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A B S T R A C T

of the dissertation for the degree of Doctor of Philosophy
(Doctor of Science)

IMPROVEMENT OF DRILL RECIPES SOLUTIONS BASED ON BACTERICIDE-INHIBITORS IN THE PROCESS OF DRILLING WELLS

Specialty: 2523.01 - "Well Drilling Technology"

Field of science: Technical sciences

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Baku – 2021

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GENERAL DESCRIPTION OF WORK

Relevance of the topic. In the process of constructing deep oil and gas wells, the problem of combating biological degradation is important. Attempts to preserve the component composition of drilling fluids from biological damage lead to a reduction in material costs and economic investment. However, the development of microorganisms in the environment of drilling fluids is the cause of a significant deterioration in their colloid-chemical and rheological parameters. This, in turn, contributes to excessive consumption of reagents, metal corrosion, disruption of the drilling drilling cycle and an increase in the cost of 1 meter of penetration.

Polymer based chemicals such as carboxyl methyl cellulose and other polysaccharides are particularly susceptible to biodegradation processes, resulting in the drilling fluid losing its stabilizing properties. In this regard, there is a need to protect these polymers from biodegradation.

Carrying out the study of the microbial decomposition of drilling fluids used in the drilling process, as well as the development of means for their protection using new nanostructured bactericidal inhibitors from biodegradation, is an important area of research and is important in the process of chemical treatment of fluids.

The purpose of the work is to improve the formulations of drilling fluids based on bactericidal – inhibitor reagents during well drilling.

The main objectives of the study

- study of the effect of bactericidal reagents on the structural-mechanical and colloidal-chemical properties of drilling fluids;
- development of a bactericidal reagent to suppress biodegradation processes in drilling fluids;
- study of the effect of nanostructured bactericidal inhibitors on the inhibitory properties of drilling fluids;
- development of bactericidal-polymer drilling fluid for drilling wells in complicated conditions;
- development of anti-corrosion composition for drilling fluids.

Methods for solving the tasks

The tasks were solved by conducting a set of scientific research and analytical methods using modern laboratory equipment.

Scientific novelty

- developed nanostructured bactericidal compositions to increase the effectiveness of polymer reagents;

- a formulation of bactericidal – polymer drilling mud with adjustable parameters for use in drilling wells in complicated conditions has been developed;

- a bactericide-inhibitor was proposed to increase the anticorrosive properties of drilling fluids.

Key Protected Provisions

- the effect of bactericidal inhibitors on the rheological and filtration properties of drilling fluids used in the process of drilling wells;

- the composition of the nanostructured bactericidal reagent for regulating the properties of drilling fluids;

- Formulation of bactericidal-polymer drilling fluid for drilling wells in complicated conditions;

- the composition of the anti-corrosion agent for drilling fluids.

The practical significance of the results

The developed compositions of bactericidal inhibitors were tested using drilling fluids of a number of wells in the deposits of our Republic as examples. In particular, according to the results of calculating the effectiveness of tests for wells No. 1820 of the «Saadan» square, well No. 670 of the Bank of «Darvin Bankasy», well No. 1887 of the «Neft Dashlary» square and well. No. 341 of the «Guneshli» area, the economic effect amounted to 38,163.13 manat. The formulation of bactericidal-polymer drilling mud without accidents and complications was introduced in the well. No. 1241 and 1255 pl. «Pirallahi».

Dissertation approbation

The materials that make up the main content of the dissertation were reported and discussed at:

- IV International Youth Scientific and Technical Seminar "Topical Issues of the Development of Oil Rims in Gas and Gas

Condensate Fields", dedicated to the 66th anniversary of the founding of Gazprom VNIIGAZ LLC, Moscow, June 4, 2014;

- X International Conference "Global Science and Innovation", Chicago, USA, March 1st-2nd, 2017;

- scientific and practical conference of young scientists and specialists dedicated to the 84th anniversary of the birth of the National Leader of Azerbaijan G.A. Aliyev, Baku, Azerbaijan Technical University, May 4-5, 2017;

- International scientific-practical conference "TATNEFT" named after V.D. Shashina, Kazan, September 2-3, 2017

Publications

The main provisions of the dissertation are reflected in 11 scientific works, including 1 monograph, 5 articles, 4 abstracts and 1 Patent of the Azerbaijan Republic.

Structure and scope of work

The dissertation consists of an introduction, four chapters, a list of references, including 120 titles and 3 appendices. The work is presented on 153 pages, contains 11 tables and 20 pictures.

SUMMARY OF WORK

In the introduction, the relevance of the thesis is substantiated, the goal, the main tasks are formulated and its practical value is indicated.

