cost of hydrocarbon production by:

- Reducing the cost of operation and maintenance of production wells;
- Reduction of capital investments in the construction of reservoirs, oil collectors and reduction of costs during peration and repair;

Table 1.

Name of indicators	Unit of measurement	Before the use of the DC technology	After the application of the DC technology			
		Well № 145	Well № 147	Well № 37	Well № 156	Well № 200
Oil production	thousand tons	9,6	126,6	24,7	39,7	22,4
Liquid production	thousand tons	17,6	197,5	25,4	41,8	23
Revenue	thousand manat	11340,5	149552,6	56228,1	90374,7	50992,3
Capital expenditures	thousandmanat thousand manat	9031,0	15421,1	14531,4	9306,3	14557,0
Operating costs	thousand manat	1737,4	22912,4	4470,3	7185,0	4054,0
Profit due to increased production	thousand manat	9603,0	126640,1	51757,8	83189,6	46938,2
Profit due to cost reduction	thousand manat	-	2640,9	3530,6	8755,7	3505,0
Total profit	thousand manat	9603,0	129281,0	55288,4	91945,3	50443,3
Discounted Cash Flow (NPV)	thousand manat	-2263,2	73830,9	23169,4	51289,7	19633,2
Profitability Index (PI)		1,1	8,96	3,80	9,88	3,47
Payback period	year	1,833	0,494	0,412	0,568	0,385

RESULTS

When analyzing the economic efficiency (Table 2), it can be seen that the cost of drilling a directional well requires considerable expenses, but the self-sufficiency of the well due to the reduction in drilling wells at the field and the costs of seismic exploration, as well as the resulting large inflow of oil, the self-sufficiency for drilling a well is within 0.494 years (about 6 months) [6]. The economic effect of the introduction of the technology of dual completion operation is obtained mainly by reducing the cost of drilling additional wells, as well as by a second additional elevator, which in turn makes it

- Reduction of capital investments for drilling production wells.

Since, in our scientific work, we investigated the use of a system of dual completion from several productive horizons with the use of multi-packer-sectional layouts.

CONCLUSIONS

One of the strategically important tasks for the enterprise is to stabilize the volumes of profitable oil production at the fields under development, increase the inter-repair period of well equipment, search, selection and introduction of new effective types of well equipment, new technologies to maintain the operability of wells (including chemical reagents) [11, 12]. In this paper, a proposal for the introduction of equipment for the DC is considered. The technology of dual completion exploitation of reservoirs by one well has confirmed its prospects.

When implementing the DC method, the following advantages are observed:

- the economic effect of the introduction of the technology of dual completion operation is obtained mainly by reducing the cost of drilling additional wells, as well as due to the second additional elevator, which in turn makes it possible to shorten the payback period and reduce operating costs.
- the costs of well construction are reduced almost several times
- the costs of field development are reduced during development,
- reduced requirements for equipment and materials for drilling wells and production of products;
- non-industrial stocks are involved in the development;
- the operating conditions of low-yielding formations are improving (the timing of gushing is increasing, periodically operating wells are switched to continuous operation due to the gas lift method, inter-repair periods are increasing, freezing of water pipelines is prevented, etc.) due to the introduction to other development facilities.

The proposed DC project is economically attractive due to additional oil production, a high yield index and a low payback period.

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