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# STUDY AND DEVELOPMENT OF WEIGHTED DRILLING FLUIDS BASED ON LOCAL RAW MATERIALS

**Abstract.** The article shows the importance of obtaining weighted drilling fluids based on 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 weighted drilling fluid were investigated and recommended new compositions of chemical reagents based on local and raw materials of Uzbekistan.

**Keywords:** chemical reagents, drilling fluids, stabilization, weighting agent, barite, viscosity, density, oil and gas well.

**Introduction**

At the present for processing of drilling fluids, environmentally friendly modifications of natural polymers have become widespread, opening up additional opportunities for the preparation and use of drilling fluids with high technological characteristics that have a minimal impact on environmental components during their use, disposal and safe disposal. For stabilization the properties of mineralized drilling fluids, starch reagents related to natural polysaccharides are used. Additions of starch reagents to the drilling fluid can effectively reduce the filtration rate of mineralized drilling fluids, while they have complete solubility in salt solutions used to prepare the drilling fluid. The construction of oil and gas wells is invariably associated with the occurrence of various complications, the final cost of drilling depends on the choice of a method for solving which. One of the common problems is catastrophic loss of drilling fluid.

Present time for obtaining and stabilization of drilling fluids for drilling oil and gas wells use more than 3000 kind of chemicals in the world. Such as Carboxymethylcellulose, polyacrylamide, hydrolyzed polyacrylonitrile, ferrochrome-lignosulphonate, grafite, chrompick, NaOH, $Na_2CO_3$ 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 weighted 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 [1–3].

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. The most important weighting additive in drilling fluids is barium sulfate ($BaSO_4$). Barite is a dense mineral comprising barium sulfate. The specific gravity of barite is at least 4.20 g/cm$^3$ to meet API specifications for producing mud densities from 9 to 19 lbm/gal. However, a variety of materials have been used as weighting agents for drilling fluids including siderite (3.08 g/cm$^3$), calcium carbonate (2.7–2.8 g/cm$^3$), hematite (5.05 g/cm$^3$), ilmetite (4.6 g/cm$^3$), and galena (7.5 g/cm$^3$).

**Methods and materials**

The American Petroleum Institute (API) publishes documents relating to oilfield standards, including drilling fluids testing procedures. 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.

For stabilization and obtaining weighted 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 weightings 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 [1–3].

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 color.

For obtaining weighted drilling fluids used Fluid-Loss-Control Additives. Clays, dispersants, and polymers such as starch are widely used as fluid-loss-control additives. Sodium montmorillonite (bentonite) is the primary fluid-loss-control additive in most waterbased drilling fluids. The colloidal-sized sodium-bentonite particles are very thin and sheetlike or platelike with a large surface area, and they form a compressible filter cake. Inhibitive mud systems inhibit the hydration of bentonite and greatly diminish its effectiveness. Therefore, bentonite should be prehydrated in fresh water before being added to these systems. The larger and thicker particles of sodium montmorillonite do not exhibit the same fluid-loss-control characteristics. 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 Screening criteria and screening algorithms should be developed for enhanced oil recovery techniques. 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 [3–5].

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. Weighting materials are added to the drilling fluid to attain the high density required to equalize formation pressure and control the well during drilling operations. There are many options for weighting materials that can be used with drilling fluids such as calcite, barite, hematite, manganese tetra oxide, ilmenite, and iron oxide. These materials are different in density and other properties; therefore, the final density of drilling fluid varies accordingly [5–7].

**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. [8–9].
- **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.
- **Determination of the stability index by the stability cylinder TS-2.**

Operating procedure:

– pour a thoroughly mixed sample of the solution into a cylinder with a volume of 720 $cm^3$ to the edge;

– set the filled cylinder in a quiet place and leave it alone for a day;

– after 24 hours, open the cork, drain the upper part of the sample solution along with the settled water;

– thoroughly mix the drained solution and determine its density, $\rho_1$;

– closing the tap with a stopper, thoroughly mix the lower half of the solution remaining in the cylinder and determine its density, $\rho_2$;

– the stability index is calculated by the difference in densities;

$$C = \rho_1 - \rho_2, \text{ g/cm}^3$$

- **Determination of sedimentation rate.** To determine the sedimentation index, a glass cylinder with a capacity of 100 $cm^3$ is used.

Operating procedure:

– a thoroughly mixed sample of the drilling fluid is poured into the cylinder up to 100 $cm^3$;

– put the cylinder with the solution in a calm place and leave it alone for 24 hours;

– after 24 hours, the reference position of the solution interface level is determined on a cylinder scale.

The sedimentation rate is calculated by the formula:

$$S = 100 - V, \text{ cm}^3.$$

where $S$ is an indicator of sedimentation,%;

$V$ is the position of the solution interface level, $cm^3$ [10].

**Results and discussion**

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

There are formed water in oil emulsions. The emulsified phase is the calcium chloride brine and the continuous phase is the oil. It is characterized by its low electrical stabilities and high fluid loss values. Oil systems require additional gelling agents for viscosity. These types of systems have many advantages. They are not very reactive. They are also stable at high temperature and pressure, high contamination resistance and not corrosive, but also they have some drawbacks: they are expensive and harmful for environment.

