

New composition of chemicals and heavy drilling fluids for drilling oil and gas wells

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Abstract. The article shows the importance of obtaining new composition of heavy drilling fluids based on composite chemical reagents from local raw materials and industrial wastes for drilling oil and gas wells. In the process of building oil and gas wells to maintain the stability of the walls, to prevent the flow of salts, and to prevent the penetration of formation fluids into the well, it becomes necessary to increase the density of the drilling fluid, which can be accomplished by introducing components with increased density. For obtaining and stabilization heavy drilling fluid were investigated and recommended new compositions of powder water soluble gossypol resin and carboxymethylcellulose sodium and other minerals. Stabilization indexes and their determination in the drilling process of oil and gas wells have been investigated. The result of research have been implemented in the drilling process of oil and gas wells with abnormally high reservoir pressure.

1 Introduction

As the demand for energy increases, harsh and extreme environments are explored for hydrocarbon; and deeper wells have been drilled to reach targets in formations with very high temperatures and pressures [1]. The successful completion of an oil well depends to a considerable extent on the properties of the drilling fluid. Drilling fluids serve several fundamental functions: (i) to remove the cuttings generated by the drill bit from the borehole, (ii) to control the downhole formation pressures, to overcome the fluid pressure of the formation, (iv) to avoid damage to the producing formation and (v) to cool and lubricate the drill bit, etc [2-4].

The cost of the drilling fluid itself is relatively small in comparison to the overall cost of drilling a well, but the choice of the right fluid and maintenance of its properties while drilling profoundly influence the total well costs. In addition, the drilling fluid affects formation evaluation and the subsequent productivity of the well. The fluid also needs to be environmentally benign and generate minimal waste [5].

Present time for obtaining and stabilization of drilling fluids for drilling oil and gas

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wells use more than 3000 kind of chemicals in the world. Such as Carboxymethylcellulose, polyacrylamide, hydrolyzed polyacrylonitrile, ferrochrome-lignosulphonate, graphite, chrompick, NaOH, Na₂CO₃ and others. In the Republic of Uzbekistan for drilling oil and gas wells use about 3.5-4 thousand ton chemical reagents every year. Based on the analysis of basic research in the field of chemistry and biochemistry of carbohydrates, generalizing the practice of drilling wells, polysaccharides are used as polymer reagents for regulating the filtration and rheological properties of lighted and heavy drilling fluids. The main reason for the choice of polysaccharides is their ability to chemical and biological destruction, due to which is possible to destroy and remove the formed clogging layer during the drilling process, and almost complete recovery of reservoir properties [6].

Most of global drilling operations use water-based drilling fluids, because of their lower environmental impact and lower costs. However, water-based drilling fluids are limited by their abilities of dissolving salts and interfering with the flow of oil and gas through porous rocks. Oil-based drilling fluids, owing to their excellent lubricity, high rate of penetration, shale inhibition, wellbore stability, high lubricity, high thermal stability, are expected to be used to drill difficult wells [7].

In all cotton producing countries and factories proceeding cotton seeds gossypol resin is formed as a final product, which has a viscous-fluid consistency, and now find its effective implementation. The transformation of the viscous fluid gossypol resin into a powdered material by modification of the various ingredients of the organic and inorganic origin can bring to the commercial introduction of the products and to expand the field of efficient use in large-tonnage quantities [8].

A successful oil well drilling depends largely on a good mud Program. During drilling, mud provides sufficient hydrostatic pressure, removes drill cuttings and cools drill bits. Mud additives are always required to provide sufficient hydrostatic pressure to ensure borehole stability. Barium Sulphate (BaSO₄) also known as barite is the prevalent heavy material but there is need to develop local materials to augment the use of Barite. This study was aimed at assessing the suitability of galena, a lead sulfide (PbS), as an alternative heavy material in drilling fluids [9].

