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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

INVESTIGATION OF THE OIL PRODUCTION PROCESS UNDER THE IMPACT OF NANOCOMPOSITION ON THE WELL-FORMATION SYSTEM

Specialty: 2525.01 – “Development and exploitation of oil and gas fields”

Field of science: Technical sciences

Applicant: **Jamal Aydamir Aliyev**

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The work was performed at "OilGasScientificResearchProject" Institute of State Oil Company of Azerbaijan Republic.

Scientific supervisor: Doctor of Technical Sciences, Professor
Eldar Gasham Shahbazov

Official opponents: Doctor of Technical Sciences, Associate Professor
Hajan Gulu Hajiyev
PhD in Technics, Associate Professor
Bunyad Zinhar Kazymov
PhD of Technical Sciences, associate professor
Malik Gurban Abdullayev

Dissertation Council ED 2.03 of Supreme Attestation Commission under the President of the Republic of Azerbaijan operating at Azerbaijan State Oil and Industry University

Chairman of the Dissertation council: Doctor of Technical Science,associate professor
Arif Alakbar Suleymanov

Scientific secretary of the Dissertation council: PhD in Technics, associate professor
Yelena Yevgenyevna Shmoncheva

Chairman of the scientific seminar: Doctor of Technical Science, professor
Arif Mikayil Mammad-zada

I confirm the signatures
Scientific Secretary of ASOIU,
PhD in Technics, associate professor **N.T.Aliyeva**

GENERAL FEATURES OF THE WORK

The actuality of the subject. From 1847 to 2016, 1 billion tons of oil was produced from the oil fields discovered in the onshore territory of Azerbaijan using various methods of influence and 92 million tons of oil are expected to be produced, which indicates a recent oil recovery factor of 0.403. If we take into account that the balance reserves of oil fields discovered in our onshore territory are 2,707 million tons, then the amount of non-recoverable oil will be 1 billion 615 million tons, i.e. 59.7% of reserves remain in the ground. The last oil recovery factor from the fields discovered in the Azerbaijani Caspian Sea was 0.442, which means that 55.8% of the balance reserves in the ground - 1 billion 988 million tons.

As a result of using conventional methods in the fields of Azerbaijan, the final oil recovery coefficients fluctuate on average in the range of 0.403-0.442, and the bulk of oil reserves (55.8-59.7%) remain underground with non-recoverable oil reserves.

The above shows that the subject "Study of oil production under the influence of nanocomposites in the formation-well system " is relevant, and its implementation is of great scientific and practical importance.

Purpose of work. Intensification of the oil production process by means of the action of the nanocomposite on the "reservoir-well" system.

Research issues:

- analysis of traditional methods of impact on oil fields Azerbaijan, which is at the final stage of operation;
- development and research of nanocomposites based on the effect of "small impact and excitement ";
- investigation of the relationship between the size and density of nanoparticles and the effect their impact;
- creation of an intelligent well control system for the purpose of managing oil production;
- application of the developed technologies in production.

The main points of the study:

- the possibility of increasing production from wells in long term operation, when exposed to nanocomposites;

- limiting the formation and flushing of salt deposits, ASP, sand plugs in equipment, in the bottomhole zone and in the wellbore using nanocomposites;

- reducing the cost of oil produced using nanocomposites.

Scientific innovation:

1. A new composition of surfactant + nanoparticles has been developed to regulate the surface tension at the border of oil and water.

2. The study of nanostructuring and destruction of the system at different concentrations of the NANOPAV system obtained with the addition of Al (50-70 nm), Cu (60-80 nm) and Fe (90-110 nm) nanoparticles to the Alkan DE-202 B reagent.

3. Developed a composition consisting of surfactants, high viscosity polymers, inhibited acids, copper nanoparticles 60-80 nm in size in various proportions against the scaling process in the "reservoir-well" system and production equipment.

4. In order to restore the permeability of clay rocks, a nanosystem has been developed, consisting of an organic solvent, surfactant and aluminum nanoparticles with a size of 50-70 nm.

5. Developed a strengthening composition with the addition of nanoparticles to prevent ingress of sand into the well from the formation.

6. Developed a nanosystem and a technology for its injection through injection wells to ensure the flow of oil into production wells.

Scientific and practical value of the work:

- in principle, using nanotechnology, it is economically possible to extract not.

- less than 10-15% (360-540 million tons) of oil from ~ 3.6 billion tons, related to hard-to recover resources of Azerbaijan.

- application of methods of stimulation on the basis of nano made it possible reduction in the cost of oil produced.

- the developed technologies are currently being applied at the facilities PA "AzNeft".

Actual materials.

The dissertation is based on the large-scale research work carried out in the "Department of Nanotechnologies" of the State Oil Company of Azerbaijan, "Laboratory of Nanotechnologies in Oil and

Gas Production" of the Institute "OilGasScientificResearchProject", the results of their application in the field of oil production and stock materials.

Approbation of the obtained results and published scientific publications.

