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# A POLYMER-CONTAINING REAGENT FOR REDUCING DRILLING FLUID LOSS DURING OIL AND GAS WELL DRILLINGS

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A B S T R A C T

In this article, the authors propose a composition for a polymer-containing drilling fluid and ways to reduce its loss during drilling of oil and gas wells. Theoretical aspects of drilling fluid loss are presented, including the characteristics and causes of fluid absorption by the rock. The main problems of drilling fluid loss associated with the instability of clay-argillite rocks of the South Torgay basin in Kazakhstan are described. The polymer-containing drilling fluid was obtained by adding polyacrylonitrile modified with fatty acid salts, which are a saponified fraction of the tar from the distillation of cottonseed oil fatty acids. The results of spectral studies of the modified polymer reagent polyacrylonitrile are provided. The authors present the results of studies on the effects of modified polyacrylonitrile, as well as crushed cotton stalks in various ratios on the properties of drilling fluid. These studies were conducted to reduce the rate of fluid loss through the borehole crust. Based on these conducted studies,on the effect of modified polyacrylonitrile and crushed cotton stalks on the rheological properties of the drilling fluid. A diagram of an experimental setup for determining the rate of drilling fluid passage through rock is presented, as well as when adding tar-modified polyacrylonitrile to the fluid. Existing methods for reducing drilling fluid loss are analyzed, and recommendations for implementation of this composition are proposed to increase the efficiency of the drilling process in complicated geological conditions.

**Keywords:** drilling; well; rock; loss (absorption); oil; gas; drilling fluid; tar; polyacrylonitrile; modification; spectroscopy.

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## 1. Introduction

The use of water-soluble polymer-based drilling fluids is widely practiced in well drilling within the South Torgay oil and gas region (OGR), which is a sedimentary basin located in southern Kazakhstan. This region is the youngest OGR discovered in Kazakhstan, at the end of the last century. Half of the fields identified here have already been explored in the current century. This oil and gas basin is a rift-like depression formed to the east of the Karatau Mountains, between the Ulytau and Lower Syr Darya arches, characterized by a distinct two-tier structure [1-3].

It should be noted that the oil and gas fields of this basin are in the final stages of production. The well products extracted from these fields are emulsified, paraffinic, with significant amounts of formation water.

Therefore, in the future, it is advisable to conduct exploration appraisal and production well drilling in this oil and gas basin to identify new oil-bearing formations. These activities will require new drilling, development, and well operation technologies. Drilling wells to the specified depth is impossible without drilling fluids, that possess the necessary performance requirements, including those for reducing fluid loss.

In the practice of drilling oil and gas wells, drilling fluids that, have a high water-holding capacity, due to polymer additives which helps reduce the degree of complications associated with fluid loss during its circulation, have become widely used. In the geological sections of oil and gas fields located in the southern fields of Kazakhstan, the most common complications are losses of wellbore stability, which manifest as absorption (loss), caving, collapses of clay rocks, etc. [4-6].

Absorption of drilling fluids and other liquids in absorbing formations is ensured by the presence of pores, channels, cracks, voids in the rocks penetrated by the well and (or) insufficient stability (resistance) of the rocks to the pressure of the fluid column in the well, resulting in hydraulic fracturing of the rocks, and penetration of circulating fluid into the cracks.

Thus, the foregoing shows that oil and gas drilling takes place in challenging geological and climatic conditions.

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Specifically, the South Torgai OGR is predominantly flat, largely occupied by hummocky sandy massifs: Kyzylkum Desert, Aral Karakum Desert, and the Aryskum Desert.

To improve the efficiency of drilling operations, specially formulated drilling fluids are needed to reduce the rate of fluid absorption below critical values. For this purpose, polymers are added to drilling fluids. Their main function during well drilling is to seal the borehole walls, remove rock, reduce bit wear, and decrease the rate of drill pipe corrosion. regulation of viscosity and density of the fluid.

The works [7-10] demonstrate that a significant improvement in the technical and economic performance of drilling is achieved by using clay-free and low-clay fluids. To regulate the properties of low-clay fluids, clay powders of various grades are used, typically 5-10 %, with the addition of resins and polymers [11-13].

