

Development of a method for injecting drilling mud into an oil reservoir

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Abstract

The technological scheme of formation, utilization and involvement in the production cycle of oil sludge is considered. A new combined method of application of composite solutions for neutralization of drilling sludge is described. An innovative method of injection of drilling sludge into an oil reservoir and the corresponding scheme of the technological process for the effective use of accumulated oil waste are proposed. The developed scheme was tested on wells No. 2158 of the NGDU "Neft Dashlary" and No. 753 of the Khara-Zira Island field.

Keywords: drilling cuttings injection, disposal, drilling cuttings processing scheme, pulp preparation, oil reservoir.

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1. Introduction

Oil is known to be an integral part of the energy supply. The world consumes approximately more than 100 million barrels of crude oil per day. Oil consumption continues to increase. Oil is mixed with some impurities to form oil sludge (OS) during the process of oil production, storage, transportation and refining. OS is a pollutant in the petrochemical industry [1-7]. The annual global production of OS exceeds 10 million tons. Due to the lack of effective oil purification facilities, many millions of tons of OS are deposited in the world.

With the increase in the total volume of oil well drilling, the amount of waste - drilling sludge (DS) - increases. DS remains accumulate and are stored on the territory of the drilling site. They have a negative impact on the environment. Therefore, the disposal of environmentally hazardous drilling waste is important and relevant [8-14].

Oil sludges OS are divided into several groups by composition and properties. Drilling cuttings (DS) - are formed during drilling of oil wells. Consists of water, clay, sand and substances included in the composition of the drilling mud. Washing sludge (WS) - is formed during well flushing. WS contains clay, water, sand, additives of reagents and washing liquid. Industrial sludge (IS) - is formed during oil refining, therefore it contains oil fractions - fuel oil, kerosene, paraffin, etc. Transport sludge (TS) - occurs during transportation of oil and oil products, during emergency emissions into the environment.

Such waste is dangerous regardless of the group it belongs to. Disposal of oil sludge by burning is prohibited. Special methods are used to dispose of oil sludge, which reduce and/or neutralize the harmful effects of OS on the environment.

The purpose of this work is to study the process of pumping extracted sludge after its chemical treatment into the layer.

2. Experimental Methodology

The objects of the study were samples of drilling mud extracted from well No. 2158 of the Oil and Gas Production Department "Neff Dashlari".

To the initial 100 g sludge sample taken for control, 400 ml of distilled water are added in a ratio of 1:4. Similarly, to the experimental 100 g sample of such sludge, 400 ml of water and 10 ml of a 1% solution of sodium salt of 4-cyclohexene-1,2-dicarboxylic acid are added.

After 24 hours, the reaction in the experimental sample of sludge shows accumulation of oil products. An oily layer of light-yellow liquid forms on the surface of the experimental sample compared to the control sample. The volume of the experimental sample with the oily layer increases compared to the control sample. The amount of oil product layer collected on the surface of the sludge was 3.6 g in the control sample and 4.3 g in the experimental sample. The pH of the medium was 8.

After separating and removing the oil product from the drill cuttings sample, 10 ml of 3% H₂O₂ solution is added to the mixture. This increases the degree of separation of the liquid contained in the drilling mixture from the clay. After 3 days, accumulation of light-yellow low-viscosity liquid is observed on the surface of the drill cuttings sample. After processing the drill cuttings samples, the liquid is collected, transferred to a beaker and measured. A volume of 375 ml of liquid is evaporated at a temperature of 100°C in a distillation apparatus. This volume consists of 355 ml of water. The residue remaining at the bottom of the flask is transferred from the flask to a porcelain cup and evaporated. The mass of the solid residue was 3.5 g.

Thus, the properties of drill cuttings in various states of aggregation (liquid, solid, oily) were studied.

Figure 1 shows the process flow diagram for pumping drilling fluid into the formation. The drilling fluid purified in this manner and the prepared pulp (liquid with a high content of solid particles) were used in production conditions. The injection of the solution and pulp was carried out using special pumping equipment resistant to the effects of abrasive particles.

Preliminary experiments have shown that for optimal operation of the technological system devices it is necessary to estimate the consumed energy. The amount of energy required for the operation of some devices is shown in Table 1.