The results of the dissertation work were applied in the fields under the responsibility of OGPD SOCAR, and the main provisions were published in 18 articles (12 of them in domestic publications, two of them abroad, 1 in the internal conference materials of the republic, three in the proceedings of international conferences (one of them abroad) in the collections required by the Supreme Council of the Attestation Commission under the President of the Republic of Azerbaijan).

The scope and structure of the work.

The dissertation consists of an introduction, four chapters, a conclusion, a bibliography containing 121 sources, 10 appendices, and a list of abbreviations. The total volume of the work is 199 pages, including 74 figures and 31 tables. Excluding figures and tables, the dissertation contains 225214 characters.

The author expresses gratitude to the management of the "Neftqazelmitədqiqatlayihə" Institute and the staff of its department for their assistance and support in carrying out this work.

THE CONTENT OF THE WORK

The introduction gives the relevance, purpose, defended provisions, scientific innovations and results of the dissertation.

The first chapter is devoted to the analysis of traditional impact methods on formations at the final stage of exploitation. Initially, information about the current state of exploitation indicators of Azerbaijan's onshore fields is provided.

To date, 81 oil and gas fields have been discovered in Azerbaijan, of which 54 are located onshore and 27 in the Caspian Sea. As of 01.01.2018, a total of 2 billion tons of oil, condensate and more than 800 billion m^3 of gas were produced from these fields.

The average statistical value of SNVA for 391 oil fields located in onshore Azerbaijan is 0.3436, with 95% confidence interval 0.3224 to 0.3638, and for 154 sites in the Caspian Sea of Azerbaijan the average statistical value of SNVA ranges from 0.383 with 95% confidence interval from 0.3595 to 0.4065. Despite the use of various impact methods, it is planned that about 60% of the discovered oil reserves will remain underground.

Most of the existing oil fields in Azerbaijan are in the final stage of development, and this stage is characterized by a decrease in production, an increase in the number of repairs and an increase in unit costs.

Despite the use of all existing modifications to increase oil recovery by water injection of oil fields, widely used in the industry, this method does not provide the required level of oil production from the reservoir. This method is not justified, especially in the production of heterogeneous and high-density oils. Ultimately, this situation requires the search for new methods to improve the efficiency of water injection method.

Analysis of the positive and negative effects of long-term treatments shows that in most cases the effects are both local and short-term. Consequently, there is a need to apply a better and more efficient new technology - nanotechnology - to improve the physical and chemical properties of the working solutions injected with water, and thus improve the injection method. The nanotechnological basis of improving the oil recovery factor is based on the mobility of petroleum hydrocarbons by nanoparticles as a result of the complex action of surfactants, demulsifiers, acids, alkalis and molecules of bacteria that oxidize hydrocarbons. As a result, new oil-compressing substances such as CH_4, CO_2, H_2 and N_2 are formed in the formation.

The second chapter investigates the development and application of nanocomposite based on the "minor impact and excitation" effect, and identifies the methods for developing the methodology for conducting the research

Entirely new substances and materials with synergistic effects can be obtained by using very small particles in the range of 0.1-100 nm to place or control atoms and molecules in a new order.

Currently, one of the most important problems of the oil industry is the development of new technologies that increase the efficiency of oil production. The development of nanotechnology in this direction is of great scientific and practical importance and can bring great economic benefit.

The idea of applying nanotechnology in the oil industry belongs to academician A. Mirzajanzade, and the development of this idea was carried out by SOCAR, the Azerbaijan State Oil Academy and a group of oil scientists from Baku State University.

At the initial stage of research on the development of nanotechnology in the oil industry, nanoscale materials were developed on the basis of laboratory experiments.

As a result of scientific and experimental research conducted at SOCAR, it was determined that it is possible to stimulate the process of gas separation from rocks with the help of metallic nanoparticles. As a result, the dynamics of the "water-oil-gas" system and additional reservoir pressure due to imbalance in the reservoir environment can be provided.

Analysis of the effects obtained shows that these complications can be eliminated by creating a nano-environment within the processes taking place (sand formation, flooding, corrosion, formation of paraffin and salt deposits)[1].

Carrying out of experimental, theoretical and analytical researches of nanostructured systems from a series of innovative technologies for extraction of residual oil in the fields in the final stage of operation, development of nanotechnological methods against production complications, reduction of operating costs, extension of the repair period, improvement of environmental parameters, reduction of the volume of produced water and utilization are actual problems[2].

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[1] Əliyev C.A. Neftçıxarmada mürəkkəbləşmələrə qarşı nanosistem. "Azərbaycan geoloqu" Azərbaycan neftçi geoloqları cəmiyyətinin elmi bülleteni - Bakı: - 2020 - № 24, - 87-90 s.

[2] Şahbazov E.Q. Həsənova A.M., Əliyev C.A. Nanotexnologiyanın tətbiqilə layda sulaşmanın məhdudlaşdırılması. Azərbaycan Neft Təsərrüfatı, - Bakı: -2021, - № 08, - 36-38 s.

The NANOSAM system based on SAM and nanoparticles was developed to increase the oil recovery factor by improving the rheological properties of hydrocarbons in the formation. In this system, the relationship between surface tension and nanoparticle concentration ($f(x) = ax^2 + bx + c$; $a > 0$; $[a] < 1$) was determined. At very low (ultra-small) nanoparticle concentrations (40-20; 20-10; 10-15 nm), the surface tension had a minimum value.

