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DEVELOPMENT OF PROFILES AND NEW TECHNOLOGY OPTIMIZATION MEASURES ENSURING EFFICIENT OPERATION OF INCLINED WELLS

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ABSTRACT

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AZƏRBAYCAN RESPUBLİKASI TƏHSİL NAZİRLİYİ AZƏRBAYCAN DÖVLƏT NEFT VƏ SƏNAYE UNİVERSİTETİ

GENERAL CHARACTERISTICS OF WORK

The urgency of the subject

It is intended to implement high-speed development and operation of oil fields in offshore and other difficult geographical areas. As under such difficult conditions, if the development of the field is not completed during the service life of the materials of hydrotechnical structures - piers and platforms, a large amount of funds must be spent on the subsequent repair and restoration works of obsolete facilities and equipment.

At the same time, the development of oil fields under such conditions in accordance with economic requirements is carried out by drilling wells in a cluster form from one platform with a sloping profile.

The deviation of the wellbore from the vertical and the different shape of the profile in the subsoil cause a sharp change in the operation indicators. Thus, in different methods of operation, the condition of the profile affects the production which is the main indicator of well productivity and other parameters that determine it. Due to the deviation of the profile from the vertical, the probability of complications in the operation process increases significantly. Therefore, when designing a well, in addition to drilling, the effectiveness of its profile in the long-term post-drilling operation should be taken into account. Thus, in the design of an inclined well, it is necessary to choose such a profile that it can be optimal both from the point of view of drilling and also operation.

Along with these, increasing the efficiency of production wells, including inclined wells by applying new technique and technologies in any method of operation is of great importance. Especially in the final stage of development, the solution of issues such as increasing the oil yield of non-homogeneous layers which are typical for the fields in Azerbaijan, regulation of high watering process, prevention of sand that is the most complex problem is of great interest.

The development and application of nanotechnologies in the oil industry of our country founded by academician A.X. founded by Mirzajanzadeh was aimed at solving many problems existing in oil extraction processes. Continuation of works in this direction through their scientific and practical substantiation, development of new fluid nanosystems for using in technological operations and creation of nanotechnologies on this basis are urgent and prospective as a new scientific direction.

The purpose and objectives of the research:

The purpose of the study is to develop new technology optimization measures in order to increase the efficiency of the profiles and the operation of fields ensuring the efficient operation of inclined wells and existing profile production wells in the oil production process by conducting theoretical and experimental research.

The following main issues have been resolved to achieve the goal:

- Evaluation of profiles based on technical and economic indicators of inclined wells;
- Analysis of well profiles based on inclinometer data and study of the impact of borehole inclination parameters on the technological processes of existing operating methods;
- Study of the effect of the borehole profile on the operating ratio of production wells;
- Selection of technologically optimal profiles according to the operating indicators of inclined wells;
- Study of the effect of the profiles of wells with gas lift system on the consumption of the working agent;
- Substantiation of decision-making issues for taking geological and technical measures under mining conditions by applying utility theory;
- Development of dispersed liquid systems with nano - bentonite structure and development of technology to increase oil yield of non-homogeneous layers;
- Analysis of the causes of watering in inclined wells and development of water isolation technology;
- Development of nanotechnology to eliminate the complications caused by sand formation in production wells and sand blockage;

● Development of techniques and technologies for the methods of impact on the wellbore zone to increase the efficiency of wells by applying physical fields.

Research methods: The problems of the dissertation have been resolved using experimental and theoretical methods jointly, and the accuracy of the results has been confirmed by the application of mathematical statistics, fuzzy logic, engineering and computer graphics and the use of modern precision diffractometers and microscopes, as well as nanoscale devices.

Main provisions intended to be defended:

♦ selection of optimal profiles to improve the operating indicators of inclined wells.

♦ development of new optimization measures to eliminate the complications caused by the formation of sand in inclined wells;

♦ enrichment of nano - bentonite clay, which is a local raw material, comparative study of rheology and swelling process of raw and enriched nano - bentonite suspensions, development of technology for oil squeezing on the basis of enriched nano-bentonite;

♦ study of the impact of inclined well profiles on the extraction watering and isolation of watering through nanotechnology;

♦ Optimal decision-making under the conditions of uncertainty by applying inaccurate probabilities and intervals based on the theory of utility in oil extraction processes;

♦ study of the effect of magnetic field on capillary events in the layer and increase in the efficiency of wells.

♦ increase of oil extraction factor as a result of application of physical fields, optimization of extraction and operation indicators of wells;

♦ Development of scientific bases for optimal decision making in order to ensure the improvement of the working conditions of wells on the basis of the development of new techniques and technologies that generate acoustic waves, taking necessary measures for the regulation, improvement and increasing of the joint operation of the layer - well system through magnetic fields, as well as ultrasonic waves.

Scientific innovations of the research

♦ On the basis of dependencies and regularities between inclinometer, technical-economic and technological parameters, taking into consideration the specific features of marine conditions, the main directions for the efficient operation of inclined extraction wells and improvement of oil fields have been identified;

♦ The dependence of the tension generated during the upward movement of the plunger at the depth of the pump release on the intensity of profile bending was found in the method of operation with a rod well pump;

♦ In the gas lift operation method, the consumption of the working agent required to lift light and heavy oils to the surface was evaluated, and for the first time it was found that the working agent was used less to lift heavy oil, which enable to take into consideration this fact while determining the optimal well regim and significantly decrease the gas consumption required to raise oil to the surface according to the mining studies;

♦ In vertical and inclined wells with gas lift system, a nano-fluid system has been developed and applied to prevent sand blockage by injecting fluid into the pipe space;

♦ Based on the analysis of various criteria under the conditions of uncertainty, optimal decision-making options have been identified in order to determine the number of additional wells to be drilled for carrying out any technological measure on the field and compacting the development network;

♦ A hydrodynamic mixer has been created for the preparation of dispersed fluid systems for its use in technological operations;

♦ A new viscometer was developed and applied to study the rheology of fluid systems;

♦ Hydrodynamic wave generators have been proposed to affect the layer and its wellbore area;

♦ New nano – bentonite -based gasket and technology have been developed to compact oil into the wellbore zone in the layer;

♦ New nanotechnology has been developed to prevent the flow of layer waters into oil wells;

♦ A positive effect of magnetized water on capillary absorption processes was found in layer models consisting of porous media of different components;

♦ A new method has been developed to eliminate the negative impact of mechanical mixing on the operation of the pump in sand wells by means of a magnetic field in the rod well pumping method;

♦ A new content, ultrasonic-activated microemulsion and technological method has been developed to affect the wellbore zone of the layer.

Practical significance of the research

4 methodological guidelines have been developed and published that cover urgent issues such as the improvement, regulation of the development and operation of oil fields based on the analysis of parameters and technological indicators characterizing the wellbore profiles of inclined production wells, as well as optimization of technological processes, selection of appropriate technological schemes by applying various methods to increase the productivity of extraction wells, putting wells into operation after the application and assessment of the processing of results.

Sand block removal method (AR's Patent No. I 2013 0024) was tested at wells No. 1361 and 1373 operating from the Buzovna field of OGPD named after Z.A.Taghiyev and the results were satisfactory. So, during the application period, the number of impacts with water on both wells decreased more than three times, including the repair period increased, along with the working agent supplied to the wells being decreased, the output increased significantly. This method has been applied in the wells of the Oil Rocks field and high results have been obtained. Testing and application works have been approved by relevant acts.

In recent years, the bidder has been the scientific supervisor and responsible participant of the following topics that are of practical importance for production on a contractual basis in cooperation with Azneft PU:

♦ Development of new technology for the preparation of emulsions for use in the operations carried out in oil wells;

♦ Study of the effect of nanoparticles on the processes occurring in production wells during sand- fluid relations;

♦ Increasing the efficiency of the methods of impact on the wellbore zone by adjusting the rheological parameters of the fluids used;

♦ Study of the causes of decline in productivity after technological operations carried out in wells and development of relevant measures to restore production;

♦ Development of a method to increase the oil yield of heterogeneous layers by applying a gasket with new composition;

♦ Development of impact technology to the wellbore zone through activated microemulsion;

♦ Regulation of the permeability of the wellbore zone with the use of acid and alkaline systems.

The author was awarded a silver medal of the USSR's Exhibition of Achievements of National Economy and a cash prize of the Offshore Oil and Gas Production PU for the application of the methodology for optimizing the working mode of wells in the gas-lift operation method in production.