The first chapter of the dissertation presents an analysis of the works devoted to the development and implementation of new types of drilling fluids used in the construction of deep oil and gas wells. The materials reflecting the current state of the technology of preparation, as well as the regulation of the structural-mechanical and colloidal-chemical properties of drilling fluids taking into account bactericidal – inhibitory protection are presented. The methodological principles of solving problems in the field of bactericidal protection of drilling fluids are described.

The second chapter is devoted to the development and research of new bactericidal – inhibitor reagents for processing drilling fluids. It is indicated that drilling fluids are multicomponent colloidal systems and various reagents that make up the drilling fluids are potential sources of development of the bacterial background. In addition, when the drilling fluid comes into contact with rocks, formation waters, the colloidal system is intensively enriched with microbiological, chemical and sulfate-reducing bacteria (SRB). Despite the fact that today various inhibitors for inhibiting bacteria in drilling fluids are known, their multicomponent nature, uneconomicity, and most importantly, negative impact on the environment, require their revision.

In order to maintain the stability of polymer-containing drilling fluids, a new formulation of a bactericidal – inhibitory reagent and a drilling fluid based on it was developed for use in the process of drilling productive formations, bringing the well to the design depth without accidents and complications. The proposed drilling fluid includes clay, a polymer, a viscosity reducer, an alkalinity regulator, a surfactant - a bactericidal inhibitor (A – G – 2014), a weighting agent and water, where Laprol 3003 composition with copper nanoparticles enters as an A – G – 2014 the sizes of which are 40-60 nm with a specific surface area of 12.0 m^2 /g.

Reagent A – G – 2014 is a transparent liquid, which has the following technical characteristics:

- density, kg/m^3 1035 - 1040
- hydroxyl number, mg KOH/g 41.0 - 46.0
- acid number, mg KOH/g, not more than 0.05
- pH 6.0 - 6.5
- kinematic viscosity at 25 ° C, m^2/s 155
- mass fraction of water, %, not more than 0.10
- iodine number, g iodine/100 g, not more than 1.50
- mass fraction of potassium, mg/kg, not more than 3.5

To prepare the solution, a certain amount of clay is added to the volume of salt or fresh water to obtain a homogeneous colloidal mass. In order to reduce water loss, a polymer is added to the suspension, as a result of which stability and an increase in the viscosity of the solution are ensured. Rheological parameters, such as plastic and effective viscosity, dynamic shear stress, are adjusted after adding an aqueous-alkaline solution of viscosity reducer. Then, the drilling fluid is weighted and the entire drilling fluid is treated with a bactericidal inhibitor. The prepared drilling fluid is characterized by adjustable structural-mechanical, colloidal-chemical and tribotechnological indicators. The advantage of this drilling fluid is its possession of bactericidal properties, which prolongs the activity of the solution in comparison with analogues. In this drilling fluid, the destruction of microorganisms occurs, as well as the restriction of the destruction of components, primarily the polymer.

The bactericidal properties of the drilling fluid are estimated by the total number of microbes, i.e. by the number of microbes included in 1 ml or 1 gr. drilling mud. The essence of this assessment is to determine the number of bacteria (microbes) in the composition of the primary drilling fluid. With the addition of bactericides throughout the day, the dynamics of changes in the number of bacteria is measured, and as a result, it becomes possible to assess the effectiveness of the bactericide. Over a given period of time, drilling fluid is incubated. The essence of the incubation conditions is that at temperatures of +300° C and +700° C, it is possible to assess the vital activity of sulfate-reducing and heat-resistant organotrophic

bacteria, respectively. Using a luminometer, a luminescence index is measured. The total number of bacteria in the primary drilling fluid was $8.5 \cdot 10^8$. After the addition of the bactericide prototype, this number decreased to $3.1 \cdot 10^5$. Over the next day, this number remained constant, and over the third day, a gradual increase to $5.1 \cdot 10^5$ was observed. And starting from the fourth day there is an increase in this indicator.

As a result of the restoration of the bactericidal medium, there is an increase in the fluid loss of the drilling fluid. After introducing into the composition of the proposed new bactericidal additives, the existing bacterial environment practically "fades", the destruction of bacteria is 75.4-89.1%. Under the action of the prototype, the destruction of bacteria is low, is 50.7%. A comparison of the properties of the proposed drilling fluid with the prototype is given and it is revealed that, unlike the prototype, the structural-mechanical, colloid-chemical, tribotechnological indicators of the proposed drilling fluid are characterized by minimal water loss, static and dynamic shear stresses, minimal nominal and plastic viscosity, and clay cake This drilling fluid is characterized by minimal friction and maximum inhibition (90.1 - 96.5%).