Injection of nanoparticles into the oil reservoir together with SAM during oil production affects the hydrodynamic properties of the reservoir, stimulates the flow of fluid from the reservoir to the well, reduces the pressure in the pumping system from 15 to 7 atm and increases the well production by 1.2-1.5 times.

Studies have shown that nanosystems, getting into the oil environment, expand the volume of produced water under the influence of electromagnetic and thermal effects, increasing the viscosity of water and turning it into a plastic mass, which prevents the movement of produced water, reduces oil viscosity and creates nanoparticles in the "formation -well" system, causing a decrease in physical and hydraulic resistance.

Analytical studies have shown that when the nanosystem is introduced into the layer, the temperature in the nanosystem increases due to "small impact and excitation," the chemical properties of the metal nanoparticles change and strong magnetic properties emerge depending on their size[3].

When using a nanosystem consisting of metallic nanoparticles and SAM, reducing surface tension and increasing the boundary wetting angle as a result of physical and chemical processes at the interface increased oil flowability and facilitated its compression in the wellbore.

The effect of metallic nanoparticles on the change in the interfacial tension of aqueous solutions of SAM at the boundary with kerosene was studied on a stalagmometer at a temperature of 293^0K.

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[3] Abbasov C.S., Əliyev C.A. Yerin təkində temperaturun dəyişməsinə oroqrafiyanın təsir xüsusiyyətləri (Siyəzən monoklinalı timsalında). "Azərbaycan geoloqu" Azərbaycan neftçi geoloqları cəmiyyətinin elmi bülleteni, - Bakı: - 2019, -№ 23, - 102-106 s.

Aluminum and iron nanoparticles were used in the study. Aqueous solutions of anionic and nonionic reagents were studied as SAM.

Studies have shown that the surface tension of NANOSAM solutions is significantly lower than that of SAM solutions of the same concentration. Thus, the surface tension of NANO-sulfanol solution is 70-87% lower than the surface tension of sulfanol solution.

A similar situation is observed for other NANOSAM formulations. Thus, the decrease in surface tension in NANO-Alkan-202 solutions is 60-65% compared to the corresponding value of this SAM solution.

Based on the analysis of experimental data, it was found that the reduction of surface tension in NANOSAM systems compared to aqueous SAM solutions increases the concentration of NANO particles in the solution after reaching a certain value, which leads to the separation of some of them from the studied solution. The regularities obtained are characteristic of all the studied NANOSAM compositions.

The effect of Al nanoparticles on the surface tension of non-ionic SAM solutions is also subject to the above regularity.

A comparative analysis of the effect of Fe nanoparticles on the surface tension of non-ionic SAM solutions of different molecular structures showed that, the best results were obtained with NANO Fe sulfanol solution.

According to laboratory tests, the ability of NANOSAM composition to protect against salt deposition in mineralized formation waters is 3.5 times higher than that of SAM, and more than 2.5 times higher than that of corrosion. The protective effect of paraffin deposition inhibitors with nanoparticles in high paraffin oils increases by 16-20%.

A wide range of laboratory work made it possible to determine the basic dependence patterns of the type, size and components of SAM and nanoparticles used in the aforementioned technological processes.

In the wells 405, 429 of the Sanga,al-Duvanni-Xara Zira field, 1056, 1089 of the Palchiq Pilpilasi field, a study was carried out to prevent ARPD from nanocomposites prepared with the addition of Al and Cu nanoparticles. When studying the compositions of these solvents prepared in different proportions, it was found that the effectiveness of the effect depends to some extent on the technology of its application.

The amount of components included in the new composition of diesel fuel, light pyrolysis resin, laprol and Al nanoparticles is as follows (in % by mass) : light pyrolysis resin (90-96% aromatic hydrocarbons) 40-50; diesel 40-50; Laprol 3603 polyester resin 0.5-1.0 and 0.001-0.0005% Al nanoparticles. To study changes in the permeability coefficient due to formation pore contamination, the reservoir model was saturated with oil, the permeability coefficient was determined and the oil was compressed with filtrate. The high permeability layer becomes contaminated relatively quickly (2 days), and the low permeability layer becomes contaminated later (3 days). In the experiments, the average contamination time was adopted 2.5 days. Subsequent experiments were devoted to cleaning the filtrate from the low-permeability layer. The experiments were performed at different closed storage times. At the end of the storage period, the model was saturated with oil and the permeability coefficient was determined. Thus, the dependence was identified between the closed storage time (t) of the layer model and cleaning of pores and change of permeability coefficient. The permeability coefficient of the high-permeability layer increases from 0.16 μm^2 to 0.32 μm^2, and the permeability coefficient of the low-permeability layer increases from 0.08 μm^2 to 0.14 μm^2. This means that the initial conductivity is restored by 47% and 35%, respectively. Increasing the number of exposure cycles leads to an increase in conductivity, but the growth rate decreases sharply after 4-5 cycles[4].