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

Table 1.– Physical-chemical properties of weighting materials

| Name of weightings | Physical chemical properties | | | | |
|---|---|---|---|---|---|
| | Density, kg/m³ | Mohs hardness | Sieve residue, 0071,% | Humidity,% | pH |
| Clay | 2550–2650 | 2–2.5 | 5 | 2 | 7.5 |
| Marble flour | 2600–2700 | 2.5–3.0 | 6 | 1.5 | 7–8 |
| CPS | 2700–2750 | 2.5–3.0 | 6 | 1.8 | 11–12 |
| Dolomite | 2800–2900 | 2.5–3.0 | 6,5 | 1.2 | 7–8 |
| Barite (Uz) | 3850–4100 | 3.0–3.5 | 10 | 1.9 | 7–7.5 |
| Barite (Kz) | 4100–4200 | 3.0–3.5 | 8 | 1.3 | 7 |
| Barite (Ru) | 4150–4250 | 3.0–3.5 | 7 | 1.1 | 7–8 |
| Okalina | 4800–4900 | 5–6 | 8 | 0.9 | 7–7.5 |
| Hematite | 5100–5300 | 5–7 | 9 | 0.8 | 7–7.5 |

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

Figure 1 presents, that with a weighting of the drilling fluid of hematite up to 70–72%, the density of the solution increases to 2.4–2.50 $g/cm^3$, and the shear stress is in the range 55–60 $mgf/cm^2$.

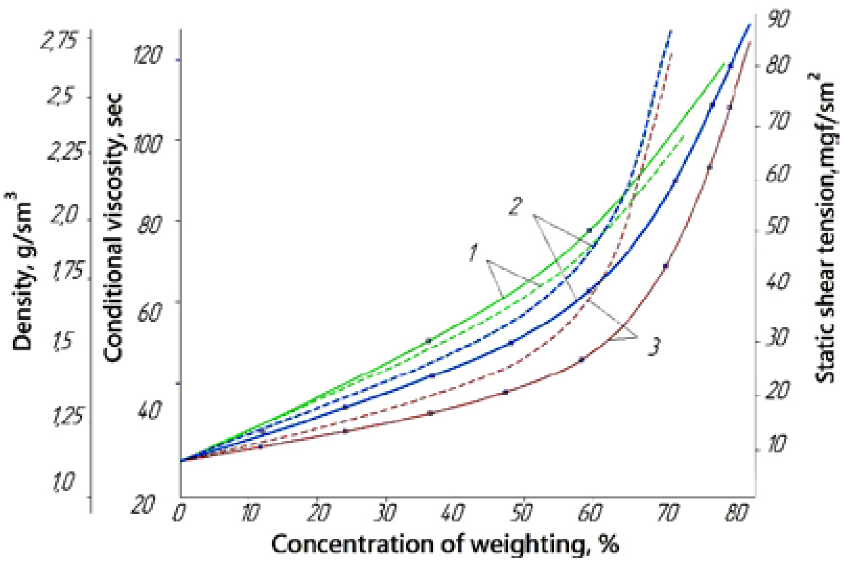


Figure 1. Dependence of Density (1), viscosity (2) and Shear stress (3) of drilling fluids basis MBR with barite and hematite contents

The water loss values hardly change and amount to 5–6 $cm^3$/30 min, the hydrogen index is 11. When adding barite weighting agents in an amount of 60––65%, the density of the solution is 2.1–2.2 g/$cm^3$, while the nominal viscosity of the drilling fluid is 100–110 s and the Shear stress of the solution is 62––64 mgf/$cm^2$ for 10 min. The fluid loss of the solution is 5–6 $cm^3$/30 min, the hydrogen index is 10–11.

The Implementation of the research results shows that with an increase in the MBR concentration from 0.5 to 4%, the conditional viscosity of the $T_{500}$ increases from 40 to 82 s, the pH of the solution increases from 7 to 9, the water loss decreases from 14 to 3 $cm^3$ in 30 minutes and the stability of the solution reaches up to 0.05 g/$cm^3$. The speed of drilling have been increased by 10–15%.

Obtained weighted drilling based on composite chemical reagents type MBR have following advantages compare with existent drilling reagents:

– salt stable;
– thermal stable;
– long life time;
– multifunction;
– ecological safe

**Conclusion.** Research results of this work show that stabilization indexes of drilling fluids play main role for drilling oil and gas wells without any accident. According to the doing this research have been concluded that mainly three factors impact to stabilization indexes of weighted drilling fluids:

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

As well as have been found out effective composition of gossypol resin, minerals and carboxymethylcellulose for stabilization and obtaining weighted drilling fluids. It can be seen that obtained stable weighted drilling fluids based on composite chemical reagents have a multifunction. On the basis of this research result developed composite chemical reagents based on local and raw materials, production wastes as well as weighting agents have been proposed new compositions of weighted drilling fluids, as well as recommended for use in drilling of oil and gas wells with abnormally high reservoir pressure (AHRP). As well as by implementation of the results of the work will be solved some ecological problems of oil fat factories and metallurgical plants.

**Conflicts of interest**

The authors declare, that there is no conflict of interest regarding the publication of this article.

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