Also, the patent entitled "Method of increasing the oil yield of layers with non-homogeneous collectors" which the author received together with others, was awarded third place and a cash prize in the 3rd Republican competition held by the State Committee for Standardization, Metrology and Patents.

104. **Approbation and publication of the research**. The main provisions of the dissertation were reported and discussed at the below mentioned Republican and international conferences: XXXVI Berg- und Huttenmenischer Tag, (Bergakademie Freiberg, June 11-14, 1985), All-Union Conference On "Application of non-Newtonian systems in technological processes of oil and gas production" (Ufa, September 22 - 24, 1987); scientific-practical conference on "Development of the Caspian Sea shelf" held by "Caspian Sea Oil and Gas" PU (Baku, 1991); joint international conference on petrochemistry held by the Georgian National Academy of Sciences and Tbilisi State University on the occasion of the 100th anniversary of academician L.D. Melikadze (Tbilisi, October 1-2, 2012);

international scientific conference held by ANAS on "Non-Newtonian systems in the oil and gas industry" dedicated to the 85th anniversary of academician A.Kh. Mirzajanzade (Baku, November 21-22, 2013); international scientific-technical conference on "Modern technologies in oil and gas – 2014" held by the Ufa State Petroleum Technological University of the Ministry of Education and Science of the Russian Federation (Oktyabrsk, 2014); the Republican scientific conference on "The Contract of the Century is Heydar Aliyev's new oil strategy" dedicated to the 20th anniversary of the "Contract of the Century" held by Sumgayit State University (Sumgayit, September 23-24, 2014); the inter-regional scientific-technical conference on "The problems of development and operation of fields with high-viscosity oils and bitumens" held by Ukhta State Technical University (Ukhta, November 11-12, 2014); a the republican scientific-practical conference on petrochemical synthesis dedicated to the 90th anniversary of academician Soltan Mehdiyev held by the ANAS Institute of Petrochemical Processes named after academician Y. Mammadaliyev (Baku, December 2-3, 2014); scientific-practical conferences "Caspian Oil and Gas Field - 2014" and "Caspian Oil and Gas Field - 2016" (Baku, December 24-25, 2014; Baku, December 29-30, 2016); international conference - the 12th International Conference on Application of Fuzzy Systems and Soft Computing. Procedia Computer Science, ICAFS. 2016, August 29-30, Vienna, Austria; "Modern problems of innovative technologies in oil and gas production and applied mathematics". Proceedings of the international conference dedicated to the 90th anniversary of Academician Azad Khalil oglu Mirzajanzade .Baku, 2018, 13-14 dekember.

The main provisions of the dissertation were published in 62 scientific works, including 1 monograph and monographs of other authors, 4 methodical guidance, 7 patent documents of the Republic of Azerbaijan, 1 document of Germany, 1 document of Russian Federation, 1 USSR authorship certificate, 1 textbook, articles, theses, set of works of republican and international conferences.

The organization where the dissertation work is implemented: The dissertation work was carried out at the Scientific

Research Institute “Geotechnological problems of oil, gas and chemistry" under the Azerbaijan State University of Oil and Industry.

Structure and volume of the research work: The dissertation consists of an introduction, 7 chapters, main conclusions, a list of 272 references and appendix. The volume of the research work is published in 368 pages, its text includes 108 figures, 59 tables, and the research work consists of four hundred and thirty-seven thousand twenty-one characters.

The author thinks that he is obliged to note that many provisions and scientific directions of the dissertation work were proposed by late academician A.Kh. Mirzajanzade (may His soul rest in peace!) and the solution of these issues was carried out directly under his leadership.

The author expresses his deep gratitude to the academician F.A. Aliyev, the corresponding members of ANAS R.A. Aliyev and R.S. Gurbanova for their attention and their valuable recommendations in setting problems in the implementation of dissertation work and discussing the obtained results.

The author also thanked Ph.D in Technical Science Y.M.Aliyev for his support in the preparation of the dissertation and for his valuable advice and recommendations during its application in production, at the same time, the staff of the Scientific Research Institute “Geotechnological problems of oil, gas and chemistry" and the Department of “Oil Engineering” of the Azerbaijan State University of Oil and Industry.

CONTENTS OF THE RESEARCH WORK

In the introductory part, the urgence of the topic of the dissertation is substantiated, the purpose of the research work and the main scientific issues submitted for defense are identified, the scientific innovations of the dissertation, the goals and objectives of the research work are interpreted.

The first chapter gives a comprehensive analysis of the application of new technologies for the development of oil fields and increasing oil yield of layers through inclined wells, as well as improvement of the operating indicators of wells. In accordance with the content of the dissertation, information on existing developments in the above mentioned field is grouped, systematized, methodological principles and main directions of the improvement of applied technologies are identified.

Factors causing complications in the operation of inclined wells in different exploitation methods specific to the offshore fields of Azerbaijan under difficult geographical conditions are analyzed and ways to regulate them are shown.

A wide classification of technologies applied to achieve successful results in the development of oil fields and operation of production wells is given, achieving high level modernization and improvement of technological processes on the basis of their comprehensive analysis is put forward as the main objective.

In addition, special attention is paid to the development of nanotechnologies, the so-called modern technology, and their application in various fields of the oil industry. The development of nano-liquid systems in the new composition and the possibility of their use in various technological operations are considered, and it is noted that at present, these issues are urgent.

It is mentioned that despite the fact that enough scientific and research works on the application of physical fields, especially magnetic fields and acoustic waves have been conducted, the urgency of the problem has not lost its scientific and practical significance. The discovery and use of new technical and technological solutions in these areas have been assessed as a key factor in the intensification of oil extraction processes.

The development of other technologies, including watering of well products which cause the most complications in the oil extraction process and its consequences and the problems caused by the appearance of sand are widely analyzed, it is substantiated that new technological measures taken to prevent layer waters entering into wells, develop new isolation methods and eliminate sand blockage are promising, and their practical effectiveness is noted.

In the second chapter, based on the inclinometer data of the profiles of inclined wells, the analysis of their technical and economic indicators in different operating methods is given. Regarding this, the inclinometer data of the profiles of production wells operating in the Oil Rocks and Mud Terrace offshore fields - bending (zenith) α and azimuth α angles, bending intensities of these angles at different intervals along the wellbore $\Delta\alpha$, $\Delta\varphi$, as well as the vertical deviation distance of the wellbore, ℓ parameters were collected, systematized and extensively analyzed. It has been determined that it is possible and expedient to use these parameters to characterize the impact of the profiles of inclined wells on the operating indicators. Based on the inclinometer data of the profiles of 110 wells operating from the Oil Rocks and Mud Terrace fields, the distribution curves of the specified parameters are constructed, it is shown that they correspond to the statistically normal distribution law, at the same time, the empirical dependence with the minimum dispersion (DS = 0,45) between the maximum values of the parameters α and ℓ was determined as follows.

$$\alpha = 8.588\ell^{0.607}e^{0.022\ell} \quad (1)$$

The impact of the wellbore profile on the technical and economic indicators of production wells in well rod pump (WRP) and gas lift operation methods was considered. For this purpose, the technical and economic indicators of 93 WRP wells operating from the Oil Rocks and Mud Terrace fields were grouped under bending angles 0^0, 10^0, 20^0, 30^0, 40^0 and the gas lift fund of the Oil Rocks field (110 wells) under bending angles at 0^0, 10^0, 20^0, 30^0, 40^0 and 50^0 bending angles and classification of the distribution of costs by groups was provided. Three main economic indicators for both methods of operation - the cost of construction of hydrotechnical structures, special operating costs and total specific costs were identified and the impact of the maximum value of the bending angle on these parameters was studied. It is shown that with the increase in the maximum bending angle, the cost of construction of hydrotechnical structures decreases, the specific operating costs increase, and the total specific costs decrease to a certain extent, and then they begin to increase.

A comparison of the dependence of special operating costs on The curvature of the wellbore of inclined wells shows that the special operating costs under the same value of bending angle is much higher in gas-lift operating method than WRP.

The comparison of the dependence of total specific costs on the bending angle shows that the minimum cost of costs is observed at the values of the angle of inclination at 40^0–43^0 və 30^0–33^0 respectively in the gas lift and WRP operating methods. This indicates that the opportunities of the application of the WRP operating method under the conditions of the inclined profile of wells at sea is limited.

On the basis of technical and economic indicators, the parameters related to the improvement of oil fields are analyzed. Inclined wells are again grouped by 0^0, 10^0, 20^0, 30^0, 40^0 and 50^0, and the dependence of these parameters on the maximum bending angle was studied determining the specific costs for drilling and construction of hydrotechnical structures for each group.

