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DEVELOPMENT OF EFFECTIVE COMPOSITIONS OF DRILLING FLUIDS TO IMPROVE THE QUALITY OF DRILLING WELLS IN THE CASPIAN BASIN OF KAZAKHSTAN

Specialty: 2523.01 – Well Drilling Technology

Branch of science: Technical sciences

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ABSTRACT

of dissertation for a degree Doctor of Philosophy

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GENERAL DESCRIPTION OF WORK

The rationale and extent of development.

When drilling wells in the Caspian depression of Kazakhstan, the issues of improving the composition of drilling mud, especially when drilling complex geological sheets, which are described by high pore and formation pressures and temperatures, saline and highly colloidal clay sediments that easily change into the circulating solution, are of critical importance.

The key objectives in drilling these wells are to maintain wellbore stability, ensure cuttings removal, and eliminate drill string puffs and seizures. The main role in solving these problems belongs to drilling mud, which should have high inhibiting, lubricating and dynamic properties.

One of the main directions in the improvement of drilling mud formulations is the use of polymeric reagents that improve their technological performance by selecting the optimal concentration, evaluating the conditions of their use with other components.

Normally, clay, clay hydrogel, low-silicate, oil-emulsion, inhibiting, humate, hydrogel drilling fluids, as well as solutions obtained by condensation of magnesium hydroxides from carnalities or bischofite brines are widely used in drilling and penetration of promising horizons in the Caspian depression of Kazakhstan. The latter are mainly highly mineralized suspensions in which condensed, insoluble compounds of polyvalent metals (hydroxides, silicates, carbonates, etc.) are the only or additional structure-forming phase in the process of drilling mud preparation. In addition, clay-free and low-solids polymer solutions are used. However, these polymer solutions do not always contribute to solving the tasks set, since when drilling wells, their complication is observed, especially tool grabbing and tightening. To improve drilling efficiency, it is proposed to introduce drilling mud based on xanthan resin and lignosulfonate polymer, which is relevant, as it improves the technological performance of drilling mud, increases drilling speed, reduces the number of complications, reduces the consumption of chemical reagents.

The purpose and objectives of the study are to develop effective drilling mud compositions to improve the quality of drilling wells in the Caspian basin of Kazakhstan.

The main objectives of the study:

- search and study of fractional analysis of drilling mud prepared on the basis of new reagents for the purpose of their introduction in the exploration areas of the Kazakh part of the Caspian depression;
- development of drilling muds with combination of xanthan gum and lignosulfonate reagents;
- development of formulations of drilling muds using polymers capable of regulating their technological parameters by reducing rheological properties and reducing the penetration of fluids into the formation;
- introduction of formulations of low-clay and clay-free (polymer) drilling fluids treated with complex polymers in the exploration areas of the south-east of the Caspian Basin of Kazakhstan.

Research methods.

The assigned tasks were solved by carrying out laboratory and field studies, processing of the obtained results with the help of statistical methods and implementation of new developments on the wells being drilled.

The main provisions submitted for protection:

1. Drilling mud formulation based on xanthan resin and lignosulfonate, which contributes to the improvement of technological indicators of drilling deep wells in saline deposits;
2. Composition of inhibited drilling mud for drilling of unstable rocks;
3. Composition of low clay drilling mud for drilling of terrigenous rocks in complicated conditions.

Scientific novelty of the research:

- the composition of a biopolymer drilling mud based on xanthan resin and lignosulfonate for drilling salt deposits has been developed.

- an inhibited drilling mud was developed to maintain well wall stability during well drilling;

- a composition of drilling mud with a low content of solid phase was developed for drilling terrigenous rocks in complicated conditions.

Practical significance of the results of the work.

Methodical and scientific-practical recommendations on the selection of optimum formulations of drilling muds for maintenance of technological parameters have been developed, which have been implemented in difficult mining and geological conditions of the Caspian depression of Kazakhstan in the areas of Eastern Moldabek, Burbaital, Kazhitali-4 and Tobearal, the economic effect for $4.4 thousand has been obtained.

A new drilling mud was developed for drilling saline deposits (Innovative Patent of the Republic of Kazakhstan No. 23529).

Approbation of the work.

The materials of the thesis work were reported and discussed:

- at the VII International Scientific and Practical Conference. Astrakhan, 2008;

- at the International Scientific and Practical Conference "Current Issues of Oil and Gas Complex of Kazakhstan", Aktau, 2011;

- at the International Scientific and Practical Conference "Kazan Fair" in Tatneftekhiminvest-Holding, JSC TAIF, CJSC Neftekonsorcium, Tatarstan branch of the Central Committee of Rosnedra for Internal Affairs, JSC, Kazan, September 2-3, 2015.