In the process of rock destruction, drilling fluid performs various functions. The quality of well construction is associated with the correct choice of the type of drilling fluid and the management of its properties. In difficult geological conditions, due to the correct selection of the drilling fluid formulation, the risk of accidents and complications can be reduced. However, during drilling, the drilling fluid used is exposed to various factors. Among these factors is an increase in temperature and pressure along the wellbore. To avoid these factors, to date, numerous chemical reagents and materials are developed and implemented. Note that the drilled formations are diverse in chemical nature, and therefore the process of rock destruction can rightly be considered a physicochemical process. Salt rocks due to easy solubility cause coagulation of drilling fluids. Under the influence of mineralized formation water, drilling fluids also coagulate, their structural-mechanical and filtration properties deteriorate. The negative effect of microorganisms on the properties

of drilling fluids has also been established. During drilling, the vital activity of cellulose-decomposing and other types of bacteria leads to a rapid deterioration of the technological properties of the drilling fluid, which is expressed, in particular, in a change in the rheological properties and in an increase in the filtration rate. Various inhibitors have been widely used as a bactericidal additive in drilling fluids, which include Formaldehyde, Glycosal, LPE-11, Catamine, SNPCH-1004 and several others.

It was of interest to study the effect of the new bactericidal inhibitor on the rheological properties of aqueous suspensions and drilling fluids selected from drilling wells in offshore fields of Azerbaijan. In particular, the effects of polymers and polymer compositions with a bactericide on the stabilizing properties of a 15% aqueous suspension of Karachukhur clay prepared in sea water were investigated. The suspension under study, which had a water loss of 13.5 cm^3 at a plastic viscosity of 18.0 mPa·s, stabilized, in one case with the addition of 0.75% KMS-350, and in the other with KMS-600. After the addition of polymers, the value of water loss decreased, respectively, to 6.0 cm^3 and 3.0 cm^3, and due to the compositions to 5.8 and 2.4 cm^3. Within 30 days, the “memory" was studied, namely, the preservation of the stabilizing effect in solution. At a temperature of 50° C, water loss was determined every day using an OFITE HTHP filter press. During the first 6 days, the studied indicator of water loss changed with a slight deviation (0.5) from the initial value corresponding to the stabilized indicator with the help of KMS-350. After that, it was found that as a result of the destruction of the polymer, an increase in the yield of the suspension occurred.

Similar experiments were carried out with a composition whose composition consisted of a polymer with 0.5% bactericide. The process of maintaining the stabilizing effect was observed for 15 days, after which a slight increase in water loss was observed with a deviation from the initial value. In experiments conducted with CMC-600, the results were obtained, from which it is seen that after 19 days there was a destruction of the polymer, which corresponded to an increase in the water loss of the suspension. And in a stabilized

suspension with the composition of KMC-600 and a bactericide, the preservation of the value of water loss was stable during the entire period of research. Thus, the introduction of a new bactericide ensures the maintenance of the stabilizing properties of the polymer reagent in the drilling fluid. This is closely related, first of all, to the suppression of cellulose-degrading bacteria in the test medium.

It is known that a number of factors influence the magnitude and rate of clay swelling. Unlike other rocks, clay rocks are capable of spontaneous dispersion upon swelling. The higher the degree of dispersion, the greater the speed and magnitude of the swelling. It was of interest to study the inhibitory ability of a polymer composition with a developed bactericidal inhibitor in drilling mud. As a composition, CMC-350 with 0.5% bactericide and CMC-600 with the same bactericide concentration, as well as polymer reagents without bactericide, were investigated. The experiments showed that the greatest decrease in swelling occurs at polymer concentrations up to 0.45–0.5%. With an increase in concentration above the indicated, these changes are less significant. A synergy of the action of the polymer with a bactericide was revealed, the mechanism of which can be explained by the fact that the presence of a bactericide in a colloidal solution enhances the physicochemical interaction of the polymer with the surface of clay mineral particles. Adsorbing a clay-bactericidal-polymer complex on clay, modifies its surface and prevents the swelling process. Thus, it has been established that, along with controlling the structural-mechanical and filtration properties of clay suspensions and drilling fluids, the proposed bactericide acts as an active inhibitor in the process of clay swelling.

