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Disposal of Oil and Gas and Power Industries to Improve Industrial and Environmental Safety

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Abstract. The technological processes associated with drilling wells and potentially dangerous sources of environmental pollution are considered. Industrial soot waste from heat generating plants, oil and gas reprocesses are a source of harmful chemical and biological formations entering the environment. The results of experimental studies on the utilization of drilling sludge and soot waste during the production of fibrous concrete and industrial and environmental safety are presented.

1. Introduction

In the world practice, oil and gas resources of the continental shelf have long been the main sources of increasing oil and gas production. Currently, the share of hydrocarbons produced on the continental shelf is more than a quarter of the world's production, and it continues to grow. Russia has the world's largest continental shelf, whose oil and gas potential accounts for almost a third of the total resources of the subsoil of the World Ocean shelf.

The development of oil and gas fields in Russia requires the use of special technologies and technical means for the construction of oil and gas wells, which is primarily associated with specific mining and geological and climatic conditions, as well as industrial and environmental safety requirements in the areas of work.

2. Relevance

As is known, many complications that occur while drilling directional and horizontal wells with a large deviation from the mouth and large azimuth turns, one way or another, are related to the type and quality of the drilling mud used. Poor well cleaning, excessive torque, sludge of the wellbore, sticking of the drilling tool, disturbance of the well walls, loss of circulation, complications during down hole logging and casing stripping, and other problems that greatly retard and increase the cost of drilling are usually the result of a mismatch of drilling mud to the drilling conditions.

In order for the drilling mud to match the program values of the project, it is necessary during the well drilling process to ensure the effective operation of the cleaning system for the removal of active drilled rock. A well-tuned drilling mud cleaning system can help to conduct a well operation with minimal costs for the preparation and processing of drilling mud, which in turn will lead to a reduction in the price of the project as a whole.



3. Problem statement

In the process of drilling wells, it is necessary to reduce the volume of discharge of drilling waste and formation water at offshore oil and gas production facilities. This is quite feasible in a technological sense and in most cases promises economic benefits. There are no special technical difficulties to reduce such discharges to zero level, using for this purpose the newest technologies of reverse injection, recycling of waste on the principle of a circular closed cycle and disposal of drilling waste. Where geological conditions do not allow the injection of waste into the well, they should be transported to land for disposal and processing.

It is necessary to strengthen control over observance of legislative norms aimed at reducing the volume of discharges or achieving "zero discharges" and not allowing corporations to save on environmental technologies. The order of waste management and environmental control of all types of economic activities in the waste management system for field development are regulated by statutes documents [1-4].

Technological processes associated with drilling wells are potentially dangerous sources of environment pollution and its individual components.

Possible impact on the main components of the environment (air, water, plant, animal life and man) is due to the toxicity of natural hydrocarbons, their associates, a wide variety of chemical reagents used in technological processes.

Drilling technology wastes include drilling mud, spent drilling fluids and drilling wastewater. They are formed in the process of well washing.

In the process of performing the works during deposit development, the following measures are provided for the safe handling of waste and minimization of the volumes of their formation:

- improvement of mud cleaning quality by applying advanced technologies and technical means (vibro sieve, sand separator, silt separator, degasser, centrifuge);
- maximum use of spent drilling mud for preparation of working drilling fluids while drilling subsequent intervals;
- waste sorting, collection and storage in sealed containers and containers on offshore platforms;
- waste order management provides transfer to specialized enterprises that have licenses to carry out hazardous waste management activities.

A growing number of areas are currently being allocated for industrial wastes, including soot wastes from heat generating plants, ashes formed as a result of burning coal at thermoelectric power station (TPS), waste from boiler plants, as well as soot formed as a result of the operation of oil and gas refineries. These products are the source of entry into the environment of harmful chemical and biological formations that affect both specific parts of nature and the biosphere as a whole. The accumulation of industrial wastes is an urgent problem for modern society. Obviously, this situation poses a serious threat to the environment. In addition, these areas require significant expenses for their maintenance, which leads to an increase in the cost of heat and energy supply.

To solve this environmental problem, there are technologies for the utilization of drilling and soot wastes by using them as an additive in the production of concrete mixtures [5-12].

At the moment, developed a huge number of high-strength composite materials, in particular concrete. This is due to the fact that high demands are placed not only on the quality characteristics of concrete, such as durability, strength and crack resistance, but also the task of reducing the construction time by applying appropriate technologies that facilitate labor in the process of direct use. Also, the issue of reducing concrete cost remains relevant, since it is known that concrete works are among the most expensive.

4. Theoretical part

It is proposed to solve qualitative as well as technical and economic problems by three-dimensional reinforcement of the concrete matrix with basalt or steel fabric (fiber) [13-23], as well as its modification at the micro level with the use of drilling waste and soot.

Volgograd State Technical University has developed technologies for obtaining composite materials using waste from oil and gas production and heat power engineering. In particular, the production of concretes with drilling sludge and soot in its composition has been widely used.

To increase the strength characteristics of the concrete mix, studies have been conducted to evaluate the effect of industrial waste on the physical and mechanical properties of fibrous concrete.