Publications.

Key results of the thesis have been published in 20 scientific papers, of which 16 articles, 3 theses and 1 patent of the Republic of Kazakhstan.

Structure and scope of work.

The thesis work consists of an introduction, four chapters, conclusions and appendices. The work is presented on 214 pages of typewritten text, containing 51 Tables and 31 Figures, of which the first chapter includes 33299 characters, the second chapter - 74355 characters, the third chapter - 17873 characters, the fourth chapter -

38776 characters. The whole work includes 175474 characters. The list of references used includes 191 titles.

The author feels obliged to express his gratitude to his supervisor, laureate of the UNESCO Prize in Science, Doctor of Technical Sciences, Associate Professor E.A. Kyazimov and the Director of Geology Department of KazNIGRI LLP, PhD. L.V. Shestoperova, who provided invaluable assistance in completing the dissertation work.

CONTENT OF WORK

In **introduction** the relevance of the problem under consideration is substantiated, the goals and objectives of the thesis work, the main scientific provisions, their reliability, scientific novelty and practical value of the research results are formulated.

The first chapter summarizes the geological structure, lithological and stratigraphic features of sections and oil and gas bearing capacity of the southern and southeastern parts of the Pre-Caspian depression of Kazakhstan (Table 1). In this connection, methodological principles of development and management of drilling mud properties in complicated conditions of Kazakhstan are proposed. Drilling mud interaction with rocks in a stressed-deformed state causes macro- and micro-cracks in the rock structure due to internal stresses, their moistening with loss of strength properties is observed. In this regard, the processes leading to creep and collapse of the walls of the well are intensifying. At the same time, it is advisable that drilling mud and its filtrate, penetrating into the pore space and rock cracks, slow down the above processes.

Hence, when selecting the type and composition of drilling mud for the passage of unstable deposits, it is necessary to emphasize not only its resistance to thermal aging, salt aggression, but also its ability to slow down the processes of rock de-strengthening and creep at its contact with the solution. To this end, experimental studies were conducted, in which an artificial core was prepared in a steel matrix by pressing mineral powders of a given composition.[1] During the test, the core was in a volume-tensioned state created by two punches and a matrix. By changing the longitudinal deformation of the core, the stable state of the rock under the action of drilling mud was qualitatively evaluated. By measuring the diameter of the "artificial hole" the final result of the impact of the mud on the rock was evaluated by the formation of caverns and constrictions.

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[1] Казымов, Э.А., Исламов, Х.М. Разработка эффективных составов буровых растворов для повышения качества бурения скважин. // SOCAR Proceedings, - 2023, - № 1, - с.19-25.

By measuring the diameter of the "artificial well", the final result of the effect of the solution on the rock was estimated by the formation of cavities and constrictions. The studies were carried out at a temperature and pressure corresponding to the depth of the investigated rock. The rock samples were tested in uniaxial compression to evaluate the effect of polymer reagents, which were used to impregnate the rock in order to harden it and reduce permeability.

Table 1

Mineralization and chemical composition of reservoir waters, used for the preparation of drilling fluids on separate squares

Field	Miqdarı, q/l					
	Total	Cl^-	Ca^{2+}	Mg^{2+}	$Na^+ + K^+$	SO^{2-}_4
Ayrankol	3,50	0,26	0,28	-	2,94	0,02
Northern Cotyrtas	3,85	2,4	0,2	0,05	1,2	-
Eastern Moldabek	72,18	59,1	3,4	0,122	9,5	0,05
Janatalap	108,0	67,45	3,0	1,82	24,57	0,24
Kisimbay	20,0	11,2	0,4	0,9	7,5	-
Karatobe-Burbaytal	255,1	161,0	0,35	8,98	83,9	-
Matken	4,0	2,52	0,04	0,03	1,41	-
Jubantam-Jusalisay	179,0	57,3	1,06	5,7	81,34	33,6
Munayli	312,2	163,3	6,53	2,0	132,6	7,89

Pressing the powder particles resulted in the formation of a fine porous solid composed of hard mineral particles. When the core was moistened or impregnated with liquid penetrating into such contacts, there was a weakening of bonds between particles, as a result of which the strength parameters of the core and the time of its steady state in the solution medium changed dramatically. Halite (coarse-

grained rock salt, technical) was chosen as a source material for preparation of artificial cores.