The works of domestic and foreign experts involved in the development and implementation of new drilling operations showed that deposits with hydrocarbon reserves, and especially in reservoir fluids, contain a huge amount of sulfate bacteria. These bacteria cause enormous damage to the drilling fluids used. Infection of drilling fluids with a combination of microorganisms, both aerobic and anaerobic, worsens their rheological properties, leads to coagulation, to stratification. In order to neutralize these bacteria, special antiseptics are introduced into the drilling fluids to protect the

reagents from microbiological degradation. Despite the wide range of bactericidal reagents, their use is accompanied by certain limitations. This is primarily due to hygiene and environmental restrictions on the use of these reagents. In order to study the bactericidal properties of the proposed reagent, laboratory tests were carried out, the initial stage was the preparation for sampling. The number of SRB was determined by the method of limiting dilutions by seeding, selected drilling fluid from drilling well No. 341, on the Postgate medium. The corrosion rate was determined by the gravimetric method taking into account the weight loss of the sample, its surface area and test time. The protective effect of the bactericide – inhibitor was calculated taking into account the corrosion rates before and after the introduction of the reagent in concentrations of 0.1–0.8%. Three parallel tests were conducted for each concentration, the results of which were compared with a control sample. Based on the studies, it was found that the greatest suppression of Sulfate Reducing Bacteria (SRB) was observed at a reagent concentration of 0.5%. Next, the effect of a bactericidal reagent on the properties of polymer-lignosulfonate drilling mud with different solid phase contents was examined. The rheological properties of drilling fluids prepared in seawater were investigated. The solids content in the studied media was 8–22%. The effect of bactericidal additives on the prepared solutions was studied in concentrations of 0.1-0.8%. It was revealed that with the addition of the developed reagent, an intensive decrease in the value of the dynamic shear stress of drilling fluids is observed. This tendency is especially noticeable when the concentration of the reagent is increased to 0.5%. The change in the coefficient of friction of the filter cake from the content of the bactericidal inhibitor in the drilling fluid was studied. It has been established that the A-G-2014 reagent gives the solution additional lubricating properties, which is very important during the operation of the bit and drill string.

The change in the fluid loss of a colloidal suspension containing 18% sodium bentonite clay stabilized with an SMS polymer (USA) and a polymer composition with a bactericide was studied. With an initial water loss of 21.0 cm^3 in 30 minutes. after the addition of reagents, the studied parameter drops sharply. Within

three weeks, this indicator was re-measured under laboratory conditions in stabilized suspensions and an increase in water loss was observed. However, the bactericide used somewhat enhanced the stabilizing effect of the studied polymer.

Bench tests of a drilling fluid treated with the developed bactericide at an optimal concentration of 0.5% were carried out in laboratory conditions on pipe steels of grades St-3 and E at a temperature of 80^0 C. The bactericidal and inhibitory properties of the drilling fluid were studied. It was revealed that a new bactericidal inhibitor inhibits the development of sulfate-reducing bacteria in a weighted drilling fluid treated with various chemicals, slows down the corrosion rate by 80.1-91.4% while suppressing the growth and development of SRB.

Experimental studies of the bactericidal effect of reagents on the cement-bentonite mixture stabilized with Starch, which is widely used in Russia and the USA, as well as the management of the rheological and technological properties of this composition, were also carried out. At first, the ATREN-Bio brand A multifunctional bactericide was used as a bactericidal reagent in experiments. Earlier studies have revealed that microbiological corrosion of drill pipes and drilling equipment is observed when molds are exposed. This bactericide is designed to inhibit the growth of SVB, which cause corrosion processes of drilling equipment, as well as deterioration of the properties of the drilling fluid. An analysis of the most widespread mold fungus of the species Aspergillusniger from the genus Aspergillus was carried out. In the analysis, the effect of the ATREN-Bio bactericide on mold microorganisms at the molecular level was revealed.

Sowing Aspergillusniger was carried out on the environment of Saburo. Sowing colonies on a sterilized medium was carried out using Drigalski spatula. Cement samples were applied to the medium with a thickness equal to the thickness of the medium (4 mm). For analysis, the following samples were used:

- Portland cement brand "G" + bentonite + water (control sample);

- Portland cement brand "G" + bentonite + bactericide ATREN-Bio + water (processed sample).

In the thermostat, incubation of Petri dishes was observed at a temperature of 25º C. On the tenth day, samples were removed from the habitat under a layer of cement – bentonite mixture using a bacterial loop and plated on Saburo. On the twentieth day on the material taken under the control sample layer, the formation of a white layer of the fungal colony was detected, and on the thirtieth day the characteristic black-pigmented colonies were already detected. At the same time, the formation of colonies on Saburo medium was not detected on the material that was taken from under the layer of cement – bentonite mixture enriched with the ATREN-Bio bactericide. It should be noted that this bactericide can be used to treat drilling fluids prepared in sea water at concentrations of 0.15-0.25%. Also, experiments were carried out on the effect of bactericides on a clay suspension stabilized with 0.5% starch reagent. The test suspension had a nominal viscosity of 42 seconds, with a water loss of 22.5 cm^3 in 30 minutes.