The permeability coefficient of the high-permeability layer increases from 0.25 μm^2 to 0.46 μm^2, and the permeability coefficient of the low-permeability layer increases from 0.05 μm^2 to 0.23 μm^2. This indicates restoration of 84 and 90% of the original conductivity. Thus, experimentally high efficiency of injecting the nanosystem

[4] Алиев Дж. А. Разработка и исследование новой нанокомпозиции для ликвидации асфальтено-смоло-парафиновых отложений. - “SOCAR Proceedings” - Баку: - 2023, - No. 2, - 82-87 p.

based on the theory of "small impact and excitation" in the wellbore to clean the heterogeneous layer of impurities and increase the filtration area in the bottomhole zone was confirmed.

Nanoparticles consisting of various solvents (from light pyrolysis resin and diesel fuel, condensate), Al nanoparticles and polymers were developed for field tests to extend the filtration zone in low permeability clay layers and prevent ARPD, and production tests were applied to the Palchiq Pilpilasi production well.

New nanosystems of laboratory origin dissolve sedimentary salts in formations, wellbores, elevator tubes and reservoirs, isolate ions that form salt crystals, form nanoparticles, adsorb on the inner walls of the tubes, forming a protective layer and weakening the effects of aggressive media. Application works were carried out in production wells 1547 and 1806 in Saadan field. Before the start of the application work, period between repair of well No. 1547 was 5-7 days, and then 70 days. The pressure at the wellhead before the application was 4 atm, at the flowline 2 atm, and after the application the pressure at the wellhead was 2 atm, at the flowline 0.5 atm. Currently, the pressure at the wellhead remains constant.

Carbon dioxide formed during the injection of a nanocomposition consisting of Al metal nanoparticles (50-70nm) and SAM in well 1806 of Saadan field SAM led to an increase in water viscosity and a decrease in oil viscosity, water in the well fluid decreased, and oil increased. The period between repair before the application of nanocomposite in this well was 7-10 days, and then 90 days. Before application, water production in well 1806 was 18 m^3, oil production was 0.2 tons, after application, produced water decreased by 60-80%, and oil production increased by 30-50%. Power consumption was reduced during the reduction in water production and had a negligible effect on pollution.(Fig. 1)

A disperse system undergoes a series of intermediate states during the transition from a single atom to a mass state along the measurement axis, including cluster formation, nanoparticle formation, and nano- or ultradisperse media.

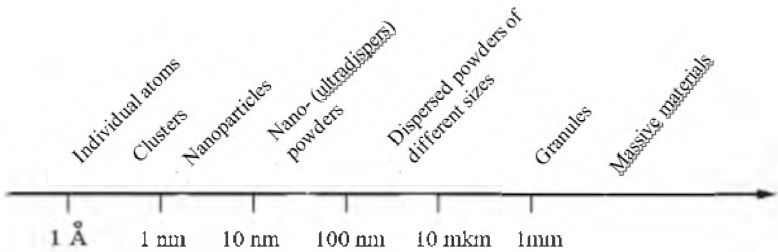

Figure 1. Scheme of classification of disperse materials by dispersed phase dimensions

Subsequently, the determination of the exploitation regimes of the reservoir based on new approaches has been examined. It is known from global experience of oil and gas production that the results of field development remain unsatisfactory. For example, in the former USSR, the average value of the oil recovery factor for multi-year fields is only 0.35. It should be noted that comprehensive geological and technical measures were taken to achieve this result, and appropriate adjustments were made to development projects from time to time.

The classification of modes is based on the appearance of the energy present in the layer.

In water pressure regime, the driving force in the oil layer is the pressure created by external or bottom water. In the effectiv water pressure regime, the oil recovery factor ranges from 0.60-0.70.

The elastic water pressure regime is considered quite suitable for development and allows increasing oil recovery of the layers to the level of 0.50-0.60.

The pressure created by the gas, which expands during the process of development in gas pressure regime, pushes the oil to the bottom of the well. In this mode, the oil recovery factor can be increased to 0.40-0.50.

In order to increase the efficiency of development of oil fields operating in the mode of dissolved gas, gas or air extracted from produced oil is injected into the reservoir; the intracircuit or circuit method of flooding is used. In this type of fields, the level of the final oil recovery factor of 0.30-0.35 is considered optimal. Gravity mode occurs when the gas in the field is completely depleted.

The intensity of development of fields characterized by gravity mode is weak. The final oil recovery factor is 0.10-0.20.

In mixed development, several natural energies simultaneously affect the movement of oil in the fields. Mixed regimes can be of natural or anthropogenic origin.

For effective development of mixed mode fields, it is necessary to consider the role of factors that make up the energy of the bed. In all possible cases, methods of artificial influence on the field should be applied.

The third chapter discusses the creation of an intelligent management system for wells for the purpose of controlling oil production. It explores ways to create an intelligent information database in the reservoir-well system. For this purpose models, technologies and methods of enhanced oil recovery should be created and it is necessary to create a new generation of robotic control, diagnostic and management systems that provide “online” management of oil production processes.