In the practice of well drilling, polyacrylonitrile is used as a stabilizer and an effective filtration reducer for clay drilling fluids. It should be noted that polyacrylonitrile performs filtration in clay drilling fluids, and conversely, as a filtration reducer in fluids without a solid phase. However, as a water-phase thickener, it can be successfully used in clay-free systems, including mineralized aqueous solutions.

Effective measures to combat the problem of drilling fluid loss include its prevention. Solutions with high rheological and mechanical properties flow less intensively into the formation. In this case, the differential pressure in the "wellbore-formation" system is of decisive importance. Drilling fluid loss into the formation can be prevented by the following measures: 1) Reducing the differential pressure; 2) Improving the rheological properties of the solution; 3) Reducing the consumption of drilling fluid during circulation; 4) Using lightweight solutions, gaseous agents, and aerated liquid; 5) Using fillers; 6) Intermediate flushing.

Catastrophic fluids losses into the formation are eliminated by sealing the pore channels (cracks) with special substances. These can be cementing slurry or a mixture of cement and other materials (bentonite, gypsum, alabaster, asbestos, sawdust, etc.). The problems regarding of drilling fluid loss and measures to reduce it during oil and gas well drilling are discussed in [14-18].

For twenty years, the Department of Oil and Gas Engineering at M. Auezov South Kazakhstan Research University has been conducting research into developing new drilling fluid compositions for use in drilling oil and gas wells. New drilling fluid compositions have been developed using local raw materials (clay powders, by-products of the oil and fat industry) and various polymer additives [19-21].

Optimal compositions and technology for obtaining multifunctional composite chemical reagents for obtaining lightweight drilling fluids, intended for drilling oil and gas wells.

The aim of this work is to obtain a lightweight polymer-containing drilling fluid that reduces the volume of absorption during the drilling of oil and gas wells are proposed in [22-25].

## Materials and methods

The initial cotton tar used for modification and similar products has a saponification value of 80–130 mg KOH. Saponified tar, at a temperature of 120–130 °C, contains 45–50 % fatty acid salts, 8–10 % glycerides, condensation products, polymerization products, gossypol, and its derivatives.

Modification of polyacrylonitrile grade (PAN) AK-636 was carried out as follows. Polyacrylonitrile (6-8 %) and tar were added to an aqueous solution containing clay powder (4-6 %). Saponification of the tar containing polyacrylonitrile was carried out with a 20% sodium hydroxide solution at a temperature of 120-130 °C. After saponification process, the calculated amount of crushed cotton stem mass (CCM) and carboxymethyl cellulose (CMC) were added to the solution, and the properties of the finished drilling fluid were determined. As the solution circulated and entered the rock, the modified polyacrylonitrile (MPAN) swelled, reducing the speed at which it passed through the rock and thereby reducing the volume of solution absorbed.

As the drilling fluid circulates, the concentration of crushed cotton stalks will decrease due to partial settling in the borehole crust. Therefore, during drilling fluid circulation, it is necessary to adjust it by periodically adding crushed cotton stalks to bring it back to the original concentration. The modified polyacrylonitrile and bentonite clay solution is adjusted in the same manner .

The losses (absorption) of drilling fluid were determined by the formula:

$$Q = V \cdot S$$

where:

$Q$ is the volumetric flow rate; $V$ – the flow velocity; $S$ – the cross-sectional area of the flow through the rock.

Based on the volume of drilling fluid loss $Q$, we determine the absorption rate (passage) of the solution through the rock:

$$V = \frac{4 \cdot Q}{\pi \cdot D^2}$$

where:

$V$ is the solution flow rate, m/s; $D$ – the solution volume flow rate, $m^3$/sec; $D^2$ – the internal diameter of the pipe, m.

Thus, in the present study, a relationship was established between the permeability of the medium and the required concentration of the modified polymer in the drilling fluid composition, ensuring the maximum value of the residual resistance factor. A porous medium with a permeability that allows the prepared drilling fluid composition to pass through this porous medium was considered .

The resistance factor ($R_{res}$) proposed in [21, 26, 27] was adopted as a parameter characterizing the change in the permeability of the porous medium when it was treated with the drilling mud prepared by us. The residual resistance factor is defined as a value representing the ratio of the permeabilities of the porous medium to water before and after its treatment with the drilling fluid:

$$R_{res} = \frac{K_w}{K_p}$$

Where $K_w$ and $K_p$ are, respectively, the permeability of the porous medium to water before and after treatment of the porous medium with drilling fluid.