Further, a sample of the suspension was kept at a temperature of 85 ° C for the development of microflora. Similar experiments were carried out with the same suspension treated with both 0.5% starch reagent and ATREN-Bio bactericide. After the introduction of the bactericide, the conditional viscosity of the suspension decreased to a value of 54 seconds, and the filtration rate to a value of 14.5 cm^3 in 30 minutes. Applying the method on a bioluminometer, the luminescence index was determined, which assessed the degree of toxicity compared to a standard sample. 10-week analyzes of the studied parameters allowed us to conclude the following conclusion: if in the initial suspension, stabilized by starch, without a bactericide, the total microbial number with a luminescence index of 78.3%, in 1 ml of solution is 12.3×10^8, then in a medium with a bactericide complete suppression of sulfate-reducing bacteria and a decrease in luminescence to 70%.

Comparative analyzes of bactericidal properties have also been carried out by bactericides such as MICIDE and Glycosal. After introducing MICIDE into the initial suspension, the total microbial

number decreased to 5.1 x 10^6, and under the influence of Glycosal to 2.4 x 10^5. Thus, the activity of bactericides can be represented in the following sequence:

ATREN-Bio> Glycosal> MICIDE

Thus, the experiments thoroughly confirm the feasibility of using bactericidal reagents in the preparation of drilling and clay-cement mortars. It was found that bactericidal inhibitors for a long time support the initial rheological parameters of the suspension.

The third chapter of the dissertation is devoted to the study of the influence of types of drilling fluids on the anticorrosive properties of drilling equipment. To date, various technological approaches are known aimed at protecting metal during well construction. By classifying certain technologies, it is possible to identify factors that require a review of existing ideas in solving this problem. It is especially necessary to consider environmental and economic factors in solving these problems. The main difficulty that arises in this is the scientifically based selection of an anticorrosive reagent or composition. In general, the process of activation of corrosion most intensively occurs in the environment of thionic bacteria. These bacteria mainly propagate among microorganisms. Species of thionic bacteria, namely T. Thioparus, T. Dentrificuns, T. Thiooxidans, T. Ferrooxidans, T. Novellus, are characteristic species of these bacteria. Anaerobic corrosion in the environment of drilling fluids occurs due to sulfate-reducing bacteria (SRB). These bacteria are activated due to the mineralogical composition of water. Also, SRB can be included in the formation water, which, when ingested, changes its properties. It should be noted that the development of SRB is seriously affected by both temperature and pH. So, at a temperature of 2-85°C and at a pH of 5.0-10.0, the development of SRB is observed. From the life of SRB, H_2S is formed, which is the main source of the process of corrosion of drilling equipment. In this regard, it is very important to suppress the development of bacteria in a colloidal solution.

An analysis of the work performed indicates the feasibility of new experimental studies taking into account the types of drilling fluids used in drilling. The task was set to study the influence of the

developed new bactericidal compositions on drilling fluids, in connection with which a technique was proposed for assessing the corrosion properties of drilling fluids. During the drilling of deep wells, the circulating drilling fluid is in close contact with various rocks. The salts contained in these rocks, as well as all sludge, radically changes the structural – mechanical and colloidal – chemical properties of the drilling fluid, the restoration of which requires a large amount of reagents and materials. And if you consider that the process of drilling mud regeneration is an energy-intensive technology, then the entire cycle of cleaning and processing the drilling fluid can lead to both energy and material costs. In order to quickly assess the aggressiveness of the medium, the Monicor – 2M laboratory instrument was used, which is an indicator of the rate of corrosion of steel metal in a drilling fluid environment. This device is used with a sensor having two electrodes. The values of the corrosion rate of the sensor electrodes are measured in mm / year and covers a wide measurement range from 0.001 to 10.0 with a measurement error of not more than five percent. With an interval of 65 seconds, you can get reliable information about the studied indicator.

A clay suspension of bentonite clay prepared in sea water was used as the initial solution. The bentonite content in the solution was 22%. To stabilize the aqueous suspension used KMS-350, and as a viscosity reducer FXLS. The compositions were treated with bactericidal inhibitors, and then the corrosion index was evaluated. As a bactericide-inhibitor, a new composition was proposed (A-G-2016), consisting of polypropylene glycol (PPG) with metallic copper nanoparticles, the sizes of which were 40-60 nm. The metal nanoparticles used was characterized by a bulk density of 5000 kg / m^3, a molar mass of 150–4500 g / mol, and a density of 1002–1020 kg/m^3.