A system of "noise monitoring", diagnostics and control should be created to provide “online” management of oil production processes, that is:

- the parameters of technological processes should be controlled;
- the initial period of equipment faults should be diagnosed;
- rational management technologies of water injection and preparation of nanocomponents should be created;
- complex control, diagnostics and management algorithms for “online” oil production processes should be created;
- real-time (online) adequacy of dynamograms must be met, algorithms, technologies, software must be created that allow identification;
- intelligent “noise” control and “noise” diagnostic technologies and hardware software tools (software) should be created to change the technical condition of objects;

- intelligent robust control management systems should be created to increase the profitability of facilities.

With the implementation of the proposed program:

1. According to the results obtained on production wells, it is possible to increase oil production rate by optimal management of quantity and quality of nano-components injected into injection wells with feedback (Oil / Water ratio varies).
2. By optimally controlling the spraying of nanocomponents in production wells, oil production rate increases and equipment wear and tear is prevented.
3. Due to intelligent "online" control of nano-components, the water content of the fluid produced from the production well is reduced (Oil / Water ratio varies).
4. It saves electricity and prevents environmental pollution.

Developing a decision-making mechanism based on the existing database is an important part of this system.Decision making is a process in itself. This process should be set up and implemented in the following sequence:

1. Diagnosis of the problem - it is necessary to decide on what work (issue).
2. Determination of criteria - what is the problem and what standards were violated.
3. Search for alternatives - what are the options to overcome the identified shortcomings.
4. Evaluation of alternatives - which option is more profitable in solving the problem and corresponds to the capabilities of the enterprise.
5. Decision making - choosing the most effective decision option.
6. Execution of the decision - changing the course of the case in accordance with the decision.

The decision-making process ends with feedback. This means that the decision made must be directly related to the problem or issue to be solved and must be compared with the actual situation at the time of the decision. In this regard, each decision must meet the following requirements: a) should be appropriate; b) have quantitative and qualitative indicators; v) should be optimal; q) must have a concrete character; e) should be stimulating; j) must be flexible; d) be effective; z) should be on time.

To reduce or eliminate the risk factor in decision-making, it is important, first of all, to reduce uncertainty, and in doing so to eliminate the limited information about the problem to be solved.

The fourth chapter reflects the effects obtained from the application of developed technologies and scientific results in production. For this purpose, exploitation objects and wells have been selected primarily for the application of new nanotechnologies.

The following oil fields, injection and production wells were selected to apply the developed nanotechnologies:

Wells No 2055, 2065, 3354, 3789, 3668 were selected for the application of nanotechnologies developed at Bibiheybat field.

The amount of alkaline formation water in the products of wells No. 1729, 795, 312, 1650, 977, 1965, 1659, 2335 operated in Palchiq Pilpilesi field varies mainly in 51-85% range However, produced water from some wells is coarse and has a high chemical content of sulfate ions. The content of $Ca^{2+} + Mg^{2+}$ ions forming scale in the produced water varies in 54-342 mg / l range.Wells No. 2357, 2345, 4217, 2568 and 2572 were selected for application of the nanosystem in the Palchiq Pilpilesi field.

In addition, newly developed nanocomposites were applied in the fields of Chilov, Darwin bank and Pirallahi Island field, in the operated wells of after Buzovna, Lokbatan-Puta-Qushxana and Saadan fields. The production of the oil wells No 2061, 3496, 2368, 2009 and 2786 around the water injection well No. 2055 in Bibiheybat field were regularly measured, and oil and water were analyzed in the extracted liquid. During the test period, the amount of oil in the liquid produced from 5 production wells increased from 5.8 t / day to 6.85 t / day (+1.05), which means 18% increase. The amount of water in the extracted liquid decreased from 72.7 t / day to 70.85 t / day, ie 1.85 t / day[5].

[5] Şahbazov E.Q., Əliyev C.A. “Bibiheybətneft” yatağında ağır neftlərin çıxarılmasında və nəqlində nanotexnologiyanin tətbiqi. Azərbaycan Ali Texniki Məktəblərinin Xəbərləri, - Bakı: - 2019, - cild 21, - № 4, - 37-42 s.

The production of the oil wells No 2781, 2913, 3363, 2951, 2467, 3383 and 2852 around the water injection well No. 3354 in Bibiheybat field were regularly measured, and oil and water were analyzed in the extracted liquid. During the test period, the amount of oil in the liquid extracted from 7 production wells increased from 3.1 t / day to 3.92 t / day (+0.82), ie increased by 26%. The amount of water in the extracted liquid increased from 6.3 t / day to 7.76 t / day, ie 1.46 t / day.

Technical and technological parameter were collected and analyzed for 5 production wells around the selected water injection well No. 2065 in Bibiheybat field. Special equipment for the preparation of nanocomposites and injection into the well near the water injection well No. 2065 was installed, the working capacity was checked and the process was started. 2300 liters of nanocomposition (384 liters per 70 m3 of water per day) were pumped by the dosing pump through the water injection well for 6 days, and only 70 m3 of produced water was pumped for the next 6 days. Application-testing work lasted (6 + 6) x5 = 60 days. The production were measured 1 time before and 9 times after application in operation wells around water injection well No. 2065, as a result of which production increased by 22% and a decrease in the cost of oil extraction was achieved.