The dependence between the specific costs spent for drilling and the bending angle has shown that as the bending angle increases, the specific costs also increase.

However, the above mentioned dependence reflects only a certain part of the change in the technical and economic indicators of the reconstruction of offshore fields, depending on the profiles of the inclined wells. As a rule, the construction of wells under offshore conditions is formed as a result of drilling costs and the cost of building special foundations for drilling rigs. Therefore, depending on the degree of bending, it is necessary to study the change in the specific costs (per well) for the construction of hydro - technical structures. For this purpose, the share of costs per well during the construction of the platforms around the pier was identified. It was determined that as the value of the bending angle increases, the special costs of construction of hydrotechnical structures sharply increase.

Based on the analysis of repair works, the profile of the wells was assessed. For this purpose, the bending coefficient (k) characterizing the ratio of the vertical deviation distance of the wellbore to the total length of the wellbore was applied. As can be seen, actually this parameter is a quantity comprising the sinus of the vertical deviation angle of the wellbore.

Based on the inclinometer data of 110 wells of the V tectonic block of the Oil Rocks field, the value of k was calculated for each well, it was divided into intervals by special methodology, the number of wells per interval was determined, dependence between the amount of underground and overhaul works, the number of broken operating pipelines and the number of wells removed from the balance and k was determined. It was found that with the increase in the value of k, the number of repair works in the wells (both underground and capital) initially increases, but after a certain value of k (k = 0.38), it begins to decrease sharply. Along with this, after the indicated value of k, the number of broken pipelines in each interval and the value of the parameters of the share of wells removed from the total balance continue to increase.

In the next study, the analysis of the operation of wells in only one horizon was considered. Such wells were selected that they had been removed from the balance or transferred to another horizon after completion of operation on any horizon. For this purpose, the data of 41 production wells, which completed their service life for this or that reason operating from the GUG (a layer of sandy topsoil) horizon for one reason or another were reviewed and analyzed by the above mentioned method. The period of consecutive operation of wells in the GUG horizon and the dependence of the number of repair works carried out during this period on k were considered. The results of the analysis showed that with the increase in the value of k, the continuous operation time of the wells sharply decreases. This is explained by the fact that it is impossible to eliminate technical shortcomings formed in inclined wells with a large curvature of the wellbore, which leads to the rapid failure of wells. The dynamics of repair works coincides with the above mentioned results.

It can be concluded that for inclined wells operating from any field under specific natural and technical conditions, there is such a value of the vertical deviation parameter of their wellbore that after this value, the result of repair works in such wells is either inefficient or generally, such repair is not possible to be carried out.

In addition, the impact of the wellbore profile on the costs of repair works conducted in wells was considered. As the main economic indicator, the parameter (C), which reflects cost per repair, has been taken.

The dependence of the costs of major repairs (C) on the intensity of bending (α) and change in direction (n) of wellbore was studied. It was determined that as the bending angle of the pipe increases, the cost per repair also begins to increase, and the impact of the intensity of the change in the direction of the wellbore also shows itself. Also, the cost of repairs increases sharply with the increase in the intensity of the change of direction of the wellbore at the same value of the bending angle of the wellbore. At the same time, as the bending angle and the bending intensity of the wellbore direction increase, the rate of increase in repair costs increases even more.

The issues of decision-making for taking various geological and technical measures (GTM) under the conditions of uncertainty were considered. In this regard, the principle of making a single decision has been implemented choosing the most appropriate one out of several alternatives by applying the theory of utility and establishing a utility function.

Under such risk conditions, Von Neumann–Morgenstern utility function was used to evaluate the relative advantage of each alternative outcome and select the best activity:

$$U(x) = pU(x_1) + (1 - p)\,U(x \qquad (2)$$

here: x_1 - the best object selected with the probability of p; x_2 – the worst object selected with additional probability of (1-p).

The essence of this function is that for U (x) $x \neq x_1$, x_2, that is, there is such a number p in the interval of $0<p<1$ within $x_2<x<x_1$, that it is also unique. The quantity x corresponding to this condition

is called the deterministic equivalent and it is considered the basis of utility theory.

According to the utility theory, the effectiveness of the method of impact on the well bottom with surface-active substances applied in the Oil Rocks OGPD was analyzed and the optimal cost estimate for the implementation of this measure was determined.

The compaction of the development network by drilling additional wells and the economic justification of the optimal number of wells included in the development process at this stage were implemented through the analysis and application of many criteria. Firstly, the dynamics of production indicators of block V wells on the GUG horizon of the Oil Rocks field was developed by applying the logistic equation, three stages in the dynamics of oil, water production and oil yield coefficient were determined by the Levenberg–Marquardt algorithm, the impact of drilled additional wells on dynamic processes at these stages was confirmed.

Then, Laplace, Gurvich, Wald, and Savage criteria were analyzed based on the profit generated from production wells as an economic indicator, the optimal number of additional wells to be drilled for each criterion was determined based on the actual profit, and the result was compared with the weighted average for mathematical expected value.

The issue of determining the total number of wells for geological and technical measures under mining conditions was considered. To solve this problem, the Choquet integral, which is still based on the utility function model but evaluated at interval, was used:

$$U(f_1) = \sum_{j=1}^{m} \left(X_{i(j)} - X_{i(j+1)}\right) \eta_{\{(1),\dots,(j)\}} \tag{3}$$

here: $\eta_{\{(1),\dots,(j)\}}$ non – linear measure, the result of alternative f_i in the condition of $X_{i(j)} = f_i\left(S_{(j)}\right) S_{(j)}$, index () shows that the values of $X_{i(j)}$ is mentioned according to the rule as $X_{i(j)} \geq X_{i(j+1)}$

və $X_{i(m+1)} = 0$. By means of this measure, non – linearity of the choices of the decision maker can be modelized under uncertainty conditions.

The applied utility function model allows to take into account the accuracy of information related to decision and the non-linearity of decision-making issues when comparing alternatives (number of alternate wells). The solution of the problem of four alternative practical decision-making shows the reliability of the utility function model evaluated at intervals and its feasibility.

For the first time, the issue of investment with probabilities given in the form of intervals in oil extraction was considered. The solutions for the issue of three alternative (hydraulic fracturing of the layer, development of well bottom, injection of polymer solution into wells), four criteria (environmental imbalance, period between repairs, increase in output, payback) investment decision-making were studied, invested alternative (development of well bottom) was determined. It was noted that to invest in geological and technical measures, it is more expedient to use the method based on interval probabilities unlike decision-making based on classical probabilities.

The third chapter is devoted to the study of the impact of well profiles on technological parameters in WRP and gas lift operation methods.

Parameters characterizing the operation of inclined wells with the method of WRP were analyzed, their impact on the operation of the pumping unit was studied. It was determined that the bending intensity that characterizes the position of the wellbore at the discharge depth of the pumping unit is one of the main parameters affecting its operation.

The bending intensity can generally be determined as follows taking into account the simultaneous change of the zenith and azimuth angles:

$$\alpha_2 = 2arc\sin\sqrt{\sin^2\frac{\Delta\alpha}{2}+\sin^2\frac{\Delta\varphi}{2}\sin^2\alpha_{orta}} \qquad (4)$$

α_{orta} – average bending angle in a given interval: $\alpha_{orta} = (\alpha_1 + \alpha_3)/2$.

The maximum value of the bending (zenith) angle of the wellbore at the discharge depth of the pumping unit and the impact of the bending intensity parameters on the oil injection coefficient of the pump were studied by WRP method. It has been determined that there is a dependence of oil injection coefficient on both parameters, and as their value increases, the oil injection coefficient decreases, but the impact of bending intensity on pump operation is stronger, the oil injection coefficient decreases more intensively with increasing value of this parameter.

Also, the dependence of the period between repairs on both parameters, which is a key indicator in WRP method, was studied. In this case, with the increase of both parameters, a sharp decrease in the period between repairs was observed. It has been determined that when the value of the bending angle increases from 10^0 to $40^0$and the bending intensity is 4^0 per 10 m, the period between repairs is reduced more than 2 times.