It was found that bactericidal inhibitors significantly reduce the corrosive activity of the studied drilling fluid. Studies have shown that polymer and petroleum-based solutions are also committed to destruction processes due to bacteria, and therefore lose their stability, have limitations for reuse, and their further restoration

requires a lot of time and material resources. In particular, the aqueous phase of the drilling fluid determines the electrochemical nature of the corrosion of the drilling equipment. With an increase in this phase, the rate of corrosion damage to the metal increases. Due to the electrochemical heterogeneous interaction of the salt-containing components of the drilling fluid with the metal, corrosion leads to spontaneous destruction of the surface of the latter.

In order to study the corrosion activity of various drilling fluids, a series of experimental studies were carried out using steel grade St.3.

Highly mineralized colloidal suspensions, treated drilling fluids and clay-free calcium bromide saline solutions were used as drilling fluids. Note that brine calcium bromide is an active source of metal corrosion. However, thanks to the aqueous solution of calcium bromide, it is possible to obtain high-density fluids, which, in turn, can replace high-density drilling fluids used as perforation fluids in the development of productive horizons with abnormally high reservoir pressures.

The experiments were carried out according to the methodology to obtain an estimate of the corrosion rate of the metal. The studies were carried out at 90 ° C using steel plates with dimensions of 1.5 x 1.5 x 1.5 cm, which were previously ground, placed in a desiccator for 2 hours, and then weighed with an accuracy of 0.00001 g. The samples on special holders made of fluoroplastic were placed in glasses, inserted into the holder, which was mounted on the mixer. The cage rotated at a frequency of 200 rpm and was placed in a thermostat heated to a predetermined temperature. After the experiment, the plates were washed with water, kept in a desiccator and weighed, and then the corrosion rate was calculated by the formula. The corrosion properties of potassium chloride, calcium chloride, polymer lignosulfonate, polymer emulsion drilling fluids, as well as perforation fluid of calcium bromide ($CaBr_2$) were investigated. The average corrosion rate was determined by the results of measurements carried out within six hours. This method is based on determining the measurement of the mass of a sample after exposure to a drilling fluid. In this case, when exposed to an

aggressive environment - drilling mud, the test sample is weighed and the metal mass loss is determined.

In the first case, there was a study of the effect of potassium chloride drilling fluid on St3 metal. For this medium, the average corrosion rate was 0.35 g/m^2·h, for calcium chloride drilling mud 0.54 g/m^2·h. We also investigated polymer lignosulfonate and polymer emulsion solutions, which are characterized by a corrosion rate of 0.72 and 0.18 g/m^2·h, respectively. It was revealed that polymer-lignosulfonate drilling fluid is the most aggressive medium for the metal under study, however, a saturated calcium bromide solution is practically not inferior to polymer-lignosulfonate drilling mud in aggressive properties.

The fourth chapter is devoted to testing and then implementing the developed technologies in the drilling fluids used in the fields of Azerbaijan. For this purpose, samples of circulating drilling fluids were taken from the wells being drilled in the land and sea fields of the Republic. Drilling fluids from the «Saadan», «Darvin Bankasy», «Neft Dashlary» and «Guneshli» fields were presented as objects of research. For example, drilling mud well No. 1820 of the «Saadan» area was characterized by uncontrolled structural-mechanical and colloidal-chemical properties, had a density 1374 kg/m^3, and a non-flowing viscosity. The values of the static shear stress of static shear stress for 1 and 10 minutes were very high, and the water yield was 5.5 cm^3 for 30 minutes, with a filtration crust thickness of 3.0 mm, pH=8.2.

The rheological parameters of the drilling mud were also high, the plastic and effective viscosity were 46.0 mPa·s and 23.8 mPa·s, respectively, and the dynamic shear stress was 210.6 dPa. The coefficient of friction of the filter cake was also studied, the value of which was 0.128. Given the uncontrollability of the circulating drilling fluid, it was decided to use a viscosity-reducing agent FXLS in combination with a bactericide-inhibitor A-G-2016 and a composition consisting of 10% FXLS with a bactericide-inhibitor A-G-2016 was proposed. Of the 10% FXLS, 5% and 1% of the bactericidal reagent were added to the drilling mud. As a result, the conditional viscosity from the non-fluid state decreased to 100

seconds, the static shear stress was 57-128 dPa, the water yield decreased to 5.0 cm^3 for 30 minutes.

The decrease in water yield was due to A-G 2016, and this bactericide-inhibitor increased the effect of the FXLS reagent due to the synergistic effect. The thickness of the filtration crust and the value of its friction were measured. It was found that the thickness of the filtration crust changed almost little (2.9 mm), and the coefficient of friction decreased sufficiently and amounted to 0.0875.

Rheological parameters were also studied and a decrease in the values of plastic viscosity to 24.0 mPa·s, effective viscosity to 13.6 mPa·s, and dynamic shear stress to 127.2 dPa was observed. The combination of the bactericide-inhibitor A-G- 2016 with FXLS led to positive results on the example of a well being drilled.