Technical and technological parameters on water injection well No. 3789 and 5 production wells (3792, 3668, 3796, 3795, 3794) selected on the basis of the analysis of mining and geological documents were collected and investigated at Bibiheybat field. A tank-pump-tank system has been installed near the water injection well to prepare the nanocomposition and inject it into the well. According to the approved work plan, the process was continued for two months by pumping 2304 liters of nanocomposition (384 liters per 55 m3 of water per day) for 6 days with a dosing pump through a water injection well, and only 55 m3 of produced water for the next 6 days. During this period, production was regularly measured in the operation wells under the influence of the injection well, and physicochemical and thermodynamic properties were studied by taking oil and water samples. Pre and post-application results on remarked parameters were comparatively analized. With the application of nanotechnology, the amount of the oil in the total liquid produced by the surrounding wells increased from 5.9 t / day to 6.8 t / day, ie by 15%, the amount of water produced by the wells decreased by 17-18%.

The thermodynamic properties of the oil produced from the surrounding wells before and after the nanosystem impact on the well 3668 in the Bibiheybat field were studied and this change was accompanied by decrease in the viscosity and density of oil and water in the formation conditions[6].

In order to increase the efficiency of the formation impact using nanosystem in the Palchiq Pilpilesi field, the application work was started by injecting 380 ÷ 400 liters of nanocomposition per day through the water well No. 2357 and the process lasted for two months. During this period, the production was regularly measured in production wells (2572, 2345, 2417, 2568) which are under the influence of water injection wells, and physicochemical and thermodynamic properties were studied by taking oil and water samples. Post and pre-application results for 3 months on remarked parameters were comparatively analized and as a result, the amount of oil in the fluid produced from 4 affected production wells increased by 14% from 20 tons / day to 22.8 tons / day. At the same time, the amount of water decreased by 12% from 29.1 m^3 / day to 25.61 m^3 / day.

The effect of surfactants, on nanosystemic compositions salt deposits in produced water was studied in produced water taken from Bibiheybat and Saadan fields and it was determined that 75.0-83.0% protection effect is observed from salt deposits at 150 g/t consumption of reagent. Based on the results, a new multifunctional nanosystemic salt deposition inhibitor consisting of SAM (Sulfanol, Alkane), polymer (carboxymethylcellulose) and Cu-nanoparticles was developed. Mining tests of the developed nanosystem salt deposition inhibitor were carried out in production well No. 2946 of Bibiheybat

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[6] Şahbazov E.Q., Əliyev C.A. "Bibiheybətneft" yatağında ağır neftlərin çıxarılmasında və nəqlində nanotexnologiyanin tətbiqi. Azərbaycan Ali Texniki Məktəblərinin Xəbərləri, - Bakı: - 2019, - cild 21, - № 4, - 37-42 s.

field for 42 days, its high protective effect against salt deposits was confirmed, the amount of the ions forming scales in the water increased, the viscosity of oil decreased to 40% and defects observed during the operation of horse head pump have been eliminated. Production well No. 1547 from the Saadan field was selected with the participation of "Azneft" PU and "Siyazanneft" OGPD for application and testing of nanotechnology against salt deposition in the discharge line. During the test period (90 days), 144 liters working solution (nanocomposition) was continuously injected into the well per day by a dosing pump. Pq.a. =2, 0 atm, Pa.x. =0, 5 atm olmuşdur. No cleaning or repair work was carried out on the discharge line, and the pressure at the wellhead and discharge line remained stable. Pq.a. = 2.0 atm, Pa.x. = 0.5 atm[7].

In accordance with the approved work plan to prevent salinization in the production well No. 2888 in operation at Bibiheybat field, a nanosystem with a daily capacity of 350 liters was implemented and the process lasted for 60 days. Prior to the event, the period between repairs connected with salinity in the well was 25 days, the salinity of the produced water in extracted liquid was 61.2 g / l. Only two approaching due to salinization was happened in the well during the 90 days since the introduction of the nanosystem and the period between repairs has been extended to 45 days.

Tests on application of nanotechnology against salt deposition in flow line of production well No. 402 have started at Garachukhur field. Prior to application, the period between repairs due to salinity was 15 days at the discharge line and 20 days at the collector. During the application period (32 days), no adjustment operation was carried out on the well discharge line and collector. Thus, the application of nanotechnology was found to be effective. decreased

Mining and experimental works against sand deposits in connection with the application of nanotechnologies were carried out in Buzovna field. Here, a nanocomposition was prepared against sand deposits in production well No. 1361 operating from the II-QD

[7] Aliyev J.A. Oıl recovery enhancement ın hıgh and low permeabılıty layers by the applıcatıon of nanosystem "Processes of Petrochemistry and oil Refining" (PPOR) – Baku: - 2024, - Vol 25, - No.1, - pp.41-49.

horizon of the Buzovna field, and as a result of its injection, the period between repairs was increased, the previous production of the well was restored, and the expediency of the process large-scale application was confirmed. Oil production in the well increased from 1.7 tons / day to 6.0 tons / day, and water production descreased from 14,5 tons /day to 10,0 tons /day. This increase was achieved due to the reduction of the hydraulic resistance of the injected nanosystem in the lifting pipes. At the same time, before the application, the impact on the well with the liquid was 67 times a month, but after the application it decreased to 20 times.