The permeability of rocks in water after the addition of polymers decreases sharply, and the degree of permeability reduction depends on the polymer concentration (polymer viscosity) and the initial permeability of the rock (core). Based on the available data, we conducted studies with drilling fluids, which showed that [28, 29].

That the decrease in rock permeability occurs primarily due to the adsorption of the polymer on the solid surface and the formation of the multimolecular polymer layer with high mechanical properties within the pores.

IR spectra of the solution samples and its individual components were recorded on a Shimadzu IR Prestige -21 Fourier transform IR spectrometer in the wavenumber range of 4000-5000 $cm^{-1}$ using a Miracle Attenuated Total Reflectance (ATR) accessory from Pike Technologies. The solution suspension was placed between the glass cuvettes as a thin layer (~0.035 ÷ 0.038 mm) and the spectra were recorded in the specified range. IR spectroscopy of the resulting solution mixture was carried out according to the method described in [24, 25].

## Results and discussion

The results of spectral studies of tar were preliminarily analyzed.

Figure 1 shows the IR spectra of the initial mixture of cotton tar obtained during the refining of Shymkentmay JSC (Republic of Kazakhstan, Turkestan Region). Absorption bands with peaks at 2850–2953 $cm^{-1}$ are observed, which can be attributed to both the stretching (ν) vibrations of the C–H bond in the $CH_{3-}$ (2920 $cm^{-1}$) and $–CH_{2-}$ (2850 $cm^{-1}$) groups , and to both the final and initial compounds.

For comparative analysis, IR spectra of the base polyacrylonitrile were also recorded and are shown in figure 2. The IR spectrum of polyacrylonitrile shows characteristic absorption bands corresponding to the stretching vibrations of bonds in its molecule: a peak at 2243 $cm^{-1}$ for the C≡N bond (nitrile group). The peak in the region of 2920-2935 $cm^{-1}$ should be attributed to CH bonds (in the saturated methylene group), and the bands in the region of 1454-1548 $cm^{-1}$ and 1076-107 $cm^{-1}$ are attributed to vibrations of CC, CH, and $CH_2$-CHCN bonds.

Based on the above obtained data, we modified polyacrylonitrile in a high-pressure TGYF-C reactor made of stainless steel, at a temperature of 185-200 °C and a pressure of 0.4-1.0 MPa with cotton tar in order to obtain a modified polymer reagent, which was subsequently used as an additive for drilling mud (fig. 3).

The results of IR spectroscopic studies of the modified polymer reagent show that the absorption bands with peaks of intensity at 3348 $cm^{-1}$ can apparently be attributed to the stretching (ν) vibrations of the O–H bond in groups that are characteristic of modified polyacrylonitrile.

Less intense bands at 1645 $cm^{-1}$ can be attributed to the stretching vibrations of the carbonyl groups of the naphthalene core of gossypol molecules and some of its derivatives, which are formed during the oxidation of aldehyde and hydroxyl groups under the conditions of tar production. Bands at 1548 $cm^{-1}$ should be attributed to the stretching vibrations of the aromatic rings of gossypol and some resins contained in the original tar. Absorption bands with peaks at 1384 $cm^{-1}$ should be attributed to stretching (◎sym) vibrations, which appear in the spectra of fatty acid functional groups. A strong peak in the region of 665 $cm^{-1}$ can be attributed to out-of-plane C-H deformation vibrations.

The IR spectra of the finished drilling mud (fig. 4) show that they contain broad absorption bands (bentonite) associated with vibrations of the Si-O and Al-O bonds, as well as bands in the region of 1633 $cm^{-1}$ and 3334 $cm^{-1}$ (hydroxyl groups) and characteristic peaks in the region of 559 $cm^{-1}$. Absorption bands with peaks at 1384 cm -1 can be attributed to carbonate ions ($CO_3^{2-}$). The absorption bands characteristic of acetonitrile below 2100 $cm^{-1}$, which were observed in figure 2 for the original aqueous solution of polyacrylonitrile, are very weak, indicating a decrease in the number of -C≡N groups in the finished drilling mud.