The drilling mud of well No. 670 of the «Darvin Bankasy» area was characterized by a density (p) = 1395 kg / m^3, a conditional viscosity of 100 sec, a static shear stress for 1 and 10 minutes of 135-141 dPa, a water yield value of 9.1 cm^3/30 min, a filtration crust thickness of 2.5 mm and a pH value of 8.8. The plastic viscosity was 16.0 mPa·s, the effective viscosity was 17.3 mPa·s, the dynamic shear stress was 206 dPa, and the friction coefficient of the filtration crust was 0.1051. Of the 10 % FXLS in volume, 5 % was added to the solution with 1 % A-G-2016. As a result, the conditional viscosity decreased sharply to 36 seconds, and the static shear stress for 1 and 10 minutes decreased to 63-81 dPa.

The decrease in water yield to 8.6 cm^3 in 30 min was observed, thereby reducing the thickness of the filtration crust to 2.0 mm. At the same time, the coefficient of friction of the filtration crust also decreased to a value of 0.0875. The plastic and effective viscosity, as well as the dynamic shear stress, were fully adjusted to 12 mPa·s, 10 mPa·s, and 113 dPa, respectively. The proposed formulation also gave positive results on the examples of drilling fluids of the oil field No. 1887 of the "Neft Dashlary" area and the drilling field No. 341 of the "Guneshli" area.

The formulation of drilling mud based on a bactericidal reagent was introduced at the drilling site No. 1241 of the «Pirallahi» area, which was drilled for the operational purpose of the productive

horizon and was characterized by complex lithological and stratigraphic features. The composition of the drilling mud consisted of bentonite clay, polymer, lignosulfonate, caustic soda, lubricating composition, and bactericidal reagent. 60 kg of bentonite clay, 5.5 kg of polymer, 50 kg of viscosity reducing agent, 5 kg of caustic soda, 2 liters of nanostructured bactericidal reagent, as well as water were spent on the preparation of 1 m^3 of bactericidal polymer drilling mud. In the subsequent stages of drilling, the addition of up to 2.5% of oil with graphite improved the lubricating properties of the drilling fluid compared to the initial one.

During the event, it was achieved to maintain the density of drilling mud in the range of 1190-1200 kg/m^3 in compliance with colloidal-chemical and structural-mechanical parameters. In particular, the water yield of the drilling mud did not exceed 3.0 cm^3/30 min., the conditional viscosity was 50 s, the static shear stress for 1 and 10 minutes was 15-30 dPa, and the pH was 9.0. At the same time, the thixotropy coefficient was in the range of 1.52-1.74, which allows a satisfactory removal of drilled rocks to the surface of the well. Accidents and complications did not occur during the event. With the same success, the implementation was carried out on the well 1255 area “Pirallahi".

Using regression analysis and processing of field data, an equation was obtained, from which it was revealed that such parameters of the drilling mud as water yield, thixotropy coefficient and plastic viscosity most significantly affected the mechanical drilling speed during the implementation than the density of the bactericide-polymer drilling mud.

The adequacy of the Shvedov-Bingham, Ostwald, and Herschel-Bulkley models was also evaluated using the Teil test, which amounted to 0.029426, 0.055176, and 0.032699, respectively. Calculations have shown that the Shvedov-Bingham and Herschel-Bulkley models better describe the nature of the drilling fluid under study than the Ostwald model.

CONCLUSIONS AND RECOMMENDATIONS

1. New nanostructured bactericidal inhibitors have been developed, which along with the regulation of the structural – mechanical and colloidal – chemical properties of drilling fluids provide protection of polymer reagents from biological degradation and metal from corrosion.

2. It has been established that the proposed bactericidal inhibitors in synergy with polysaccharide polymers adsorb on clay, modify its surface and prevent the swelling process, thereby exhibiting high inhibitory abilities.

3. A new composition of bactericidal – polymer drilling mud with adjustable parameters for drilling potentially unstable clay deposits and opening of reservoirs has been developed.

4. Comparative analyzes of bactericidal inhibitors in the environment of various types of drilling fluids were carried out and their activity was revealed. It was established that the studied bactericidal inhibitors can be represented in the following sequence:

ATREN-BIO> Glycosal> MICIDE

5. Studies have been conducted on the effect of bactericidal inhibitors on the properties of solutions on oil and polymer bases, in order to study their activities. It has been established that potassium chloride, calcium chloride, polymer lignosulfonate, polymer emulsion drilling fluids and perforation fluid of calcium bromide are potential sources of corrosion of the St-3 metal, and by introducing nanostructured bactericidal inhibitors into the composition, this negative factor can be significantly reduced.