Technical and mining-geological data in connection with the application of the nanosystem against sand deposit in the Buzovna field on well No. 1373 in operation from the VGD horizon were collected and analyzed. As a result of the nanosystem application, the sand deposit in the pipes was limited and the amount of mechanical mixture in the extracted liquid was reduced to an average of 2.6%. Thus, the number of impact with liquids decreased by ~ 2 times from 71 to 36, and air consumption decreased from 12,000 m^3 to 8,000 m^3.

In accordance with the plan of nanotechnologies application to production processes, hardening process of the well bottom zone with nanostructural mortar was carried out in order to prevent sand entering from the formation to well bottom in the production well No. 1155 of the Palchıq Pilpilasi field.

1552-1543 m filter interval of well No. 1155 was perforated and the well was put into operation with 5 tons of oil daily production. However, due to the sand plug, production gradually stopped for 12 days. 3 current repairs (filter washing) and 2 major repairs (fixing of QDZ) carried out in the well did not yield results, it was not possible to prevent sand. Hardening works were conducted with nanostructural mortar (NSBM) in well 1552-1541 m interval. During the process, 1.14 m3 of nanocomposite solution with a density of 1.76-1.80 g / cm^3 and 4.75 m^3 of pressure fluid were injected into the well. With the application of nanocomposite cement slurry used to fix the wellbore zone, a screen with robust scaffold permeability was created in the wellbore zone, the volume of cement slurry increased by 25% due to nanocomposition, therefore the collecting properties of cement stone improved, as a result the well was developed without perforation. Thus, the sand coming from the formation to the bottom of the well was prevented. At present, the daily production of the well is 2.0 tons oil, and in addition, 240 tons oil was produced. The sand show is almost non-existent. As a result of nanosystem development:

- layer with robust scaffold and high permeability was created in the well bottom zone;
- intensive sand flow from the formation was prevented;
- well, was developed without reperforation.

The process of washing the sand plug in the well No. 3692 of Bibiheybat field was carried out. When washing the bottom zone, a nanosystem was injected into the working solution.

The annulus pressure increased from 10 to 28 atm, and production increased from 6 tons/day to 9 tons/day. The period between repair before the process was 40 days, 55 days after the process, there was no sand appearance[8].

After the application works were carried out, the economic efficiency was calculated.

After the application works were carried out, the economic efficiency was calculated.

The effective exploitation of Azerbaijan's oil and gas fields depends on many factors, primarily on the creation and application of new advanced technologies. Stabilization of production is associated with improving the quality of repair work, especially on old and wet fields, increasing the inter-repair intervals, strengthening the fight against corrosion, salt, paraffin deposits, the development and use of surfactants and various other chemical reagents.

SOCAR currently has 6,700 active wells. 65% of the working stock of oil wells are low-yield and highly flooded wells, 20-25% of the recoverable reserves are high-viscosity oil, located in low-permeability reservoirs.

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[8] Şahbazov E.Q., Əliyev C.A. "Bibiheybətneft" yatağında ağır neftlərin çıxarılmasında və nəqlində nanotexnologiyanin tətbiqi. Azərbaycan Ali Texniki Məktəblərinin Xəbərləri, - Bakı: - 2019, - cild 21, - № 4, - 37-42 s.

Consequently, there is a great need for the application of nanotechnology in oil and gas production today and in the future.

Improving the quality of oil production, refining and transportation, reducing consumption rates and financial costs of oil and gas production are the main requirements of the day.

For the first time, theoretical and experimental studies have confirmed the effectiveness of nanotechnology in the oil industry of Azerbaijan.

For the first time, NT material based on aluminum nanoparticles was developed and protected by a patent (№A20050250).

More than 130 tons of additional oil was extracted from 7 wells in Gum Adasi and Surakhani fields for 3 months, 1-1.5 tons of additional oil was produced per day from wells 230, 326, 327, 883 of "Absheron" OGPD, more than 170 tons of additional oil was produced from 1 well (№438) for 9 months, and the amount of water in the liquid decreased by 20%.

367 tons of additional oil was produced from 48 wells in Bibiheybat field for 3 months[9].

SAM, reagents, mixtures of Fe-nanoparticles of 90-110 nm size were used in mining tests to prevent salt precipitation and economic efficiency was obtained[10].

The following formula was used to calculate the economic benefits from the application of innovation measures:

$$DXM=[(1-0,20635)x\Delta MQ \pm TTX-\Delta MN)] \text{ x } \alpha_1 \qquad (1)$$

or

$$DXM = [0,79365 \text{ x } \Delta MQ \pm TTX - \Delta MN)] \text{ x } \alpha_1 \qquad (2)$$

here: DXM – discounted net product, man.;

0,20635 – coefficient to determine the mining tax rate from the price;

ΔM – product growth after the application of the measure, ton;

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[9] Şahbazov E.Q., Əliyev C.A. "Bibiheybətneft" yatağında ağır neftlərin çıxarılmasında və nəqlində nanotexnologiyanin tətbiqi. Azərbaycan Ali Texniki Məktəblərinin Xəbərləri, - Bakı: - 2019, - cild 21, - № 4, - 37-42 s.