These results indicate a change in the structure of the obtained modified polymer reagent and a decrease in its

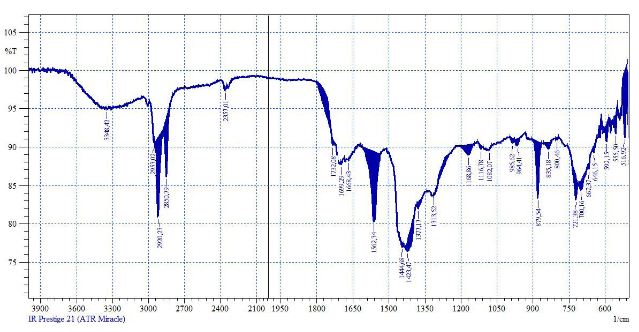



**Fig. 1. IR spectroscopy of cotton tar**

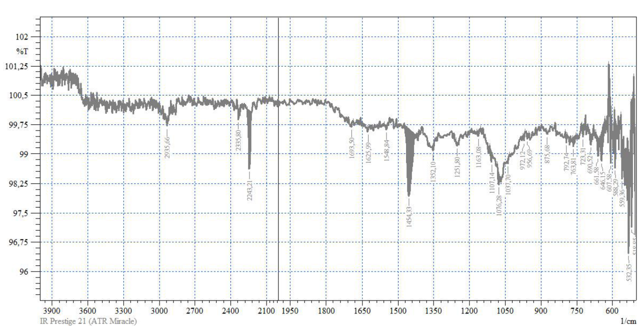



**Fig. 2. IR spectra of the initial aqueous solution of polyacrylonitrile**

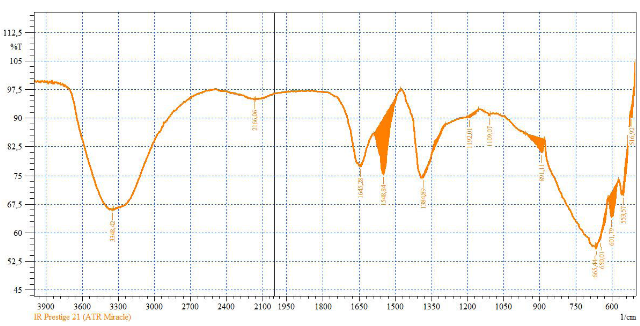



**Fig. 3. IR spectrum of the modified polymer reagent**

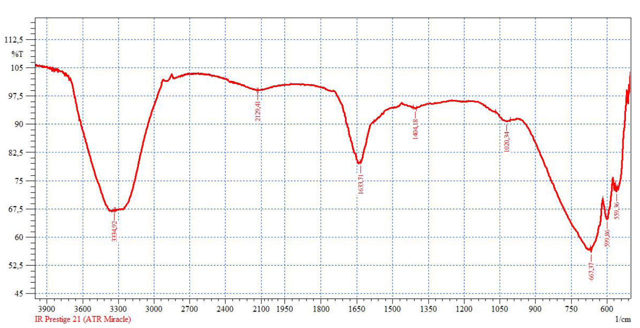



**Fig. 4. IR spectrum of the finished drilling fluid**

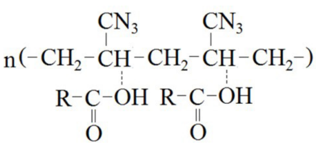
toxicity level, which can be used as an additive to drilling fluid in order to reduce its volume and losses during drilling of oil and gas wells.

The microstructure of cotton tar was studied using an SVBONYSV 189 optical microscope at a magnification of 4 × 100 (fig. 5).

A micrograph of cotton tar an amorphous, dark-brown organic matrix with pronounced porosity and inclusions of various types is observed. The pores are predominantly round or oval in shape and randomly distributed. Some areas exhibit remnants of the fibrous structure characteristic of the original cotton raw material. Light-colored mineral inclusions and areas of microcracks are visible in the light field. The main background is formed by an amorphous, dark-colored organic matrix characteristic of resinous hydrocarbon substances. In the structure numerous micropores, with diameter from 1 to 10 micrometers, are clearly visible in the structure, and predominantly round or irregular in shape.