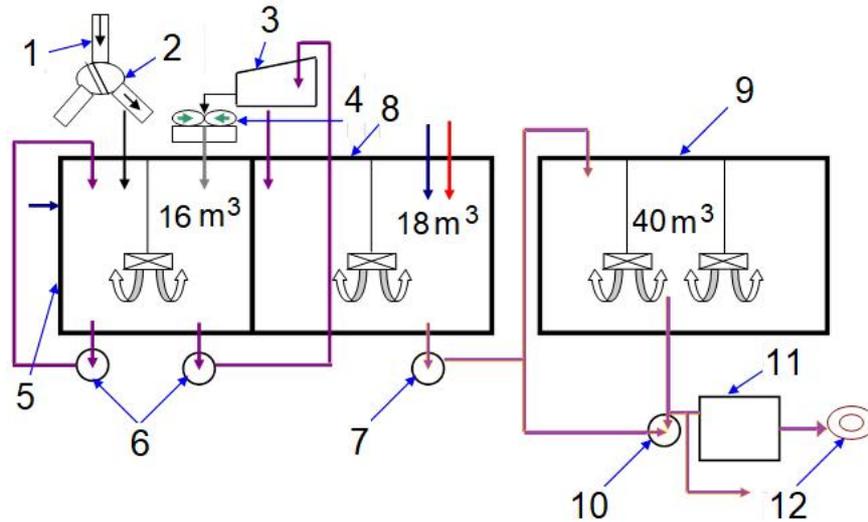


Figure 1. Flow chart of drilling mud injection into an oil well. 1 - penetration of the solution, 2 – diverter, 3 - vibrating sieve, 4 - sludge grinding, 5 - "dirty" container, 6 - centrifugal pump, 7 - transmission pump, 8 - "clean" capacity, 9 - "spare" capacity, 10 - pulp injection, 11 - high pressure pump, 12 - oil well.

Table 1. The amount of energy required to operate the main devices

Devices	Number	Power, kW		Working current, A	
		Per piece	Sum	Per piece	Total
1	2	3	4	5	6
Pump	4	64	256	80	320
Sieve	1	4	4	6	6
Mixer	2	7	15	10	20
Total	7	5	275		346

As can be seen from the table 1, the above tasks and equipment operation require a power of 275 kW. The power and electric current generated by a diesel generator designed for drilling operations cannot provide electricity for a clay mixer, vibrating screen, hydrobarite mixer, etc. For this reason, it is advisable to install an additional diesel generator for pulp preparation. For example, two diesel generators can generate more electricity. Such power will allow the above operations to be performed.

3. Results and discussion

3.1 Preparation of pulp

Applying pulp to a well is a complex process and depends on several factors. During the operation, the sludge coming out of oil well #670 was cleaned and crushed. The volume of prepared rock was 2 times

greater than the volume of rock drilled out of the well. The cost of the volume of extracted sludge is multiplied by the filling factor. The volume of pulp pumped into the well consisted of a mixture of soil sludge and water. The ratio of this mixture was 4:1 (water : suspension).

The total volume of the pulp consisted of the sum of the crushed sludge and the water mixed with it. This volume is 10 times greater than the volume of sludge removed during well drilling.

For injection into the formation, it is also necessary to take into account the volume of drilling cuttings, completion waste, and waste generated during cementing. In addition, it is necessary to take into account the volume of drilling cuttings during flushing after injection of pulp into the formation. Thus, the total volume to be injected into the formation is 12 times greater than the volume of cuttings to be extracted.

The work on processing the cuttings, preparing the pulp and drilling is carried out in parallel. During pulping, the volume of drilling cuttings increases by 10 times. Therefore, when pumping the cuttings into the formation, it is necessary to take into account the capabilities of the equipment. The cuttings coming out of the drilled interval during drilling are crushed and pumped into the formation. In this case, space must be left for the accumulation of cuttings in tanks and containers.

According to the specified technology, the extracted cuttings can be recycled before pumping the drilling waste into the formation. When drilling, large volumes of inert additives or dry cement should not be pumped into the formation. Excess amounts of these materials due to poor mixing in the pulp can lead to clogging of the space behind the tape. During the processing, before pumping, the mixture of drilling cuttings and water is crushed into small particles (0.3 mm). The small size of the particles prevents their accumulation and clogging of the annular space of the pulp injection. The properties of the pulp mainly depend on the lithology of the drilling interval, the granulometric composition and the ratio of drilling cuttings and water.

Let's estimate the total volume of fluid for treating a specific well. We will assume that the useful volume of the drilling rigs tray system is 240 m³. Let's assume that such a volume of reserve flushing fluid will be available for treating the well. Then, together with the fluid obtained, for example, from well No. 753 of the Khara-Zira Island field, we get 500-600 m³ of fluid.