The impact of the bending intensity of the profile of inclined wells during the operation by WRP method on the operation of the pumping unit was studied. For this purpose, a special study was conducted in the inclined well No. 2046 with a characteristic profile operated in the Oil Rocks field. The depth of the well was 785 m, the maximum value of the zenith angle was $47^0 15'$, and the deviation of the wellbore at the bottom of the well was 688.8 m. In the pump discharge depth zone (465-495 m), the bending intensity per 10 m at an interval of 40 m was 1^0, 2^0, 3^0 and $3^0 30'$ respectively. Dynamograms were taken by releasing the pump unit in the middle of the intervals at every 10 m length in accordance with the specified bending intensities of the wellbore. The indicators of each dynamogram were processed and the value of the tensile stress at the pump release depth was calculated, and the dependence between this parameter and the bending intensity of the wellbore was determined. It has been clear that as the bending intensity of the wellbore increases, the value of the tensile stress also increases.

The impact of the wellbore profile on the operation coefficient of production wells was studied. This parameter plays a key role in the determination of operating costs and it is also one of the key indicators of the efficient use of the well fund. It should be noted that studies were conducted separately for both gas-lift and WRP operation methods to clarify the impact of the wellbore profile on the operating factor. Analyzes were carried out on the basis of data from inclined wells of Oil Rocks and Mud Terrace fields. For both modes of operation, the coefficient of operation is defined by the following formula:

$$K_{ist} = \frac{T_1 - (T_2 + T_3)}{T_1} \qquad (5)$$

here: T_1- calendar time; T_2- idle time due to underground repair, major repair and waiting for equipment; T_3 - idle time for organizational reasons not related to underground repairs.

Discrimination method based on the minimum dispersion according to the Taylor criterion was applied to determine the nature of the change in the dependence between the calculated operation coefficient and the maximum bending angle quantities and select the model that expresses it at the best way. Ten different models were considered and the most accurate one with the least average error and the minimum variance was selected among them. It became clear that the model that meets the minimum dispersion conditions for both the gas lift and the WRP operation method is in the form of a parabola.

The impact of the profiles of inclined wells operated by the gas lift method on the consumption of the working agent was studied. It was noted that at a given depth and within the quantities of the vertical deviation of the well bottom at that depth, it is possible to drill wells of such different profiles that minimum energy consumption is required to lift the fluid to the surface in the only option between them.

For this purpose, information on the operation of gas lift wells in the Oil Rocks field was analyzed. According to this information, it was determined from the dependence between the specific consumption of the working agent (V_0) and the deviation (ℓ) parameter that the value of V_0 increases sharply with an increase in ℓ, and in this case the dependence between the parameters is in the form of a parabola.

Then the analysis of the change values of ℓ was carried out using a small sampling method. As a result, three different intervals were defined for ℓ. These are: $0 < \ell < 300$ - the first interval, $300 < \ell < 600$ - the second interval and $\ell > 600$ - the third interval.

Depending on the nature of the natural bending of inclined wells, as well as large-scale changes in the parameters α and φ, there is a change in the spatial coordinates of the wellbore in the ground. In this case, the azimuth angle φ is taken as the main determinant of the direction of change of the wellbore, that's, the number of times the angle φ changes its direction along the length of the wellbore is the main factor influencing the operation of the well during commissioning.

Experience shows that in the operation of such wells there are serious complications in any method of operation. The movement of the gas- fluid mixture in the lift pipes of gas-lift wells which wellbore is subject to spatial bending undergoes many changes that affects the energy consumption required to lift the fluid to the surface. It is of great practical importance to study the impact of the number of the changes in wellbore direction (n) on the specific consumption of the working agent during the operation of such wells.

For this purpose, the inclinometer data of the above mentioned inclined wells were analyzed using a small sampling method and the number of changes in the direction of the wellbore was determined. The obtained results are shown in the form of the dependence $V_0=f(n)$. It was determined that in this case, too, the specific consumption of the working agent V_0 increases with an increase in n parameter. However, each interval boundary of ℓ corresponds to a separate characteristic curve in the form $V_0 = f(n)$.

Thus, the main characteristic of the obtained dependencies is that the wells are grouped quite well according to the interval values of the parameter ℓ.

It should be noted that at relatively small values of vertical deviation of the wellbore ($0 < \ell < 300$ - first interval and $300 < \ell < 600$ - second interval) the specific consumption of the working agent V_0 increases slightly with an increase in the number of changes in the direction of the wellbore n, however, at large values ($\ell > 600$ - third interval) the increase in V_0 is sharp. However, the nature of the dependencies $V_0 = f$ (n) remains unchanged in terms of quality.

Thus, it was determined that the condition of the wellbore profile during the operation of inclined gas lift wells has a very serious impact on the energy consumption required for lifting the fluid to the surface. It was also shown that the factors that lead to a change in the optimal production of wells in the gas lift operation method are, among other key indicators, the amount of gas extracted together with the fluid and the physical and chemical properties of the fluid.

Extensive mining studies have been conducted to clarify the impact of these parameters on the operation of gas lift wells, as well as determine the excess amount of working agent. Studies were carried out in the gas-lift wells of the Oil Rocks and Mud Terrace fields. These two fields have been operating in parallel for a long time, and the main thing that distinguishes them is the diversity of physical and chemical properties of their oils. Mud Terrace field oil is characterized by the presence of 20-40% heavy components (asphaltene, tar, etc.). The density of oil extracted from this field is more than 920 kg / m3. On the contrary, the oil of the Oil Rocks field belongs to light oils and its density varies in the range of 840-880 kg / m3. Due to its rheological characteristics, the oil in this field behaves like ordinary Newtonian fluid.

Selecting wells with the same parameters from both fields and conducting research under the same conditions, it was determined that about twice as few working agent is used to lift heavy oil to the surface than light oil.

In general, when analyzing the operation of gaslift wells in the Mud Terrace field, it can be concluded that 70-80% less gas is used here than in the Oil Rocks field to lift oil to the surface under the same conditions.

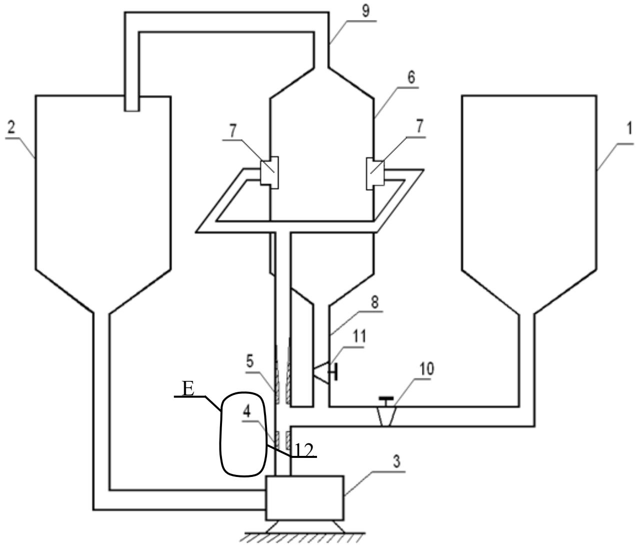
The fourth chapter is dedicated to the issues of development of new devices for the preparation of dispersed liquid systems and the study of their rheological parameters.

In order to successfully carry out various technological operations in oil extraction processes and increase their efficiency, a hydraulic mixer has been developed which provides intensive mixing of fluid and homogenization of the mixture for the preparation and application of high quality, long-lasting dispersed fluid systems (Figure 1).

The working principle of the device is as follows. The components of the mixture (emulsion) to be prepared - the dispersion medium is placed in tanks 2 and 6, and the dispersed phase is placed in tank 1 in the required amount. By starting pump 3, dispersion medium fluid circulation is created pumping dispersed phase from tank 2 to tank 6 in the 11 open conditions of 8 taps at its lower outlet and 10 closed position of the tap of tank 1. The fluid taken by the pump 3 from the tank 2 enters into the mixing tank through the nozzle 4, the mixing chamber 5 and the centrifugal injectors 7. While the injected fluid passes through the nozzle 4 and enters the mixing chamber 5, the fluid 6 in the tank is sucked out of its lower outlet 8 by tap 11 and carried to the tank 6.
In this case, the volume of fluid in tank 2 should be taken so that there remain the volume as empty as the volume of the dispersed phase in tank 1. After the dispersed fluid circulation is formed, tap 11 is closed and tap 10 is opened, the consumption of the dispersed phase sucked into the ejector E is regulated (not exceeding 10% of the pump efficiency) and the dispersed fluid is pumped to the tank 6 together. After the required volume of dispersed phase is taken from tank 1, tap 10 closes and tap 11 opens and it enters into tank 6 passing through nozzles being mixed with fluid coming from upper outlet 9 being sucked into the suction chamber E of the ejector 12, mixing chamber 5. The mixture is re-circulated until it becomes

homogeneous. The fluid hit by the pump 3 passes through the nozzle 4 of the ejector E and mixes with the fluid sucked into the mixing chamber 5, and as it exits the sprayers 7, the torches rotating in the same direction collide with each other and undergo intensive dispersion.