Micrographs of a fatty acid–polyacrylonitrile composition with polyacrylonitrile (PAN), taken at room temperature, show a two-phase structure (fig. 6). The fatty acids form crystalline inclusions of various shapes, primarily needle- and plate-shaped crystals ranging in size from 5 to 30 micrometers. Polyacrylonitrile is represented by an amorphous or powdery matrix with a rough surface. The phases are clearly separated, microcracks and gaps are visible at the boundaries, indicating weak interfacial adhesion. Under polarized light, the fatty acid crystals exhibit anisotropic optical effects, while PAN remains amorphous.

Regarding the properties of polyacrylonitrile, it should be noted that the polymer itself does not react with acid tar at temperatures of 100-120 °C. However, alkali is added under these conditions, sodium salts or alkaline hydrolysis products of polyacrylonitrile are formed. The unsaponified tar fraction, consisting of resinous compounds was separated M because these compounds impair drilling fluid circulation. The authors suggest that under these conditions, saponification of nitrile groups by alkalis results in the formation of carboxyl groups, and resistance to weak alkalis results in the formation of imide cycles. Infrared spectroscopy results indicate the likelihood of hydrogen bonding between the alkaline hydrolysis products of polyacrylonitrile and free fatty acids. Apparently, hydrogen bonding in the polymer occurs between the hydrogen atoms of the polymer chain and the oxygen atoms of the carboxyl group of the free fatty acids:



However, it should be emphasized that these data are the authors' assumptions, based on infrared spectroscopy of the starting compounds and the resulting reagent. Furthermore, the saponified fraction of the tar also contains water-soluble salts of gossypol derivatives, which also contribute to the formation of similar complexes that reduce overall drilling fluid filtration.

Mandatory component in the composition of the drilling fluid is the presence of crushed cotton stalks to give the lightweight polymer-containing clay solution additional properties to reduce its losses during well drilling.

Microscopic studies allowed for identification of the following structural features of the fluid sample. The microscopic structure of the finished drilling fluid with the addition of crushed cotton stalks is shown in figure 7. The heterogeneous structure of the drilling fluid includes solid particles dispersed in the liquid phase of the solution. The particles have different shapes and sizes, indicating a complex composition and the presence of modifying additives. A polymer structure with small particles and shapeless inclusions is also visible. Overall, the crushed cotton stalk particles contained in the drilling fluid contribute to the partial plugging of porous rock and thereby reduce the volume of drilling fluid absorption. A uniform distribution of particles is noted, which ensures the stability and homogeneity of the drilling fluid. The surface of the particles can be rough or porous, which improves their adhesion and interaction with the rest of the phase. Signs of structuring are also observed, for example, aggregation or the formation of network structures that contribute to the improvement of the rheological properties of the solution.

The ready – to-use drilling fluid is shown in figure 8. It should be noted that the saponified fraction (salts of fatty acids and gossypolates) together with polyacrylonitrile provide stability and impart additional anti-corrosion and lubricating properties to the drilling fluid, as well as reducing the rate of its absorption (loss) during drilling of rock.

The modification of the solution was aimed at improving its filtration characteristics, reducing the volume of water loss, increasing heat resistance and resistance to high pressures, which is reflected in changes in the morphology and distribution of components at the microscopic level.

Micrographs of bentonite-treated cotton stalks reveal significant changes in the surface morphology (fig. 9). The stalk surface becomes rougher and more porous compared to untreated material, indicating the adsorption and distribution of bentonite particles on the plant matrix (a). Microscopic bentonite particles are visible uniformly covering the stalk surface, which facilitates interaction between the organic and inorganic phases.