2 Methods and materials

The American Petroleum Institute (API) publishes documents relating to oilfield standards, including drilling fluids testing procedures [5]. As with any laboratory procedure requiring the use of potentially hazardous chemicals and equipment, the user is expected to have received proper training and knowledge in the use and disposal of these potentially hazardous materials. The user is responsible for compliance with all applicable local, regional, and national requirements for worker and local health, safety, and environmental liability [10].

For stabilization and obtaining heavy drilling fluids were used following materials: water-soluble modified powdered gossypol resins, carbonate-polymer sludge-waste of "Ferganazot" JSC, Na-carboxymethylcellulose "Carbonam" with 500 polymerization degree, soda ash and caustic soda. As a heavys were used - red clay, marble flour, dolomite, scale, hematite and barite.

The technology of obtaining for production of composite polymer reagents by using of low molecular weight sodium carboxymethylcellulose, alkali, and organic-mineral additives of various ratios to improve the physical and chemical properties of drilling fluids have been developed. Water-soluble modified powdery resin contains hydrophobic additives based on sodium salt of fatty acids and ionic surfactants. The use of these reagents for drilling fluids used in drilling oil and gas wells ensures the preservation of the regulated rheological and filtration properties of polymer systems at 80-190 ° C for 30-40 hours.

Method of obtaining new composite chemical reagents based on physical and chemical modification of initial materials on various ratios, environment and regime. All the physical, chemical and technological parameters of drilling fluids based on composite chemical reagents have been tested in accordance with API standards [11].

In the development of new composite chemical reagents for stabilization drilling fluids for drilling oil and gas wells we used mainly waste of oil and fat production-gossypol resin, as well as low mass carboxymethylcellulose. Gossypol resin consists of 52 to 64 of free fatty acids and their derivatives, and the rest-a product of condensation and polymerization of gossypol and its transformation, resulting from extraction of cottonseed oil, mainly in the process of distillation of fatty acids from soapstok. In the gossypol resin found 12% of the nitrogen containing compounds, 36% of the transformation products of gossypol fatty and oxide fatty acids. It is a homogenous fluid mass from dark brown to black colour [12].

Polymers are used heavily in the oil industry for controlling the drilling fluid properties or for enhanced oil recovery applications to extract the heavy oil. Polymer flooding is a very important technique to extract the heavy oil from thin and heterogeneous reservoirs [13]. Screening criteria and screening algorithms should be developed for enhanced oil recovery techniques [14]. Artificial intelligence and data mining can be used to manage the reservoir for polymer flooding, especially in case of thin and heterogeneous heavy oil reservoirs [15].

Drilling high-pressure/high-temperature (HPHT) oil and gas wells is challenging because it requires a special fluid formulation that can control the high pressure and withstand the elevated downhole temperatures [16]. Heavy materials are added to the drilling fluid to attain the high density required to equalize formation pressure and control the well during drilling operations.[17,18,19] There are many options for heavy materials that can be used with drilling fluids such as calcite, barite, hematite, manganese tetra oxide, ilmenite, and iron oxide.[20] These materials are different in density and other properties; therefore, the final density of drilling fluid varies accordingly.

Determination of physical and chemical properties of drilling fluids:

Determination of Mud Density. The weight of the mud samples was determined using the Baroid mud balance. The cup was filled completely with mud after calibration. The expelled mud was washed and the balanced arm was replaced on the base with the knife edge resting on the fulcrum.

Determination of Mud Viscosity. The mud viscosity of the samples was determined using Fann V-G meter. The Fann VG meter was filled to the 350 cc mark and placed on the movable work table. The table was adjusted until the mud surface was at the scribed line on the rotor sleeve. The motor was started with a high speed position (600 rpm) and the reading was taken from a steady indicator dial value. The reading was also obtained at the low speed of 300 rpm.

Determination of pH. The pH meter which consists of a glass electrode system, an electronic amplifier and a meter calibrated in pH units was used to test the pH of galena mud. The electrical connection with the mud was established through saturated KCl solution contained in a tube surrounding the calomel cell. The electrical potential generated in the glass - electrode system by the hydrogen ions in the drilling mud was amplified and operated the calibrated meter which indicated the pH.