Halite was chosen based on the fact that 50% of the constituent salt deposits are sodium chloride, the rest is anhydrite. The clay component of pre-salt sediments is represented by a mixed layer of hydrous mica-montmorillonite type mineral, which is the most unstable component of the rock. In the drilling mud environment, the hydroslude exhibits intense creep and quickly collapses. The content of hydroslude in the rock did not exceed 5%. To increase the sensitivity of the experiments, core samples were prepared from 100% halite taken from wells in the Volga-Ural oil and gas province and the Moscow syneclise. Natural cores sampled from a depth of 4,000 m were ground in a ball mill. The obtained samples were mixed with each other. The mixture was sieved through a sieve and divided into equal weight portions, from which artificial samples were made by pressing.

The compression stress was selected based on the calculation of the geostatic pressure corresponding to a depth of 3500-4000 m.

To conduct experimental studies, a natural core material was required, homogeneous in chemical and mineralogical composition, physical and mechanical properties and with the same overall dimensions. Thus, all studies on rock stability in the drilling fluid environment were conducted on artificial samples having homogeneous mineralogical composition, identical physical and mechanical parameters, in particular overall dimensions, moisture content, particle size. It allowed to obtain a more reliable qualitative picture of creep and stability of the rock in the solution medium with less percentage variation in the data. The data on strength properties of natural cores taken from salt deposits in Elemes-4 well and artificial cores prepared from technical rock salt with particle size from 1 to 3 mm were obtained.

The studies allowed us to record a continuous process of changing the properties of the core, including compression deformation, tensile deformation (during swelling), equilibrium state and creep of the material, including the moment of destruction of the rock structure.

Studies have been conducted to determine the stability of halite cores in the environment of drilling fluids based on water and hydrocarbons. In experiments with halite, the axial loading on the sample was 51.4% of the compressive strength of the core and was equal to 12.6 MPa.

The results of the experiments showed that mineralized clay solution, hydrogel-magnesium solution and brine have the greatest de-strengthening effect, as they are the same in terms of their effect. The maximum time of stable condition of cores in their medium does not exceed 0.05 hours, the creep rate of cores in the medium of these solutions is more than 100 mm/h. The least softening effect is provided by a hydrocarbon-based drilling mud - bitumen-lime mud.

The tests showed that the highest stability and minimum creep rate of halite is observed in hydrocarbon-based drilling mud media (creep rate varies 0.216 mm/h, steady state time is 29 hours). To compare water-based drilling mud, experiments were conducted with mineralized clay solution, rapeseed taken from the Elemes-4 well from a depth of 3900 m and hydrohelmagnesium solution.

In the medium of the best of these solutions, hydrohelmagnesium, the creep rate of halite reaches 84 mm/ h, and the steady state time is 2.8 hours. In engine oil environment, the steady state time of halite is even higher at 53 hours. The obtained research results allow us to give a comparative assessment of the effectiveness of the effect of different types of drilling fluids on the stability of rocks in the wellbore zone.

The effect of process fluids on wellbore conditions was evaluated mainly by drilling and reaming of wells and changes in the properties of drilling fluids in the process of well drilling. As the well deepens, the solutions are determined to a level regulated by geological conditions and the stability of the borehole.

Studies have shown that when using polymer solutions without a solid phase, the insulation coefficients, depending on the initial permeability of the core, are 59.7 - 99.7%.

Consequently, a screening partition is created, which prevents the penetration of filtrate and clay particles into the formation and

thereby creates favorable conditions for the qualitative opening of productive layers.

Restoration of oil tightness of cores after filtration of polymer drilling mud of selective action is higher than after filtration of clay drilling mud. This was confirmed during the construction of the Elemes-3 well on a polymer drilling mud, where an oil inflow was obtained from a depth of 2775 m.

Chemical treatment of drilling mud with special reagents is due to the requirements of deep well wiring technology. Such requirements, first of all, consist in normalization of viscosity, water yield, structural and mechanical parameters, density of washing media influence on drillability, penetration and development of productive formations.

New requirements related to the expansion of their functions are now being imposed on solutions of mass use. The task is not only to ensure normal, trouble-free conditions of well wiring, but also to positively influence the drillability, improve mechanical speeds and penetrations on the bit. The requirements for the rheological properties of solutions can also be formulated more clearly. Controlled rheology and thixotropic of solutions are required to improve drillability and proper bottom-hole cleaning that prevents re-crushing of the drilled rock. This also contributes to reduction of hydraulic losses and thus transfer of more hydraulic power to the turbine and bit.

The major challenges currently facing the chemical treatment of drilling fluids are reduced to the creation of new means and methods that would ensure the preparation of effective, accessible and relatively cheap drilling mud.