6. The proposed bactericidal inhibitors were investigated on well No. 1820, of “Saadan”, well No. 670 of “Darvin Bankasy”, well No. 1887 of “Neft Dashlary” and well No. 341 of “Guneshli” fields, and the effect amounted to 38,163.13 manats. The formulation of bactericidal-polymer drilling mud was introduced in the wells No. 1241 and 1255 of "Pirallahi" field without accidents and complications.

The main provisions of the dissertation were published in the following publications:

1. Искендерзаде, А.Э. Разработка и исследование нового бактерицида для управления свойствами буровых растворов // Строительство нефтяных и газовых скважин на суше и на море, 2014, №6, с. 17-20;

2. Искендерзаде, А.Э. Новые возможности бактерицидной защиты в нефтегазовом деле / 4-ый Международный молодежный научно-технический семинар «Актуальные вопросы разработки нефтяных оторочек на газовых и газоконденсатных месторождениях» Москва, 4 июня 2014 г;

3. Искендерзаде, А.Э. О некоторых факторах, влияющих на стабильность буровых растворов // Строительство нефтяных и газовых скважин на суше и на море, 2014, №8, с. 40-42;

4. Искендерзаде, А.Э. Разработка и исследование полимер-эмульсионного бурового раствора // Строительство нефтяных и газовых скважин на суше и на море, 2015, №1, с. 33-36;

5. Искендерзаде, А.Э. Разработка эффективных подходов для улучшения антикоррозионных свойств буровых растворов // Azərbaycan Respublikası Təhsil Nazirliyi, Azərbaycan Texniki Universiteti, "Elmi əsərlər". - Bakı, 2016, №4, səh 34-37;

6. Isgandarzada, A.E. Biological degradation process research in drilling fluids environment / X International Conference «Global Science and Innovation», Chicago, USA, March 1st-2nd, 2017;

7. Искендерзаде, А.Э. Наноструктурированные бактерицид-ингибиторы для подавления биодеструкций в бурении / Azərbaycan xalqının Ümummilli Lideri Heydər Əliyevin anadan olmasının 94-cü ildönümünə həsr olunmuş tələbə və gənc tədqiqatçıların "Gənclər və elmi innovasiyalar" mövzusunda respublika elmi-texniki konfransının materialları. Azərbaycan Respublikası Təhsil Nazirliyi, Azərbaycan Texniki Universiteti. 2017-ci il, s. 394-395;

8. Искендерзаде, А.Э. Опыт испытаний бактерицид-ингибитора на примере буровых растворов Азербайджана // Azərbaycan Milli Elmlər Akademiyası Gəncə bölməsi "Xəbərlər məcmuəsi". - Gəncə: Elm. - 2017. - №3 (69), s.67-71;

9. Искендерзаде, А.Э. Испытание наноструктурированного бактерицид-ингибитора на буровых растворов Азербайджана // Аппарат Президента Республики Татарстан, Министерство промышленности и торговли Республики Татарстан ФГБУ Российская академия наук, ГНБУ «Академия Наук Республики Татарстан», ПАО «ТАТНЕФТЬ» им. В.Д. Шашина, ЗАО «НЕФТЕКОНСОРЦИУМ», Казанский Филиал ФБУ «ГКЗ», ОАО «Казанская Ярмарка» “Горизонтальные скважины и ГРП в повышении эффективности разработки нефтяных месторождений”, 6-7 сентября 2017 г., с. 187-188.

10. Kazımov, E.A., İskəndərzadə, A.E. Patent. İxtira İ 2019 0045. Qazma məhlulu. İddia sənədinin nömrəsi a 2014 0052. İlkinlik tarixi: 20.05.2014. Dövlət reyestrində qeyd olunub: 06.09.2019.

11. Азизова, А.Э. Совершенствование рецептур буровых растворов на основе реагентов бактерицид – ингибиторов в процессе бурения скважин. Международный Издательский Дом «Вектор». Баку, 2021. 180с.

Personal contribution made by the author:

- works (1, 2, 3, 4, 5, 6, 7, 8, 9, 11) - performed independently;
- work (10) - experimental studies conduction, processing the results.

The defense will be held on “30” June 2021 at 11:00 a.m. at the meeting of the Dissertation council ED 2.03 of Supreme Attestation Commission under the President of the Republic of Azerbaijan operating at Azerbaijan State University of Oil and Industry

Address: AZ1010. Baku. D.Aliyeva st. 227

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Abstract was sent to the required addresses on “ ” may 2021.

Signed for print: 21 may 2021
Paper format: A5
Volume: 38596
Number of hard copies: 20 copies