Determination of stability and sedimentation indicators. Stability - the ability of a solution to its density over a period of time. The stability index S is a value determined by the difference in densities of the lower and upper parts of the drilling mud settled for a certain time. Sedimentation index S,%, is the value determined by the amount of the dispersed phase, separated from a certain volume of the drilling fluid as a result of gravitational separation of its components for a certain time. The sedimentation rate indirectly characterizes the stability of the drilling fluid.

3 Results and discussion

Developed new composition of chemical reagents and heavy drilling fluids for drilling in salt and chemical corrosive environments, as they are stable to cations of polyvalent salts (Mg^{++} , Ca^{++} , Na^+ , K^+). Composition of chemical reagent (CCR) is mainly about 60-65% gossypol resin and has a high lubricity due to the content in 35-40% of polymerized fatty acids, pigment, glycerin and other components. These chemical reagents as a surfactants serve to emulsify oil with water, increase drilling speed because of low coefficient of friction, play role as corrosion inhibitor.

Obtaining and modification of powder water soluble gossypol resin with mineral ingredients chemicals were investigated in the laboratory. Physical and chemical properties of heavy materials also were investigated. Results of analyses were given in the Table 1.

Table 1. Physical-chemical properties of heavy materials

Name of heavys	Physical chemical properties				
	Density, g/sm^3	Mohs hardness	Sieve residue, 0071, %	Humidity, %	pH
Clay	2.55-2.65	2-2.5	5	2	7.5
Marble flour	2.6-2.70	2.5-3.0	6	1.5	7-8
CPS	2.7-2.75	2.5-3.0	6	1.8	11-12
Dolomite	2.8-2.9	2.5-3.0	6.5	1.2	7-8
Barite (Uz)	3.85-4.1	3.0-3.5	10	1.9	7-7.5
Barite (Kz)	4.1-4.2	3.0-3.5	8	1.3	7
Barite (Ru)	4.15-4.25	3.0-3.5	7	1.1	7-8
Okalina	4.3-4.5	5-6	8	0.9	7-7.5
Hematite	4.4-4.6	5-7	9	0.8	7-7.5

As well as have been investigated physical and chemical properties drilling fluids based on composite chemical reagents and barite and hematite. Results of testing have been given on Fig. 1.

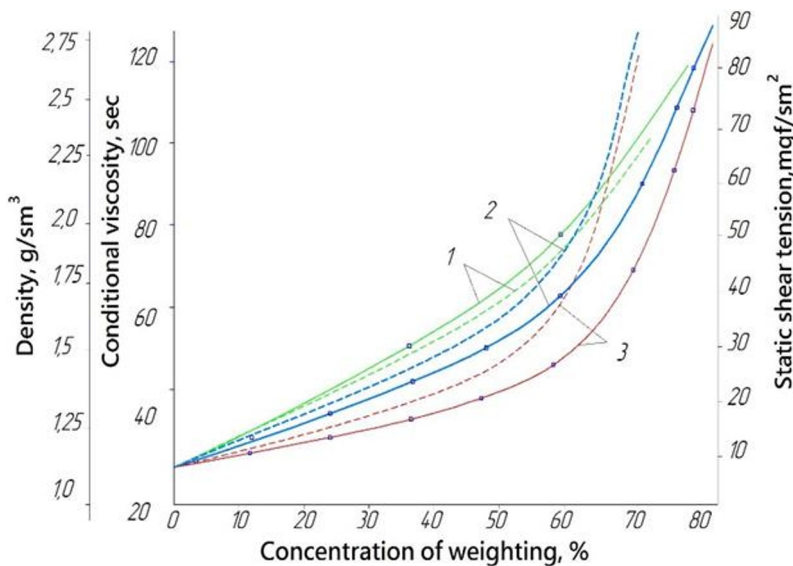


Fig. 1. Dependence of Density (1), viscosity (2) and Shear stress (3) of drilling fluids basis CCR with barite and hematite contents

Fig. 1 presents, that with a heavy of the drilling fluid of hematite up to 70-72%, the density of the solution increases to 2.4-2.50 g/cm³, and the shear stress is in the range 55-60 mgf/cm². The water loss values hardly change and amount to 5-6 cm³/30 min, the hydrogen index is 11. When adding barite heavy agents in an amount of 60-65%, the density of the solution is 2.1-2.2 g/cm³, while the nominal viscosity of the drilling fluid is 100-110 s and the Shear stress of the solution is 62-64 mgf/cm² for 10 min. The fluid loss of the solution is 5-6 cm³/30 min, the hydrogen index is 10-11.