In the Caspian depression of Kazakhstan to solve the problems associated with thickening of drilling mud, various reagents - thinners of drilling fluids are studied and introduced. Existing reagents - viscosity reducers (lignins and modified ferrochrome lignosulfonates) in usual cases provide fulfillment of this task, the more so that improvement of washing means allows to reduce requirements to retention capacity of solutions, though in certain cases, for example, at penetration of crumbling rocks it keeps its

value. The most used group of chemical reagents for the treatment of drilling fluids are water reduction reagents (CMC–ASM/60, Foralis-380P, Rhodopol-23P, modified starch IM-Lose, Duovis, Polysal, Desko and xanthan resin biopolymer.). These reagents are designed for difficult drilling conditions, in shale, chemo genic deposits, and at high bottom hole temperatures.

Given the above, we can emphasize the following stages of development and management of drilling mud properties in the complicated conditions of the Caspian depression of Kazakhstan: 1. Search and study of component composition of drilling fluids prepared on the basis of new reagents in order to introduce them in exploration areas. 2. Development of drilling mud formulations with the use of polymers that can improve the technological parameters by reducing the rheological properties and allow reducing the penetration of fluid into the formation, as well as with the combination of reagents xanthan resin and lignosulfonate. 3. Implementation of drilling mud formulations treated with polymers of complex action in the exploration areas of the southeast of the Caspian depression of Kazakhstan.

The second chapter is devoted to the development and experimental study of a biopolymer drilling mud with a low solid phase content. To this end, studies have been conducted to study the properties of drilling fluids based on xanthan gum. Experiments with xanthan resin were carried out both on waters of various mineralization and in a wide range of concentrations of the reagent itself, as well as clay and weighting solid fractions. Inhibitory salts of potassium chloride and calcium were added to the composition of the drilling mud. In particular, studies of the influence of biopolymer Rhodopol-23P on drilling mud properties have shown that the reagent is an active stabilizer, which allows to reduce the water yield of drilling mud.[2]

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[2] Исламов, Х.М. Влияние биополимера Родопол - 23П на свойства бурового раствора. // Вестник Астраханского государственного технического университета. - 2007, - №6, - с. 42-44.

Particularly, at concentrations of 0.2-0.5 % a decrease in water yield of drilling mud up to 8-10 cm^3 per 30 minutes is achieved. With the introduction of bentonite clay powder and barite weighting agent the rheological parameters of drilling mud significantly deteriorate.

Experimental studies have established that the liquefying effect of the reagent Rodopol-23P begins to show at a concentration above 0.2 %, and at a content of 0.3 % it shows a thickening effect. The reagent promotes formation of dense, thin, elastic with low friction properties of filtration crusts. The minimum crust friction coefficient is achieved at a concentration of 0.2 % and is 0.0187. As the percentage content increases, it stabilizes at 0.0364. In the future, the decrease occurs smoothly and after a concentration of 0.5% and above, it practically changes slightly, with a water output value of 8.0 cm^3/30 min.

Figure 1 shows the effects of polymers on the water recovery rate (water output) of drilling fluids.

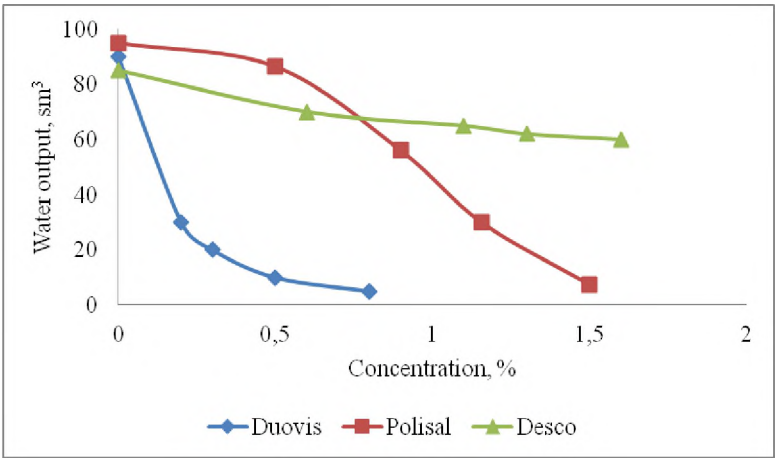

Figure 1. Change in drilling mud water output depends on the concentration of xanthan gum

In terms of both preserving the stability of passable clayey and saline rocks and increasing the technical and economic performance of drilling, the selection of components and technology of drilling

fluid preparation are very relevant for the fields of Western Kazakhstan.

It was found that complex inhibition with sodium and potassium salts not only increase the efficiency of clay rock inhibition, but also facilitate the regulation of technological indicators of drilling mud.