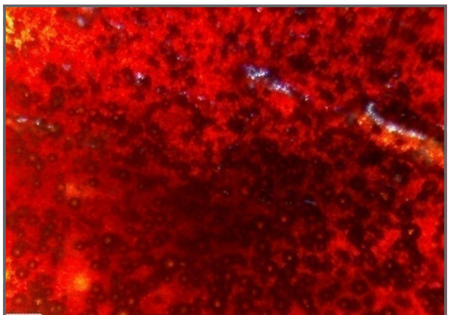


**Fig. 5. Micrographs of cotton tar**

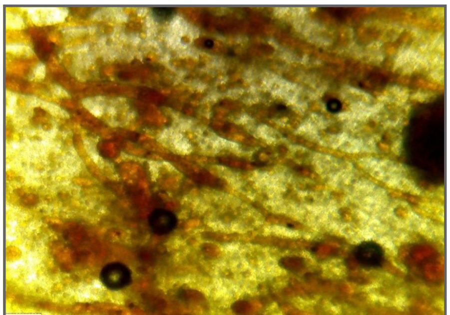


**Fig. 6. Micrographs of modified polyacrylonitrile**

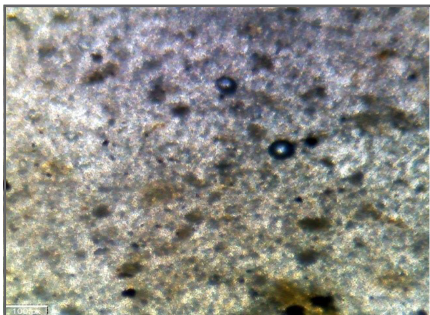


**Fig. 7. Micrograph of modified drilling fluid**


Fig. 8. Modified drilling fluid

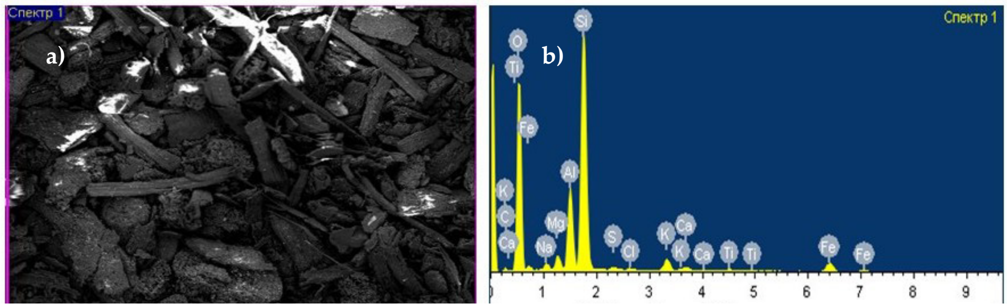



Fig. 9. Morphological (a) and elemental (b) composition of crushed cotton stalks with bentonite

The elemental composition (b) of crushed cotton stalks with bentonite, determined by energy-dispersive X-ray spectroscopy, shows the presence of the main elements: carbon (C) – 55.28%, oxygen (O) – 41.78%, as well as sodium (Na) – 1.13%, magnesium (Mg) – 0.19%, aluminum (Al) – 8.56%, silicon (Si) – 26.44%, sulfur (S) – 0.41%, chlorine (Cl) – 0.16%, potassium (K) – 1.15%, calcium (Ca) – 0.75%, which are characteristic of bentonite. The presence of silicon and aluminum confirms the successful introduction of the bentonite phase on the surface and into the structure of the stalk. The ratio of elements indicates a complex interaction between organic cotton fiber and inorganic bentonite, which can improve the physical and chemical properties of the material, such as strength, moisture resistance and adsorption characteristics.

The main ingredient of clay drilling fluid is bentonite. A natural clay mineral (clay powder) swells approximately 15 stimes when saturated with water. This forms a gel-like mass – dense and slippery. Its properties are enhanced by synthetic polymer additives.

In this way, we obtained a drilling fluid of the following composition, wt.%: modified PAN tar; clay powder (Darbaza bentonite) – 6; CMC (carboxymethyl cellulose) – 1.5; soda ash ($Na_2CO_3$) – 0.2. Then, next components were added, in the authors' opinion, they had a significant effect on the main parameters of the drilling fluid, in particular, on water loss, dynamic viscosity and, ultimately, on absorption during well drilling.

During circulation, as a part of the drilling fluid, the polymer solution penetrates pores, cracks, and voids in the rock, which are not sufficiently resistant to the wellbore fluid pressure. The reagent hardens due to the resinous mixture it contains, reducing fluid absorption.

It is assumed that upon contact with water, tar-modified polyacrylonitrile swells, increasing in volume by more than a hundredfold, while crushed cotton stalks cross-link the swollen linear PAN molecules. This creates a branched structure capable of sealing pores and cracks, forming a protective layer. The essence of the applied technology is to increase the efficiency of isolating catastrophic absorption zones in fractured formations, sink holes, and voids due to a reagent that rapidly expands in water (fig. 10).