Stabilization of drilling fluids characterizes the ability of a solution to hold particles in suspension. For ordinary solutions, its value should be no more than 0.02 g/cm³, and for heavy solutions – 0.06 g/cm³.

Fig. 2. shows the dependence of the stability of heavy drilling fluids on the concentration of composite chemical reagents (CCR) for various heavy agents.

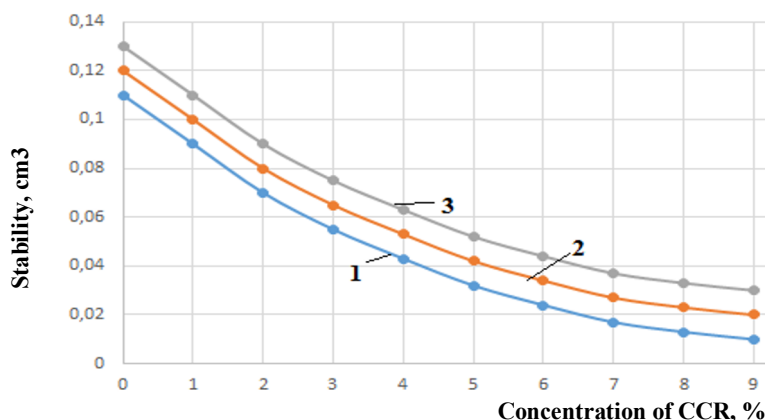


Fig. 2. Dependence of the stability of heavy drilling fluids on the concentration of the composite chemical reagent CCR. 1- Barite, 2- Okalin, 3- Hematite

Fig. 2 presents that composite chemical reagent has a positive effect on the stabilizing ability of heavy drilling fluids. With an increase in the concentration of the composite chemical reagent to 9%, the stability of hematite-heavy drilling fluids is reduced from 0,13 to 0,03 g/cm³, scale from 0,12 to 0.02 g/cm³ and barite from 0,011 to 0,01 g/cm³.

The Implementation of the research results shows that with an increase in the CCR concentration from 0.5 to 4%, the conditional viscosity of the T₅₀₀ increases from 40 to 82 s, the pH of the solution increases from 7 to 9, the water loss decreases from 14 to 3 cm³ in 30 minutes and the stability of the solution reaches up to 0,05 g/cm³. The speed of drilling have been increased by 10-15%. Obtained heavy drilling based on composite chemical reagents type CCR have following advantages compare with existent drilling reagents: -salt stable; -thermal stable;-long life time;-multifunction;-ecological safe

4 Conclusions

The research results of this work show that the composition of reagents and indicators of stabilization of drilling fluids play a decisive role for trouble-free drilling of oil and gas wells. Based on the results of the research, it was concluded that three factors mainly influence the stabilization performance of heavy drilling fluids:

- physical chemical properties of chemical reagents;
- type and dimension of heavy agents powder;
- geological conditions of the wells.

And also an effective composition of gossypol resin, minerals and carboxymethyl cellulose for stabilization and production of heavy drilling fluids was revealed. It can be seen that the obtained stable heavy drilling fluids based on composite chemical reagents have multifunctionality. Based on the results of these studies, composite chemical reagents based on local and raw materials, production waste, as well as heavy reagents have been developed, new compositions of heavy drilling fluids have been proposed, and they are also recommended for use in drilling oil and gas wells with abnormally high formation pressure (RPM) . And also, by implementing the results of the work, some environmental problems of fat-and-oil plants and metallurgical plants will be solved.

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