In this regard, when developing formulations of drilling mud intended for drilling in complicated intervals, it is necessary to provide for the presence of a sufficient amount of inhibitory additives in the filtrate. It was revealed that under conditions of loss of stability of the walls of wells, the consumption of xanthan resin to reduce filtration is significantly lower compared to CMC-350 (4 times) and Polysal (3 times).[3]

This was also confirmed during the wiring of a well in fractured mudstones on South Tyubkaragan-3. At 3018 m depth in Permo-Triassic sediments composed of mudstones, the use of humate drilling mud resulted in serious complications related to instability of the borehole walls. Following repeated attempts to increase the density of the solution by reducing filtration, it was not possible to eliminate the complication. The increase of electrolyte concentration in the aqueous phase of the drilling fluid was difficult due to the unitability of humates to salts. Therefore, to eliminate complications, inhibited drilling mud, the aqueous phase of which was represented by potassium salts, was further used. This made it possible to complete the well completion to the designed depth without additional complications and accidents. Chemical reagents - water-release reagents KSSB-2 and CMC-350 were used as stabilizers. At the same time, the concentrations of inhibited cations in the solution were in the following values: Mg^{2+}-0.16 g/l, Ca^{2+}-3.6 g/l, K^{+}-7.5 g/l. Drilling experience in this area has shown that for successful well wiring, it is necessary to take into account not only a small filtration

[3] Исламов, Х.М. Оптимизация ингибированного хлоркалиевого полимерного раствора на основе Дуовиз, Полисал, Деско. // Нефть и газ, - 2008, - №2, - с. 21-27.

value, an increase in the density of the drilling mud, but also the presence of components in its composition that provide a high degree of inhibition.

It should be noted that the inhibitory effect is due to the replacement of sodium or calcium ions by potassium ions in clay particles and fixation of potassium ions on the crystal lattice of swelling clays.

Clay strengthening is determined by the relatively small size of the hydrated potassium ion, which is introduced into the clay composition, firmly binding neighboring surfaces and thus hindering the hydration process. Ion fixation occurs due to the reduction of free space in the crystal lattice. The low hydration energy of potassium ions also favors the condition for the formation of a hardened structure. This structure enhances the cohesion of clay particles, prevents mud sticking to drill string elements, reduces the probability of tool seizure as a result of adhesive interaction, and also contributes to the preservation of reservoir properties of the productive zone.

Experimental studies were carried out using polymer condensed lignosulfonate reagent (KLSP) as an additive to drilling fluids at Burbaital, and Airankol. The reagent was prepared by modifying lignosulfonates with polyvalent metal salts and organic polyatomic alcohols. In appearance, the reagent is a viscous liquid of dark brown color, with a specific odor and a density at 20 $^{\circ}$ C of at least 1140 kg/m^3. The mass fraction of dry substances is at least 47%, pH = 4.5.

The absence of reducing substances in lignosulfonate polymers is the main factor in increasing heat resistance. Laboratory tests revealed that the reagent is an effective viscosity regulator and does not degrade filtration properties. The new reagent improves the quality of drilling mud, shows itself as an intensive liquefier, leading to the stabilization of its parameters, as well as the regulation of static and dynamic shear stresses. The reagent has high inhibiting properties, prevents clay swelling, increases well wall stability, and due to the lubricating component reduces friction between well walls and drill strings.

The concentration of lignosulfonate reagent in the drilling fluid causes low viscosity even at high concentrations of solid phase. This is due to the fact that this reagent has a significant lubricating effect in contact with clay materials, the ability to form strong, elastic adsorption films with high shielding properties in relation to electrical charges. Therefore, even with a high concentration of solid materials in the drilling mud, particle aggregation does not occur.

Addition of pitchy carbolignosulfonate almost does not affect the density of drilling mud and at introduction up to 10 % viscosity and at the same time water yield of drilling mud are reduced, and the thickness of filtration crust is reduced from 1.5 mm to 0.5 mm.

Chemical treatment of drilling mud on the Burbaital slab with 5% pitchy carbolignosulfonate reagent confirmed the liquefaction ability in a less pronounced form, which is explained by high mineralization of drilling mud. Thus, on the basis of the conducted experimental and field studies it is possible to note good compatibility of pitchy carbolignosulfonate with other reagents, and at the same time pitchy carbolignosulfonate reagent along with liquefying ability has the properties of a water-release regulator of drilling muds.[4]

An increase in the concentration of the reagent from 5% to 10%, with a constant content of the solid phase of the solution, leads to stabilization of rheological and filtration parameters of muds.

The ability to regulate the properties of drilling fluids containing Rhodopol-23P with pitchy carbolignosulfonate when they are used together was considered. It is found that by combining reagents with different active groups, it is possible to enhance the action of the necessary properties of the solution, which is a decisive factor in the process of stabilizing the parameters of drilling muds. Tests have shown that the use of combined treatment can

[4] Умралиев, Б.Т., Исламов, Х.М., Рахметов, Р.Н. Влияние конденсированного лигносульфатного полимера на технологические параметры бурового раствора. // Нефть и газ, - 2007, - №2, - с. 56-57.

significantly reduce the consumption of the main stabilizer and improve the performance of solutions. This leads to improvement of technological properties of drilling mud and at the same time technical and economic indicators of the whole cycle of well drilling are increased.