Cementing of oil wells is known to be carried out for several main reasons. This is one of the most important stages of drilling and well operation. Here are the main goals:

1. Isolation of formations - preventing fluid (oil, gas, water) flow between formations with different pressure and composition.
2. Protection of the casing - cement provides mechanical support for the column and protects it from corrosion.
3. Prevention of blowouts - cement seals the space between the pipe and the well wall, preventing uncontrolled release of gas or oil.
4. Well strengthening - cement stone increases the overall stability of the wellbore.

5. Preparation for operation - a sealed system is created, which is necessary for the safe production of hydrocarbons.

Given the above, it is not possible to use a chute system to collect the cuttings. The estimate shows that during the full drilling of this well, 640 m³ of cuttings will be extracted. The cuttings should be reduced in parts to a pulp state and introduced into the oil reservoir. The total volume of pulp produced during this time will be about 6405 m³.

The processing of drilling cuttings is carried out as follows (Figure 1). The sludge from the vibrating screen enters a "dirty" tank. Here, the treated and purified sludge is pumped into a tank that is traditionally considered "clean". The viscosity of the pulp is adjusted by adding a polymer solution or water. The pulp that has passed through the vibrating screen enters the "clean tank", and the pulp that has not passed through it is crushed again and fed to the wave mill. After processing, the pulp (prepared for introduction into the oil reservoir) is moved to the collection tank. Centrifugal pumps equipped with hard-alloy impellers are used to crush the pulp and feed it to the vibrating screen. The pulp is fed to the cementing unit equipped with a centrifugal pump and circulates in the storage tank. The pulp is pumped into the collection tank by a centrifugal pump, and from the tank into the well by a high-pressure pump. The scheme of injection of drilling cuttings into the formation is shown in Figure 2.

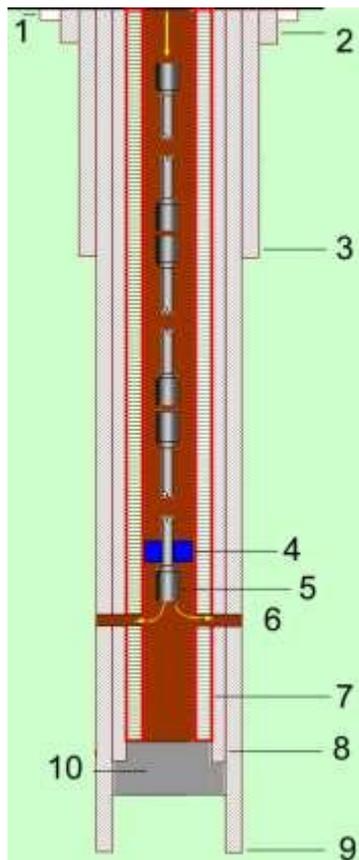


Figure 2. Scheme of injection of drilling cuttings into the formation. 1 - water separator guide, 2 - guide (cemented), 3 - conductor, 4 - packing packer, 5 - pump-compressor pipes (PCP), 6 - intervals for

injection of slurry, 7 - operating belt, 8 - "upper belt", 9 - intermediate belt, 10 - cement bridge laid in the interval.

The injection of the suspension pulp is carried out sequentially with pulsations and pressure regulation. The pulp was introduced into the well at intervals indicated in Table 2.

Table 2. Experimental data on the introduction of pulp into the well

1	50–150	35
2	150–1200	256
3	1200–2400	173
4	2400–4500	169
5	4500–5100	5
6	5100–5450	2

4. Conclusion

1. The conducted research and comparisons with field data of practical stages allowed to adjust the sludge preparation scheme and develop a technology for the utilization and processing of oil sludge.
2. The conducted research in laboratory conditions on cleaning drilling sludge from impurities using an organic reagent allowed to determine the optimal composition of this reagent. The pulp prepared in this way is environmentally safe for injection into an oil reservoir.
3. The proposed technological scheme for processing drilling mud and preparing pulp allowed the efficient use of extracted rock particles. After cleaning the mud, it was introduced into the oil reservoir. The method was tested on wells No. 2158 of the Neft Dashlari and No. 753 of the Khara-Zira Island field (Absheron, Azerbaijan) and positive results were obtained compared to the pulp prepared in the traditional way.

Conflict of interest

The authors of this work declare that they have no conflicts of interest.

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