The main parameters of the drilling fluid obtained during the experimental studies are presented in table 1. The initial drilling fluid, as shown above, contains aqueous clay powder (Darbaza bentonite), sodium hydroxide, and soda ash. Then, other components were added and measurements of the rheological parameters of the proposed drilling fluid were carried out. The resulting (lightweight polymer - containing) drilling fluid was analyzed for such parameters as density, relative viscosity, filtration properties (fluid loss), borehole cake thickness, hydrogen index (pH), and static shear stress (SSS). The latter parameter affects the ability of the solution to hold cuttings particles in suspension and prevent borehole wall collapse. Table 2 shows the rheological parameters of drilling fluids.

One of the important indicators of clay suspensions is the density and relative viscosity of the dispersed system, which is decisive in its application [22-25].

Composition No. 5, presented in table 1, provides a fairly strong 2.0 mm cake, but as the crushed cotton stalk mass increases above 2.0%, a highly permeable, loose cake with a thickness of over 3.0 mm is produced, leading to an increase in fluid loss to 4 mm or more. This drilling fluid composition maintains stable static shear stress values (72 mg/cm$^2$), which promotes optimal retention of drilled rock particles within the gel (solution).

The flow rate of the base fluid through the rock, as well as the fluid with the addition of tar-modified polyacrylonitrile, was determined on a laboratory stand (fig. 11).

The installation consists of a container for the initial drilling fluid (1) and a container for the polymer additive (2), a mixer (3); valves for shutting off liquids (4); a pump (5), a pressure gauge (6), a formation model (7), and a measuring container for the drilling fluid that has passed through the rock (8).

The homogeneous linear reservoir model is a steel pipe filled with rock with flanges built into both ends. A valve is integrated into the end flange, allowing the model to be connected to the rig and the rate of drilling fluid loss through the rock to be monitored. Crushed core, representing a rock sample extracted directly from the Ashisai field, was used as a porous medium model in the experiments. The initial drilling fluid was injected into the reservoir model, and the volumetric yield of the fluid was then determined. A polymer-modified drilling fluid was then injected into the reservoir model, and the volumetric yield of the fluid through the porous rock was again determined. Based on the data obtained, drilling fluid losses were calculated for each experiment.

Lightweight polymer flushing fluid from containers 1 and 2 with the help of pump 5, it enters the model of the layer 7, which is filled with rock, then the amount of solution at the outlet in the container 8 is determined.

When selecting polymeric substances suitable for regulating the properties of drilling fluids, it is necessary to consider the accumulation of highly polar functional groups in the polymer macromolecule, measured by the magnitude and direction of the dipole moment. In this case, when using a polymeric reagent, the accumulation of carboxyl, hydroxyl, and other polar groups in the macromolecules creates favorable conditions for the formation of stable network structures.

Saponification of nitrile groups by alkalis to form carboxyl groups, resistance to weak alkalis, and reaction with strong acids to form imide rings are expected. The results indicate the probability of hydrogen bond formation in the alkaline hydrolysis products between polyacrylonitrile. and the free fatty acids contained in this medium. The modified polyacrylonitrile chosen for use in drilling fluids is a high-molecular-weight organic hydrophilic compound, soluble in water and forming viscous solutions consisting of long macromolecules. By changing the nature of the functional groups, the conformation of the macromolecules, and their targeted modification, it becomes possible to control filtration performance, prevent the dispersion of drilled clay and other rock particles, and promote flocculation to manage the structural, mechanical, and rheological properties of the drilling fluid.

The study results show that increasing the concentration of MPAN in the drilling fluid leads to a significant reduction in filtration performance. With a 2% increase in MPAN concentration, fluid loss decreases to 3.5 cm 3/30 min.