Implementation of these formulations also ensured accident-free wells in conditions of drilling easily crumbling rocks in the exploration areas of the south-east of the Caspian depression of Kazakhstan. At the same time, the parameters of the drilling mud were regulated and maintained by systematic treatment of the drilling mud through the use of a combined reagent that had a minimal negative impact on the environment with a significant reduction in the number of complications and accidents.

Using Rhodopol-23P reagent, new drilling mud formulations were developed and implemented for wells No. 256, 1215 and 2029 of Vostochny Moldabek formation (Figure 2).

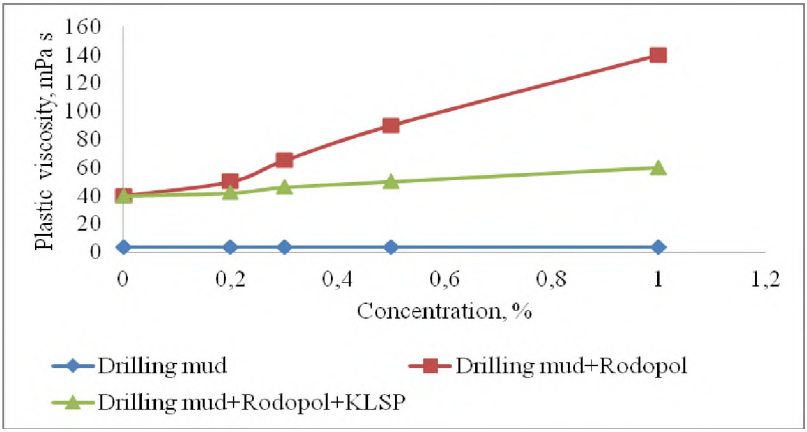

Figure 2. The change in the plastic viscosity of the drilling mud from the concentration of reagents

The first mud formulation consisted of 20 % bentonite clay, 0.2 % caustic soda, 0.25 % Rodopol-23P, 6 % KCl, 2.5 % evaporated

sulphite waste liquor - 2M, 3 % reagent - defoamer T-80 (94) and technical water.

The proposed compositions of drilling muds with a low solid phase content were aqueous solutions of high molecular weight polymers with bentonite additives. The polymer content in the drilling mud was 0.2 - 0.5%, and the bentonite fraction was 2.0 - 5.0%.

In Chapter 3, the experiment planning method was applied to select the optimum concentration of xanthan gum for the purpose of drilling mud treatment. Wilson method was also used to select the optimal concentration of the combined reagent consisting of lignosulfonate polymer and xanthan gum, which allows the regulation of structural-mechanical and colloid-chemical parameters of drilling fluids in complicated drilling conditions.

It has been established that the optimal concentration of polymer, which allows maximum reduction of water yield index of low-ligneous drilling muds, is 0.3-05%, and the viscosity reducing agent is 5-10%.

Chapter 4 presents the results of industrial tests of combined reagents Rodopol - 23P and pitchy carbolignosulfonate on wells Nos. 210, 236, 256 of East Moldabek section of Kenbai field, lithologic section of which consisted of plastic clays. The tests were carried out in the drilling range of 0 to 450 m. While drilling with polymer-based drilling mud, the mud was enriched with highly colloidal clay fraction, leading to a sharp increase in its conditional viscosity and other rheological parameters. The combined use of pitchy carbolignosulfonate and Rhodopol-23P reagents with 0.25% concentration showed the following results:

- viscosity and SNA of the solution were reduced, respectively from 60 sec. to 45 sec. and SNA_{1-10} from 40/58 dPa to 5/10 dPa;
- the filtration rate decreased from 8.0 cm^3/30 min to 6.0 cm^3/30 min.

Rodopol-23P and pitchy carbolignosulfonate reagents were successfully tested at square No. 605 in the drilling range of 300-1300 m at the Vostochny Moldabek site for drilling an inclined directional well with a horizontal end of the trunk along the

productive Triassic horizon. As the surveillance showed, from under the conductor during drilling of the cement cup, due to the ingress of calcium cations into the drilling mud, there was a sharp thickening of the mud, which led to an increase in viscosity. Since the treatment of the mud with ferro-chromelignosulfonate did not give positive results, it was decided to use a combination of reagents Rhodopol-23P and pitchy carbolignosulfonate. In this case, the reagent was introduced directly into the chute of the circulation system, resulting in liquefaction of the solution and regulation of its technological parameters.