Centrifugal injectors with tangential inlet, whirl chamber and



1,2- tanks for dispersed phase and dispersion medium, 3-pump, 4-nozzle; 5 – mixing chamber; 6 – mixing tank; 7-centrifugal injectors (sprayers); 8.9 - lower and upper outlets of the mixing tank; 10,11 – taps; 12 – suction chamber.

Figure 1. Hydrodynamic mixer

outlet nozzle are used as injectors (sprayers). These nozzles are placed in such a way that the rotation of the conical fluid nozzles (torches) expanding from them is directed in the same direction, i.e. the direction of the tangential holes should be opened clockwise in one of the sprayers and counterclockwise in the other.

Thus, the device carries out the process of three-stage mixing of components: at the first stage, while dispersion medium and dispersed fluid phases pass through the ejector, their initial mixing occurs, at the second stage, mixing of fluids occurs in centrifugal nozzles and finally at the third stage, intensive mixing and dispersion occur due to the rotation of conical expanding torches in the same direction which are sprayed from the injectors to the mixing tank front to front.

A new viscometer device has been proposed and applied. The viscometer consists of the following parts: a cylindrical vessel, a capillary fastened to its lower part by a nut, a clip placed in the central channel of the lid at the top of the vessel, a fixed pressure pipe inserted into the cylindrical vessel by means of clip and a gas line connecting it to the pressure source, manometer (pressure gauge) and reducer, level gauge and thermostat casing.

The scheme of the working principle of a viscometer is given in Figure 2. The essence of the capillary viscometer is that the known viscometer is equipped with a constant pressure tube that enters into the fluid in the cylindrical vessel through a cap located in the central channel on the top cover of the cylindrical veseel and the immersion depth is adjustable and it ensures the stabilization of the pressure at the ends of the capillary. Thus, the constant pressure created by the air (gas) entering from the upper end of the constant pressure pipe stabilizes the pressure acting on the upper end of the capillary compressing the fluid to its lower end and entering into the back of the pipe, i.e. compressed air (gas) in a volume corresponding to the volume of fluid flowing through the capillary rises above the level of the fluid behind it. Thus, in each new mode, the fluid flows through the capillary at a constant flow under pressure corresponding to the pressure in the pipe and its immersion depth and this is measured and recorded.

As a result of experiments conducted on a viscometer, the dimensions of the following quantities are recorded:

1. The radius of the capillary is R_k and the length is l_k;
2. Depth of immersion of a constant pressure pipe in a cylindrical vessel, h_b;

3. Pressure in the gas (air) line, P_x;

4. The level of fluid in a cylindrical bowl, h_m;

5. The volume of fluid flowing through the capillary is ΔV and the flow time is Δt.

Based on this information, the calculation of the pressure drop ΔP influencing on the capillary in each mode is conducted on the basis of the scheme given in Figure 2:

$$\Delta P = P_x + \rho g\,(\Delta h + l_k) - P_0 \qquad (6)$$

Here: ρ – fluid density,

P_o – pressure in capillary outlet;

Δh – distance from the end of the constant pressure pipe to the capillary;

g - free fall acceleration.

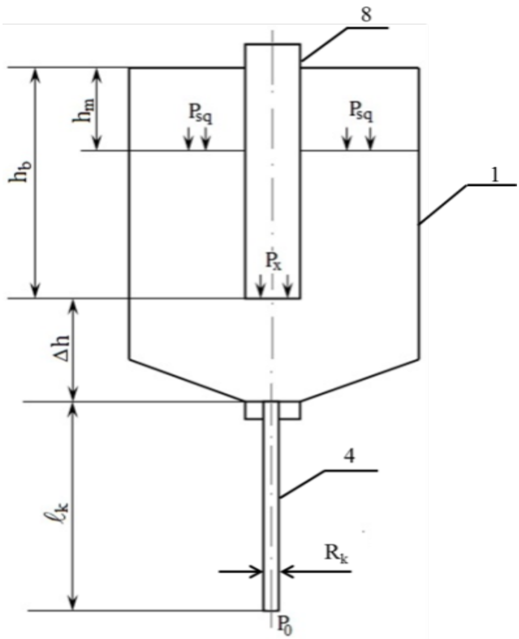


Figure 2. The scheme of the working principle of the viscometer

Fluid consumption Q is calculated dividing ΔV the volume of fluid flowing through the capillary in each mode into time Δt:

$$Q = \frac{\Delta V}{\Delta t} \quad (7)$$

Based on the calculated parameters, the shear stresses τ and velocity gradients $\dot{\gamma}$ are found from the following expressions:

$$\tau = \frac{R_k \Delta P}{2 l_k} \qquad \dot{\gamma} = \frac{4Q}{\pi R_k^2} \qquad (8)$$

As the output of the capillary in the proposed viscometer is related to the atmosphere, the pressure difference that has impact on it is formed only due to the pressure P_x at the end of the constant pressure tube inserted into the cylindrical vessel and the liquid column Δh.

Thus, the compressed gas (air) enters into the pipe and compresses the fluid into the cylindrical vessel, and after the level reaches the end of the pipe, the gas bubbles come out and rise to the level of the fluid behind the pipe, there creates a certain pressure P_{sq}. The equilibrium condition of the pressures influencing on the end of the pipe can be written as follows:

$$P_x = P_{sq} + (h_b - h_m)\rho g \qquad (9)$$

It can be seen that as the fluid level in the cylindrical vessel decreases (while h_m increases) under the condition that the pressure P_x is kept constant, the compressed air (gas) entering the cylindrical vessel increases the pressure P_m tha affects the fluid level, thus ensures that the pressure at the pipe end P_x remains constant.

In the fifth chapter, the causes of watering and sand formation of inclined wells are studied, and new technologies are developed to isolate water and eliminate sand formation. It was noted that the main reason for the watering of the offshore and onshore fields of Azerbaijan is the inflow of layer waters into wells through the highly permeable layers of non-homogeneous layers.

Also, the impact of the profiles of inclined wells on the watering of their production was studied. For this purpose, the data of 89 wells operating from the GUG horizon of the Oil Rocks field were collected, analyzed and systematized on tectonic block V.

Firstly, data of inclined wells in the pre-irrigation period were studied. The wells were divided into separate groups according to the angle of inclination of the wellbore, and the average value of production for the dry period of wells in each interval was determined. In other words, the values of the production of wells belonging to the same interval were aggregated during the same operation period, the final value obtained was divided by the number of wells and the average production per well was found.

Appropriate operations were also performed for vertical wells operating from the field during the same period. Then, to compare the production of vertical wells with inclined wells, the ratio of their production ($Q^*=Q_{mi}/Q_{ver}$) – that's, the values of production was determined. The dependence of the imported output on the angle of inclination showed that with the increase of the latter, the former begins to increase intensively and reaches a maximum at the values of 38^0–40^0 of the former, and then begins to decrease. At the same time, these dependencies also differ from each – other in the degree of layer opening. Also it is clear from the dependencies that the rate of production increases as the degree of incompleteness of the well filter increases. Grouping was performed according to the values of incompleteness of 0.15, 0.30, 0.45 and 0.60.

Then, the impact of the bending rate of the wellbore on the irrigation rate of the production in the post-irrigation period was studied. As a result of observations conducted based on the mining materials, it became clear that the inclined wells operating from the Oil Rocks field are divided into three parts according to the rate of watering: 1) slow rate watering wells; 2) medium-rate watering wells; and finally 3) high-rate watering wells. It was determined that the percentage of water in the wells belonging to the first group, i.e. in the wells watering at a slow rate, varies between 0–7%, and in the second group - in the wells watering at a medium rate, it varies between 7–14%. The third group with more than 14% belong to the high-speed wells.

It is clear from the dependences between the rate of watering and the zenith angle that characterizes the condition of the wellbore profile that as the degree of bending of the wellbore increases, the rate of irrigation of production firstly decreases to a certain extent and then increases sharply. The transition of the rate of watering from decrease to increase corresponds to the value of the zenith angle of 35^0–36^0.