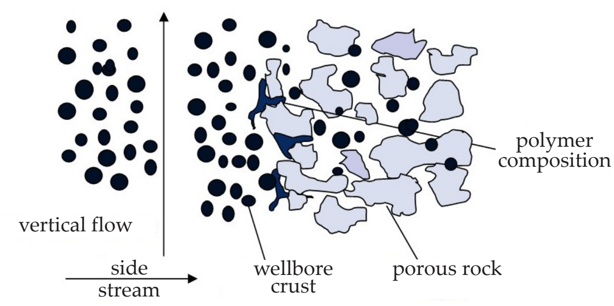



**Fig. 10. Prevention of drilling fluid absorption in the presence of MPAN**


**Fig. 11. Schematic diagram of the setup for determining the degree of drilling fluid loss**

**Table 1**

**Technological indicators of drilling fluid**

| Item No. | Fluid components, mass % | *ρ*, kg/m$^3$ | *UV*, With | *F*, cm$^3$/30 min | *Tk*, mm | *rn* | *SNS*, mg/cm$^2$ | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | 1 min | 10 min |
| 1 | Initial solution | 1.200 | 29 | 7.0 | 4.6 | 10 | 65 | 70 |
| 2 | Initial solution + 0.5 MPAN + 0.5 ref. + 0.5 CMC + 0.2 $Na_2CO_3$ | 1085 | 40 | 5.8 | 2.5 | 11 | 69 | 68 |
| 3 | Initial solution + 1.0 MPAN + 1.0 ISH + 0.75 CMC + 0.2 $Na_2CO_3$ | 1072 | 65 | 4.2 | 2.4 | 11 | 64 | 69 |
| 4 | Initial solution + 1.5 MPAN + 1.5 ISH + 1.0 CMC + 0.2 $Na_2CO_3$ | 1060 | 85 | 3.8 | 2.5 | 11 | 70 | 70 |
| 5 | Initial solution + 2.0 MPAN + 2.0 ISH + 1.25 CMC + 0.2 $Na_2CO_3$ | 1040 | 120 | 3.5 | 2.0 | 11 | 72 | 74 |
| 6 | Initial solution + 2.5 MPAN + 2.5 ISH + 1.50 CMC | 1040 | 155 | 3.9 | 3.0 | 11 | 69 | 68 |
| 7 | Initial solution + 3.0 MPAN + 3.0 ISH + 1.75 CMC + 0.2 $Na_2CO_3$ | 1040 | 255 | 4.0 | 3.5 | 11 | 67 | 67 |

**Table 2**

**Rheological parameters of drilling fluids**

| No. | Composition of drilling fluid components, mass % | Dynamic shear stress (*DSS*), Pa | Plastic viscosity (*PV*), mPa·s | Effective viscosity (*EV*), mPa·s |
|---|---|---|---|---|
| 1 | Initial solution | 13.0 | 10 | 16.5 |
| 2 | Initial solution + 0.5 MPAN + 0.5 CCM + 0.5 CMC + 0.2 $Na_2CO_3$ | 14.0 | 12 | 19 |
| 3 | Initial solution + 1.0 MPAN + 1.0 CCM + 0.75 CMC + 0.2 $Na_2CO_3$ | 15.7 | 14.5 | 22.35 |
| 4 | Initial solution + 1.5 MPAN +1.5 CCM + 1.0 CMC + 0.2 $Na_2CO_3$ | 16.5 | 15.7 | 23.95 |
| 5 | Initial solution + 2.0 MPAN + 2.0 CCM + 1.25 CMC + 0.2 $Na_2CO_3$ | 18.0 | 16.0 | 25 |
| 6 | Initial solution + 2.5 MPAN + 2.5 CCM + 1.50 CMC | 20.0 | 18.8 | 28.8 |
| 7 | Initial solution + 3.0 MPAN + 3.0 CCM + 1.75 CMC + 0.2 $Na_2CO_3$ | 30.0 | 20.5 | 35.5 |

## Conclusions

Polyacrylonitrile modified with saponified cottonseed tar is a promising additive to drilling fluids for oil and gas wells. The tar used, a waste product obtained from the alkaline refining of cottonseed oil, contains various fatty acids, gossypol derivatives, and other organic compounds. The results of the studies show that drilling fluids incorporating a polyacrylonitrile polymer reagent modified with saponified tar and crushed cotton stalks improved several parameters, including filtration properties. This indicates that the resulting solution composition meets the requirements for drilling fluids to reduce lost circulation during well drilling. The polymer reagent modified in this manner can be successfully used as an additive to drilling fluids for lost circulation control. Based on the spectral characteristics, an assumption was made about the structure of the formed complex, which has strong swelling properties, which helps prevent the penetration of drilling fluid into the space of empty rocks.

Thus, the obtained reagent is characterized by a relatively low cost, since it is obtained based on polyacrylonitrile tars from the vacuum distillation of fatty acids and can be recommended as a modifying additive to drilling fluids when drilling oil and gas wells.

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