The most important results were obtained when testing the complex action reagent Rodopol-23P and pitchy carbolignosulfonate at the Kazhigali-4 well in the range of 0 to 350 m. Drilling was accompanied by long-term intensive work in the high-colloidal clay phase. To regulate drilling mud in intervals of unstable rocks, a mixture of Rhodopol-23P and pitchy carbolignosulfonate reagents was introduced.

The use of these reagents contributed to a significant improvement of technical and economic indicators of drilling by reducing the total consumption of chemical components, increasing the mechanical rate of penetration per bit. The cost of drilling mud, with a low content of solid phase and clay-free, used to drill a well with a depth of 350-1300 m with a volume of 121.3 m^3 was, respectively, $9867.76 and $9646.9. The cost of drilling mud treated with Rodopol-23P and pitchy carbolignosulfonate reagents is $2,258.6. Thus, the economic efficiency of using solutions treated with complex reagents has increased fourfold while maintaining their basic process parameters. The economic efficiency of drilling one well amounted to4.4 thousand $/$m^3$ (Table 2). The issues related to the environmental safety of the use of chemical reagents for the treatment of drilling muds are also considered. It is noted that the increase in the volume of drilling operations has led to an intensive negative impact on the environment, which has led to the need for rapid development of new types of low-hazard and less toxic chemical reagents for the treatment of drilling muds. A comprehensive solution to the problem of ensuring compliance of drilling fluids with modern requirements,

a significant increase in technical and economic performance, along with reducing the negative impact on the environment and subsoil, can only be achieved by using new effective polymer reagents that will allow to regulate the rheological and filtration properties of drilling fluids in conditions of high temperatures and mineralization, as well as to reduce dispersion and hydration of clayey rocks in the drilling process.

Table 2

Comparison of drilling performance before and after the introduction of the chemical reagent Rodopol-23P on the East Moldabek site

№№ well.	h, m	t, hour	V_{mex}, m/ hour	t, hour	V_{mex}, m/ hour
		Before		After	
236	160-450	82,2	3,53	66,4	4,37
256	160-450	89,6	3,24	66	4,39
2029	160-450	93,5	3,10	77	3,77
458	160-550	123	3,17	95	4,11
459	160-550	119	3,27	84	4,64
434	160-550	105	3,71	93	4,19
605	160-650	98,5	4,97	112,5	4,36
Total:		101,5	3,57	84,8	4,26

High quality of wellbore cleaning, increase of wall stability and preservation of its nominal diameter in the interval of clayey rocks, use of Duovis polymer reagent together with other polymers allowed to successfully drill wells in Western Kazakhstan to the design depth with minimal complications. Other polymer reagents such as Foralis, Rhodopol-23P, and Polysal should be used to improve the properties of the clay crust of the trunk and regulate water loss.

The use of natural polymers such as KMC-ASM/60 and starch reagents in the form of modified forms is more useful in the

environmental aspect: they all belong to hazard class IV, they are actively decomposed by enzymes to form non-toxic compounds.

Development of environmentally safe technologies aimed at modification of natural polymers, carried out to obtain chemical reagents with specified properties, opens up additional opportunities for the preparation and use of drilling fluids with high technological characteristics with minimal impact on environmental components in the process of their use, utilization and disposal.

To stabilize the properties of mineralized drilling muds starch reagents belonging to natural polysaccharides are used. Addition of starch allows to effectively reduce filtration of mineralized drilling muds. Starch reagents are soluble in solutions of all salts, including calcium and magnesium chlorides. Along with this, some negative properties of starch make their use difficult. These include low thermostability of reagents, not exceeding 120^0C. At well temperatures above 120^0C drilling fluids treated with starch and saturated with sodium chloride do not lend themselves to stabilization: the introduction of starch into weighted mineralized drilling fluids causes an increase in static shear stress and viscosity of these fluids. Starches are susceptible to enzymatic degradation. In case of starch decomposition under the action of bacteria in the process of drilling, the drilling fluid parameters significantly deteriorate. This circumstance causes the necessity of application of special methods of starch protection in drilling muds, consisting in increasing pH of muds up to 11.5-12.0, in maintaining mineralization at the level exceeding 20%, introducing anti-fermenters into drilling muds. All these methods of protecting starch in drilling mud require additional costs for processing solutions and are not always reliable. In some types of seeds and corns, the starch content exceeds 70%. The development and implementation of the production of starch reagents with improved technological properties will solve the problem of recycling plant waste from agriculture.[5] The process of

[5] Кязимов, Э.А., Исламов, Х.М. Экологическая безопасность применения химических реагентов для обработки буровых растворов. // Научно-

obtaining a starch-containing reagent to stabilize the parameters of the drilling mud is based on the technology of carboxylation of natural polysaccharides. In particular, Polysalum is a modified polysaccharide (starch) containing bactericidal additives, a moderate low–hazard substance of Class IV. Its use makes it possible to store and use the solution for a long time.