In some cases, it is more appropriate to study the dependence of the water-oil factor (WOF) on the zenith angle in order to characterize how the watering of the production of inclined wells varies depending on the profile condition. In this regard, using the data from inclined wells, dependencies were established between the WOF and the zenith angle, and the results obtained show that the WOF decreases with an increase in the zenith angle. It should be noted that the above mentioned dependencies differ from each other for the value of watering rate, but at the same time, it should be mentioned that as the value of the watering rate increases, the value of the WOF also increases significantly.

Technology for layer water isolation has been developed. The technology is based on the effect of swelling and hardening of the mixture adding nanosized aluminum powder to the water-cement suspension.

The percentage of components was determined in the experiments conducted with the addition of nanosized aluminum powder to an aqueous solution of Portland cement, a new composition was developed and an isolation technology was proposed as a result of the addition of KMS polymer as a retarder to ensure that the suspension swelling process occurs within the layer. It has been shown that the use of KMS polymer can delay the onset of swelling of the mixture by 75-80 minutes during which time it is possible to apply the suspension to the watered part of the layer and use its swelling effect.

As a result of the experiments, it was determined that the components used should include in the cement suspension in the following amounts: portland cement - 28.44-66.62%; Aluminum powder in the size of 60-80 nm - 0.025-0.075%; KMS polymer – 1.0–2.0%; water - the rest.

The impact of aluminum nanoparticles on the swelling of the cement solution is due to the intensive release of hydrogen gas as a result of reactions between the components.

The causes of sand blockage in inclined wells have been studied and new technologies have been developed to eliminate the complications caused by sand.

The complications caused by sand formation in the wells were analyzed, the processes occurring in the well bottom with the formation of sand were interpreted, and extensive information was given about the process of pseudo-swelling caused by the sand-fluid mixture. The importance of the study of the disperse system created by the mixture of liquid and sand grains, which does not have a very strong stability, the processes occurring between the liquid - sand grains that make up this system, their mechanisms of action and hydrodynamic changes in the pseudo - swelling layer in accordance with the well conditions.

A fluid system of new content has been developed to prevent the sedimentation of sand entering into the wellbore zone, ensure that it is lifted to the surface together with the liquid, and thus eliminate the negative impact of sand formation on the well operation. The proposed technology regarding this is based on the principle of injecting this fluid system behind the pipe of the wells.

Research works were carried out in two stages to develop the technology. The composition of the liquid system to be used in the first stage has been determined. For this purpose, 0.1, 0.5, 1.0, 1.5 and 2.0% solutions of KMS polymer in water were prepared and their rheology was studied with a capillary viscometer. Studies have shown that the solution of KMS at any concentration behaves as a viscous - plastic liquid. And also, the dependence of the shear stress on the velocity gradient at all concentrations is of linear nature and the initial shear stress increases with an increase in concentration. The dependence between these two parameters is expressed as $\tau = a + b\dot{\gamma}$.

The experiments were then repeated adding copper (Cu) nanopowder in the size of 60 - 80 mm to the solutions. When the copper powder was added to the solution, the results showed that the nature of the dependences $\tau = f(\dot{\gamma})$ remained unchanged, but its viscosity and initial shear stress decreased, and this process manifested itself at all concentrations. The dispersity and stability of the obtained solutions were then checked. It has been determined that the most stable dispersed liquid system is obtained when 0.005 % Cu nanopowder is added to the 1.0 % solution of KMS in water.

In the second stage, the process of pseudo - swelling in a laboratory well model device with a fluid system of new content was studied.

Firstly, the experiments were performed in a vertical tube with a homogeneous degas liquid as follows: a static layer consisting of 0.5 mm diameter quartz sand in the height of 15 cm was placed on a strainer attached to the bottom of the glass tube, the working liquid pumped from the tank by a centrifugal pump passed through the sand layer and expanded its volume, thus a pseudo- swelling process occurred in the lifting pipe, then the liquid entered into the measuring vessel and its consumption being measured, created a cycle there. In this case, the changes in the sand layer were observed visually and also its swelling height was measured using a special scale. The experiments were performed sequentially with water, with a 1.0% solution of KMS in water, and then with a nano-liquid system.

The results are given in Figure 3. As can be seen, the nano-liquid system increases the height of pseudo - swelling more than water and a 1.0% solution of KMS. This means that the permeability of the sand blockage in the wellbore increases, thus the flow of liquid passing through the sand layer and the process of sand rising to the surface with the flow improve.

In the end, the experiments were carried out with a gas-liquid mixture in the lift pipes placed both vertically and at different

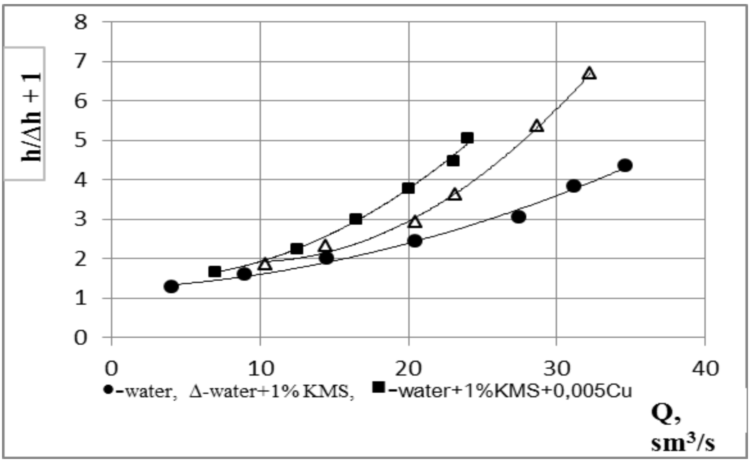


Figure 3. Dependence of sand layer expansion (pseudo-swelling) on fluid consumption

angles. The impact of the periodic gas supply on the swelling of the sand was studied in the laboratory.

The device is assembled so that the lift can be directed at the required angle to study the impact of the bending angle on the pseudo- swelling process.

The experiments were performed both in a vertical position and at angles of 10^0, 20^0, 30^0, 40^0, 50^0, 60^0 . Gas was supplied to the experimental unit both continuously and intermittently. Intermittent gas supply is provided by the electromagnetic valve.

Analysis of the results of the studies showed that in all cases, as the frequency of delivery of the working agent increases, the liquid consumption and the height of the pseudo-swelling layer firstly begin to increase and decrease after receiving the maximum value. Also, in all cases, the maximum value of both liquid consumption and sand elevation height coincided with the value of the bending angle at 30^0.

Thus, it was determined that there is such a frequency of gas supply that the liquid consumption and the height of the pseudo-swelling of sand reach maximum limit. At the same time, it became clear from the dependence of the maximum value of the relative height of the pseudo – swelling and the bending angle that the maximum value of the relative height of the pseudo – swelling layer increases as the bending angle increases and decreases after reaching the maximum value. Along with this, the maximum value of the relative height of the pseudo-swelling corresponds to the value of the angle of inclination at 30^0.

It was also determined that the maximum fluid consumption corresponds to the maximum value of the relative height of the pseudo -swelling. This is explained by the fact that the sand grains in the liquid gets such a state that the resistance to liquid flow is minimal, thereby the permeability and porosity of the sand layer increase.

At the same time, the dependence between the maximum value of fluid consumption and the angle of inclination of the lift shows that the maximum corresponds to the value of $\alpha = 30^0$.

According to the results of the experiments conducted, an opportunity has arisen to adjust the operational mode of inclined production wells. Using the obtained results, it was possible to prevent the sand from clogging in the filter of the wellbore regulating the conditions of the supply of the working agent to the well. The results showed that the best conditions for sand grains to remain suspended in the wellbore for a long time (not to sink) are created when the working agent is supplied into the well at intervals. In addition, the intermittent supply of gas in the operation of sand wells not only improves the structure of the pseudo – swelling layer, but also increases the efficiency of the elevator, and in all cases a reduction in the consumption of the working agent is observed.

This technology, which is applied in the Oil Rocks field, is based on the intermittent delivery of the working agent by means of opening and closing the gas line. As a result of intermittent supply of the working agent to the annular space of inclined gas lift wells, the gas-liquid mixture of sand content between the pump and the filter part of the wellbore is affected by waves. Thus, it ensures a process of oscillating impact on the area where the maximum sand plug is collected. Such an impact on the sandy gas-liquid mixture prevents the compaction of sand grains and allows it to remain in the suspended condition in the liquid, as a result, normal operation of the well with the formation of sand is ensured.

The sixth chapter reflects the issues regarding the development of technology to increase the oil yield of layers with heterogeneous collector properties on the basis of bentonite nanosystems.