[10] Алиев Дж. А. Разработка и исследование новой нанокомпозиции для ликвидации асфальтено-смоло-парафиновых отложений. - "SOCAR Proceedings" - Баку: - 2023, - No. 2, - 82-87 p.

Q - Selling price of 1 (one) ton of oil;

TTX – the cost of applying the technology or saving it, man.;

N – standard of conditional-variable costs per 1 (one) ton of oil (gas), man/t;

ΔMN – generally conditional variable costs, man.;

α_1 - discount rate, part of a unit.

$$DXM = [0,79365 \times (13\times53,60) - (21,975 + 31,122 + 16,628 + 3,47 + 20,906) +4984 - 13\times37,62] \times 0,909 = (553,02 - 94,10 +4494,94) \times 0,909 = 4503,05 \text{ man.}$$

Thus, the expected benefit from the use of a nanosystem for the prevention of salt deposition is 4503.05 manat, which indicates that the current work is expedient and convenient.

Calculation of the economic benefit derived from the use of a highly soluble chemical nano-system to treat ARP compounds in well 1331 in Palchiq Pilpilesi field is based on an internationally recognized standard. According to the methodological instruction, in this case the discounted net product, the costs associated with the application of the measure, the notional rate of variable costs, 1 ton of oil production tax, a report with a discount rate of 5%, are carried out according to the formula (4.1) or (4.2).

However, given the nature of the case, it is important to make some changes to formula (4.2), then:

$$DXM=[(0,79365\times\Delta M\times Q+\Delta P\times Q_q)\pm TTX-(Ş_n+Ş_q)] \times \alpha_1 \quad (3)$$

her:

ΔP - gas saving due to the reduction of the number of repairs due to the application of the measure, thousand m3;

ΔM - oil saving due to the reduction of the number of repairs due to the application of the measure, tons;

Q_q - selling price of thousand m3 of gas, man / min m^3;

$Ş_n$ – conditional variable costs for oil, man;

$Ş_q$ – conditional variable costs for gas, man.

The savings obtained using the data were calculated as follows:

$$DXM = [0,79365 \times (240\times53,60) - (2400 + 78,59 + 11,68 +250,4) + 28012 - 5997,6] \times 0,909 = (10209,51- 2740,67 + 28012 - 5997,6) \times 0,909 = 26800,27 \text{ man.}$$

Thus, as a result, we can assume that the experiment is cost-effective.

Perspectives of nanotechnology:

prevention of vibrations in the oil and gas transportation system by pipelines;

- prevention of drilling complications;
- against subsidence in paraffin wells;
- oil storage, preparation for transportation and processing.

As a result of using the patented method, oil production in affected wells increased by 1.5-2.0 times, the water content in the produced liquid decreased by 20%, and the energy intensity of oil production decreased by 15%.

CONCLUSİON

1. Increasing the concentration of nanoparticles in sam solutions from 0.0005% to 0.001% reduces the surface tension at the oil-water interface, but a further increase in nanoparticles by more than 0.001%, on the contrary, increases the surface tension.

2. Against scale deposits occurring during oil production and transportation, it was a nanosystem was used, consisting of surfactants, a high-viscosity polymer, an inhibiting acid, copper nanoparticles 60-80 nm in size, taken in various proportions, the efficiency of which varied within 80.3-92.3% depending on the amount of reagent consumed.

3. To restore the porosity and permeability of productive clay reservoirs a nanosystem consisting of an organic solvent, surfactant and aluminum particles (50-70 nm) was developed, and it was determined that it has an efficiency of up to 85-88%. As a result of cleaning the bottomhole zone around the well from ATP deposits, the new composition provides an increase in reservoir permeability.

4. Due to exposure to a solution mixed with the nanosystem, introduced through Injection wells into the reservoir, the efficiency of oil demulsification was increased. Thus, oil production increased by 13-15%, the amount of water in the produced fluid decreased by 16-18%.

5. The nanosystem used in airlift-gas-lift wells forms a nanofilm on the pipe walls, which reduces hydraulic resistance, accelerates fluid transportation and increases the time between repairs.

6. As a result of the introduction of a nanostructured binder solution into the formation and a binder mass of a solid structure was obtained in the bottomhole zone of the well, preventing the influx of sand. The overhaul period of wells increased by 2.0-2.5 times.

7. As a result of the use in the production process of the developed ingredients and technologies, an additional 4100 tons of oil were produced, the amount of water in the produced fluid decreased by 6300 m3. As a result of the strengthening work performed, the turnaround time of the wells increased by 2.0-2.5 times.

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Candidate's personal contribution

[10, 12, 13, 16, 17, 18] were performed independently,

[1-5, 9, 14, 15] involved in conducting research and summarizing the results,

[6-8, 11] involved in writing reports and analyzing the results.

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