The starch derivative from wheat – Foralis 380P is non-toxic, has better resistance to calcium salts in alkaline conditions.

The analysis of environmental indicators of drilling mud components used in drilling wells in Kazakhstan has shown that they have toxicological characteristics that are authorized for their use in the exploration and oil and gas production industry. The use of a number of reagents, tested for the possibility of providing well drilling in difficult mining and geological conditions of the Caspian Sea, allowed to reduce the toxicity of solutions.

One of the urgent problems of environmental protection technologies in drilling is maximum utilization of generated spent drilling muds and cuttings. Domestic and foreign experience shows that utilization and recycling of wastes, effective use of secondary resources are not only radical means of preventing environmental pollution, but also at the same time a solution to the problem of rational environmental management. At the same time, the remnants remaining after drilling waste must be neutralized and safely buried. In addition, when disposing of waste, it is necessary to strive for the maximum possible completeness of their use in accepted areas of disposal. Thus, the main requirements to environmental protection technologies are full compliance with environmental standards of drilling operations and maximum utilization of production and technological drilling wastes.

At the current stage of oil production increase, the oil fields of the Caspian Sea of Kazakhstan generate large volumes of wastes, predominantly accumulated in sludge pits. In accordance with the

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технический журнал «Строительство нефтяных и газовых скважин». - 2015, - №4. - с. 44-47.

regulations of oil production enterprises, one pit is built to collect drilling waste from one well pad when eight wells are drilled. If the number of wells in a pad is more than ten, several pits are built. In the process of operation the pits are filled with:

- drilling and grouting solutions, drilling wastewater and sludge;
- well testing products;
- materials for filling and chemical treatment of drilling and grouting solutions.

The percentage ratio between these components can be very diverse depending on geological conditions, technical condition of equipment, production culture, etc.

For example, when drilling a 550 m deep well, the bunker contains about 65 % of water, 30 % of cuttings (drilled rock), 4.0 % of oil, 0.5 % of bentonite and 0.5 % of various additives that ensure optimal operation of the drilling rig.

In total, technological waste in the form of sludge, drilling wastewater and spent drilling muds is generated on the territory of the drilling area. The waste consists of a mixture of chemicals contained in the drilling fluid, as well as the drilled rock itself.

For example, the calculation of the volume of drilling waste and a slurry barn on the Ayrankol square, located in the South-Embinsk oil and gas region, is given.

CONCLUSIONS

1. Scientific and practical bases of development and application of biopolymer drilling muds with regulated filtration and rheological properties in conditions of well conduction in saline and clay deposits of the Caspian depression of Kazakhstan were improved.

2.The drilling mud treated with xanthan resin was found to have low osmotic hydration, high bearing capacity in highly mineralized medium and inert to the influence of aggressive salts.

3. It is recommended to use chloroalkaliye drilling muds when drilling unstable clay shales in the fields of the Caspian depression of Kazakhstan in order to ensure accident-free wells drilling to the design depth.

4. New formulations of drilling muds based on polymer condensed lignosulfonate reagent have been developed and their high diluting and lubricating properties have been revealed when drilling wells in unstable rocks.

5. The technological efficiency of combined reagents Rhodopol-23P and pitchy carbolignosulfonate, improvement of their parameters during drilling in the exploration areas of the Caspian depression is shown, which allows to increase the drilling speed, reduce the number of complications, reduce the consumption of materials and chemical reagents. It has been established that the optimal concentration of polymer, which allows maximum reduction of water yield index of low-ligneous drilling muds, is 0.3-05%, and the viscosity reducing agent is 5-10%.

6. Low-toxic polymer (Foralis, Polysal, Duovis) and starch reagents belonging to hazard class IV are recommended for the preparation and stabilization of low-clay and clay-free drilling fluids.

7. The proposed technologies have been successfully implemented in the areas of East Moldabek, Burbaytal, Kazhigali-4 and Tobearal of the Caspian Basin of Kazakhstan, characterized by complicated mining and geological conditions, from the introduction of which an economic effect of 4400 $/m^3$ was obtained.

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Personal contribution of the applicant

The works [1, 3, 4, 5, 6, 7, 9, 10, 11, 12, 14, 15, 16, 17, 19] were carried out independently, the works [2, 8, 13, 18, 20] - carrying out experimental studies, processing of the obtained results.

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