Clay of bentonite deposit rich in montmorillonite (70-80%) at the territory of Gazakh region was used in the studies. First of all, the analysis of the composition of raw bentonite clay and the obtained results were conducted. As a result of the analysis carried out by modern devices, it was determined that the crystals in the raw bentonite are in the size of 80-130 nm. Then the process of enrichment of bentonite was carried out and its composition was cleared of large crystals; it was possible to reduce the size of the crystals in the composition of bentonite to 8-10 nm.

Then the rheological parameters and swelling processes of suspensions made of raw materials and enriched nanobentonites with water were studied comparatively. According to the results of the research, it was determined that the rheological parameters of bentonite clay suspension change sharply after its enrichment, its viscosity and density increase significantly compared to the viscosity and density of raw bentonite clay suspension, and the shear stress of the suspension of enriched bentonite clay at the same velocity gradient increases considerably.

It was determined that the swelling process of raw and enriched nanobentonite suspensions takes place in two stages, and the transition from one stage to another occurs by leaps and bounds. At the same time, the swelling of enriched nanobentonite is significantly more intensive than that of raw bentonite.

Using these properties of nanobentonite, a new technology has been developed to increase the oil yield of heterogeneous layers. The technology proposed is based on the principle of pushing oil in the layer into the well bottom of production wells by applying gasket.

To apply the method proposed, the composition obtained by adding enriched bentonite clay to the solution of KMS polymer in diesel-alkaline waste (DAW) is used as a gasket.

The main advantage of DAW is also related to its ability to produce very high sediments.

As a result of enrichment, the size of bentonite clay particles is reduced by 10-13 times compared to the size of raw bentonite clay. The solution made of small –sized bentonite clay can be easily injected into deeper and smaller permeable layers of the heterogeneous layer, which both intensifies the release of gas in the layer and creates favorable conditions for oil to be pumped into production wells, creating an equal compression zone.

Thus, a series of experiments were carried out in a special laboratory facility to study the compressive strength of the new composition. A two-layer (small and high permeability) layer model with different permeability and porosity was created through the partition, and the compression process was carried out firstly with water and then with the application of gasket in the proposed composition.

Based on the results of the experiments conducted, it was determined that the oil yield factor increases by 4.3 and 6.0% respectively in small and high-permeability layers during compression by applying gasket compared to water compression. The combined processing of the data of small and high-permeability layer showed that, under general conditions, when the gasket is applied in relation to compression, the oil yield factor increases by 6%.

The seventh chapter considers the issues of increasing the efficiency of the operation of wells with physical fields and increasing the oil yield of layers. The impact of capillary processes on the oil yield factor of the layer and the impact of magnetic field on these processes were studied, as well as wave-generating devices in the well bottom part were proposed to regulate the physical-chemical-rheological properties of liquid systems used in technological operations and increase the efficiency of production wells.

Large-scale experimental research works have been conducted to study the impact of magnetic fields on capillary processes in various porous medium. These studies were performed at the Freiberg Mining Academy in Germany and the results were confirmed with the patent of this country.

Research works were carried out in two stages in a porous medium created within a simple experimental device that was specially designed.

A CO-2 magnetic device was used to treat the water with a magnet. The value of magnetic induction in the device was ± 100 NT.

In the first series, the impact of magnetized water on the process of capillary absorption in a porous medium composed of pure quartz sand was studied. For this purpose, a sample of two pairs of porous medium saturated with “Uramol”, non-Newtonian fluid used as a household raw material in Germany, was prepared, and the process of reverse flow capillary absorption with ordinary and magnetized water under the same conditions was considered. The data obtained were expressed in terms of the time dependence of the compression ratio (V_1/V ratio, V_1 - the measured current volume of oil; V - the total volume of saturated oil in the porous medium). Then, the experiments were performed in a porous medium composed of 80% quartz sand + 20% clay. The results were processed in the same way.

It should be noted that in all these series, the experiments were performed under the condition without a lid on the upper part of the cylindrical vessel, so that the upper part was left open and conditions were created for the clay to swell freely in contact with both ordinary water and magnetized water in a porous medium with clay mixture.

The second series of similar experiments were performed in a porous medium made of pure quartz sand and also sand mixed with 20% clay. The only difference was that this time in all cases the upper part of the porous medium was covered with a porous gasket made of sand material. The gasket did not allow the volume of the porous medium to expand and rise during contact with water, i.e. swell freely, under such conditions the swelling process took place inside the porous medium. Based on the results obtained, it was determined that in all cases, magnetized water leads to an improvement in capillary absorption conditions.

Analysis of the data shows that when the experiments were performed without head gasket, that's, the porous medium was able to swell freely, then the application of magnetized water increased the compression ratio by 19% in a porous medium made of pure quartz sand and by 11% in a porous medium containing 20% clay.

At the same time, the increase in efficiency was respectively 22% and 15%. When the experiments were carried out in the presence of head gasket, that's, swelling occurred in porous medium, then the increase in the compression ratio as a result of the application of magnetized water was 16% and 12%, respectively, for porous media made of pure quartz sand and 20% clay sand. In this case, the increase in efficiency was -23% and 22%.

Under the above mentioned conditions, the impact of the duration of the process on the efficiency of the application of magnetized water was studied. It became clear that as a result of the capillary absorption process extending from 130 to 300 hours, the compression coefficient in a porous medium composed of quartz sand increases only by 1%, but for a porous medium made of sand mixed with 20% clay, this figure is 12%. The latter is due to changes that occur as a result of swelling of the clay porous medium.

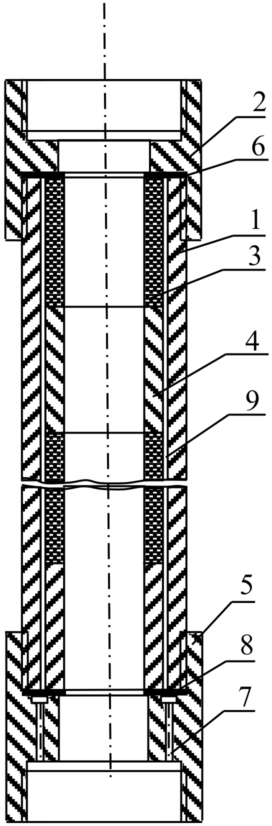
New technology has been proposed applying a constant magnetic field to increase the reliability, time between repair of rod pump and efficiency of oil extraction of the rod pump in sand wells.

The essence of the technology is that under the influence of a constant magnetic field, the multi-component product of the well changes its structure and rheological properties, increases the stability of the system, as a result, the deposition of dispersed sand particles occurs and pump penetration into the cylinder-plunger range gets limited.

The scheme of placement of the device in the well is also shown. A magnetic device with a obliquely cut pipe (pen) is lowered into the well with the pump-compressor pipes at the required depth, then the pump is lowered by means of rods and set in the support ring. While the pumpjack is running, the rods attached to its head are moved up and down together with the plunger of the pump. In this case, the well fluid (oil, water) enters the pump together with the rock particles through the annular channel of the magnetic device.

Based on this technology, it is also possible to carry out the operation of impacting the well bottom. To do this, it is enough to lift the so-called pump from the support ring and include it into the magnetic field injecting the technological fluid into the pipes.

New technology has been developed to clean the wellbore area from contaminants and restore permeability. The technology is based on the principle of creating an acid-based base-elastic microemulsion under the influence of an acoustic field (ultrasonic waves). The prepared microemulsion contains kerosene, polymer (PAA), SFM (sulfanol) and 5% hydrochloric acid. It was determined that when the microemulsion is exposed to ultrasonic frequency waves, its rheological indicators improve, and the dispersity and stability increase significantly. This allows the process to cover a wider area during microemulsion treatment of the well bottom.



1-body; 2- transmission coupling; 3-conductive tube; 4-non - conductive tube; 5-compression fitting; 6,8-compaction gasket; 7-fluid channel; 9-annular space

Figure 4. The scheme of a wave generator

The rules for the application and implementation of the technology have also been worked out.

Hydrodynamic devices generating waves of different frequencies are used to increase the efficiency of technological operations carried out during oil extraction processes, regulate the physical and chemical properties of fluids injected into the wellbore and the mode of operation of wells.

For this purpose, a new, simple structured wave generator was proposed. The scheme of a wave generator assembly is given in Figure 4. The operational principle of the generator is as follows: the generator is released through the pump-compressor pipes into the well bottom (at the required depth) and the required fluid system is pumped through it to the well bottom.

Depending on their surface, the fluid is exposed to hydraulic resistances as it passes through successively placed, 3 conductive and 4 non-conductive tubes which replace each – other. Thus, the tube with a smooth surface has a relatively low resistance to fluid during movement, while the tube with a surface permeability has a high resistance to fluid due to its rough surface. The flow of radial fluid passing through a surface with a permeable wall prevents the possibility of slipping on the walls, but this process is manifested in smooth-walled pipes. When the fluid flow passes from the high hydraulic (including local) resistance section to the smooth cross-sectional area and to the low-thickness perimeter layer, a tensile stress is created in the cross-sectional area of the flow. During the transition to the high-resistance cross-sectional area, strong compression occurs and the cycle ia repeated. In addition, a longitudinal channel was placed in the body 5 of the lower compression fitting to transfer the accumulated fluid in the annular space 9 between the generator body and the pipes.

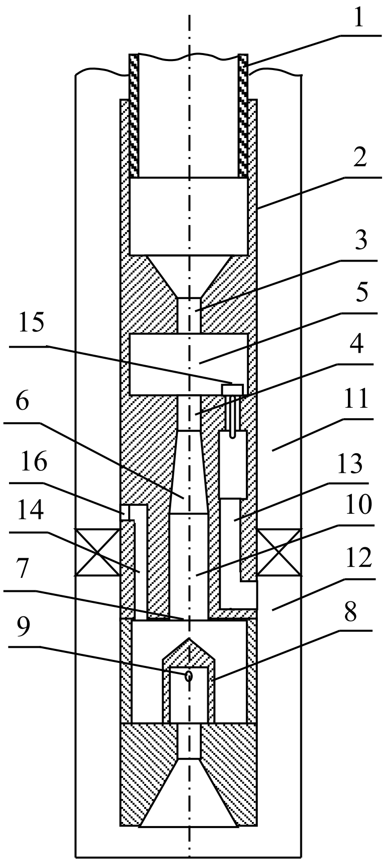
Thus, the structure of the generator allows the fluid passing through the body to slide through the area of the non-conductive tubes in turn and slow down while it passes through the area of the conductive tubes. This ensures the oscillating wave motion of the flow process.

To affect the well bottom, another new type of efficient oscillating wave device has been developed (Figure 5). The purpose of developing this device with such a design is to increase the efficiency of the device by increasing the consumption of fluid passing through the wave generator coordinating the operation of the wave generator and the jet pump. During the impact on the well bottom of the layer through the device, the fluid taken by the nozzle pump from the space behind the pipe is added to the fluid pumped from the ground surface through the pipes and passes through the generator and amplifies the resulting waves.

The placement of the throttle element at the outlet of the nozzle pump to the space behind the pipe is aimed at regulating the operation of the wave generator during the extraction of fluid from the well.

The device operates as follows.

Thus, the structure of the generator allows the fluid passing through the body to slide through the area of the non-conductive tubes in turn and slow down while it passes through the area of the conductive tubes. This ensures the oscillating wave motion of the flow process.



1-pump-compressor pipe; 2- jet pump; 3-inlet nozzle; 4-mixed chamber; 5-intake chamber; 6-diffuser; 7-diffuser`s output; 8-hydrodynamic emitter(wave generator) 9- generator tangetial input; 10-channel connecting the receving chamber of the jet pump with space under packer; 11- the space behind the pipe; 12- space under packer space; 13-14-intake valve. 15- nonret urn valve; 16-throttle item (constrict item)

Figure 5. The scheme of a wave device

To affect the well bottom, another new type of efficient oscillating wave device has been developed (Figure 5). The purpose of developing this device with such a design is to increase the efficiency of the device by increasing the consumption of fluid passing through the wave generator coordinating the operation of the wave generator and the jet pump. During the impact on the well bottom of the layer through the device, the fluid taken by the nozzle pump from the space behind the pipe is added to the fluid pumped from the ground surface through the pipes and passes through the generator and amplifies the resulting waves.

The placement of the throttle element at the outlet of the nozzle pump to the space behind the pipe is aimed at regulating the operation of the wave generator during the extraction of fluid from the well.

The device works as follows.

During the development of the well bottom of the layer, the outlet of the space behind the pipe is closed at the wellhead when the absorption capacity of the layer is sufficient. For processing, the reagent is pumped into the layer by means of pipeline 1, jet pump 2, transmission pipe 8 and hydrodynamic wave generator 7.

At this time, when the reagent enters the mixing chamber 4 through the inlet nozzle 3 and the receiving chamber 5 of the jet pump 2, the well fluid is sucked from the space under packer through the transmission pipe 10 and it is mixed with the liquid entering the pipeline.

The amount of fluid passing through the diffuser 6, channel 8 and hydrodynamic wave generator 7 is the sum of the fluids pumped from the surface through the pipeline 1 and sucked through the space under packer 10 which ensures the amplification of the generated waves.

When the well's absorption capacity is limited, the outlet of the space behind the pipe is opened at the wellhead and the fluid which is pumped through the pipeline 1 sucking the well fluid from the space under packer through channel 10 directs a part of it through the throttle element 9 to the space behind the pipe 11 and then to the ground and, together with the injected fluid, passing through a hydrodynamic wave generator transmits the remaining part to the space under packer 12. In this case, again, the amount of fluid passing through the wave generator consists of the sum of the working fluid injected from the surface and a part of the fluid absorbed from the space under packer. It should be noted that in the well-known devices of this type, all of the well fluid sucked by the jet pump from the space under packer is transferred from the space behind the pipe to the ground surface, thus the amount of fluid passing through the generator gets significantly reduced.

CONCLUSION AND RECOMMENDATIONS

1. Based on the inclinometer data and analysis of technical and economic indicators of inclined wells, the impact of the profile on the development, operation and improvement of oil fields was determined, the profiles were evaluated on different operating methods.

2. The dependence of period between repairs, underground and major repairs on the profile condition in the process of operation of inclined wells has been studied and it has been shown that there is such a limit of deviation that it is very difficult or generally impossible to carry out repair works on inclined wells.

3. As a result of study of the impact of parameters which characterize profiles of inclined wells working with different operational methods on operating indicators, proper regularities were found and recommended to be taken into account while designing the profile of the well.

4. The issues related to optimal decision making, the determination of the optimal number of wells and investment in oil production have been resolved for the implementation of geological and technical measures to increase the oil yield of wells and improve the operation of wells by applying the theory of utility and the function of utility, assessed with inaccurate probabilities and intervals.

5. Mining studies in the gas lift wells of the Oil Rocks and Mud Terrace fields showed that up to twice less working agent is required to lift heavy oils than light oils, which laid the foundation for a new methodological technology.

6. A hydrodynamic mixer was developed for the preparation of dispersed liquid systems, by means of which stable oil-water and water-oil emulsions which cannot be separated into components for a long time were obtained. It has been shown that these emulsions can be used as a buffer fluid in the acid treatment of the well bottom, as well as in the hydraulic fracturing of the layer.

7. A new capillary viscometer device was created, it was tested by rheological parameters of emulsions and put into operation.

8. The causes of watering of inclined wells were studied, the impact of the profile on the rate of watering was studied, the dependence of watering on the degree of layer opening was determined, a new technology for isolating layer waters was developed; its implementation methodology was shown and its application was recommended.

9. A new method based on nano-liquid composition was developed to prevent sedimentation of sand in pipes in the gaslift-compressor operation method, as a result of its application, the complications of sand formation in the well bottom and wellbore were eliminated and long-term operation of wells has been ensured.

10. Nanotechnology has been developed to regulate the flow of oil from non-homogeneous layers to wells on the basis of bentonite clay.

11. The process of capillary absorption using a magnetic field was studied, the impact of magnetized water on the process of capillary absorption in a porous medium consisting of quartz sand and sand-clay mixture was studied and it was determined that the efficiency of magnetized water on capillary compact is 16 – 20 in a sandy environment and 11-12% in sand - clay environment.

12. A new method based on the change in the structure of the mixture entering into the pump receiver under the influence of a constant magnetic field and thus preventing it from settling to regulate the harmful impacts of sand on the pump operation in the WRP operational method was developed.

13. Acid-based microemulsion was proposed to clear the well bottom from various sediments and contaminants using the acoustic field and increase the permeability of the layer, on the basis of it, a new technology was developed and recommended for application.

14. Wave generators of simple design with efficient working principle were invented and recommended for application to carry out various technological operations in wells and layers.

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