The joint work of a cement-sand matrix with basalt fiber and industrial waste was studied. In the course of the research, the influence of the complex addition of basalt fiber fabrics, plasticizing additives, soot waste (carbon black) on the processes of structure formation, physical, mechanical and strength characteristics of fibrous concrete was established. A preliminary selection of several compositions of concrete mixtures characterized by different contents of soot waste in a percentage by weight was made: 0.25%, 0.3%, 0.35%, 0.5%, 0.75%, 1.0%, 1.5% of the cement mass. The ratio of cement and sand is 1:2 and the consumption of the reinforcing component – basalt fiber – is accepted as constant parameters. Studies were carried out on seven compositions of fibrous concrete, among which, in the end, the optimal compositions were revealed after the experimental verification, which showed the best results. As a result, the compositions of fibrous concrete with the use of soot waste (carbon black) with high mechanical characteristics, such as strength, crack resistance, durability were developed.

In the course of further research, the influence of complex addition of basalt fabric-fiber mixture, plasticizing additives, as well as drilling and soot wastes on the physical-mechanical and strength characteristics of fibrous concrete was studied. In this regard, the selection of a concrete mixture with an optimal content of its components was carried out.

Portland cement M500 D0 manufactured by joint-stock company «Oskolcement» was used as a binder. As a fine filling aggregate, dried and ground mud slurry was used, as well as quartz sand. The binder and aggregate ratio was 1: 2. To increase the strength at the macro level, basalt fibers with a diameter of 13-17 μm and a length of 6-12 mm with a tensile strength of up to 2000 MPa were used as a disperse-reinforcing component. Fiber fabrics were dosed in the range of 0.8 kg / m^3 to 1.6 kg/ m^3 . The addition of basalt fiber fabrics contributed to blocking the formation and development of micro cracks in the structure of hardened concrete. In addition, a fine carbon black powder with a particle size of not more than 5 μm was introduced into the concrete mixture, increasing the mobility, which allows to reduce the amount of mixing water. The content of soot waste for different compositions was in the range from 0.5% to 2.0% by weight of Portland cement.

It has been experimentally proven that a higher efficiency of using soot waste in the production of fibrous concrete is achieved with their complex application with chemical additives, such as super plasticizers, cold binders, as well as hardening accelerators. To strengthen the structure at the micro level, a super plasticizer "Polyplast SP-3" was introduced into the mixture, which is a brown powder corresponding to Technical Regulations 5870-006-58042865-05. It improves wetting, workability and uniformity of cement dispersion.

Thus, the complex addition of a basalt fiber-fabric, a super plasticizer "Polyplast SP-3", as well as drill cuttings, carbon black, promotes an increase in the mobility of the mixture with a low amount of mixing of cement water, which in turn increases the uniformity and density, contributing to the increase in strength at the macro and micro levels, due to a more even distribution of dispersed fiber throughout the volume of the concrete mix.

The concrete mixture was prepared according to the following procedure. A complex additive including the super plasticizer "Polyplast SP-3" and technical carbon black were pre-dissolved with a small amount of mixing water in an ultrasonic disperser at a frequency of 20 kHz for 1 minute until a homogeneous solution was obtained and introduced into the concrete mixture after preliminary mixing of Portland cement, drill cuttings, fiber fabrics and remaining mixing of cement water.

5. Results of experimental studies

The mechanical properties of the prepared concrete mixture were determined according to a standard procedure by making specimens - beads 40x40x160 mm in size and hardening them in natural

conditions. After 28 days, these samples were tested for compressive strength and stretching during bending. The results of the seven experimental compositions were compared with the physical and mechanical properties of the reference composition prepared using the same technology, but without the use of industrial wastes (carbon black and drilling mud slurries). The quantitative composition of the concrete mixture for the production of the reference composition (1) and the optimal composition (2) is shown in the table 1.

Table 1. Quantitative compositions of concrete mixtures.

Mixture components	Quantity, kg / m ³	
	1	2
Portland cement	600	600
Drilling waste sludge	-	1200
Quartz sand	1200	-
Basalt fiber-fabrics with a diameter of 13-17 microns and a length of 6-12 mm	1.4	1.4
Super plasticizer "Polyplast SP-3"	6	6
Technical carbon black (soot)	-	3
Water l / m ³	279	310.5

Analysis of the experimental data showed that the addition of high-dispersion fibrous filler, super plasticizer "Polyplast SP-3", as well as drilling waste and technical carbon black (soot) at the indicated ratios of the constituent components at the age of 28 days to the raw material mixture, contributes to an increase in the compressive strength at 27% in relation to the reference samples. Also, the results showed an increase in bending strength by 43%.

The introduction of carbon black into fibrous concrete improves its grain composition, reducing stratification and increasing the uniformity of concrete. This is a huge plus in modern construction where, as is known, monolithic construction prevails, in which quite mobile mixtures prone to stratification are used.

The use of drilling mud extracted from the wells of the Caspian basin, which includes up to 80-90% of sandstones and limestone, contributed to the formation of a strong cement-slurry matrix and disposal of drilling waste polluting the environment.

6. Conclusions

The introduction of drilling and soot waste into fibrous concrete mixtures leads to an improvement in the rheological properties of these concretes and to an increase in their strength, while simultaneously improving the ecological state of the environment. At the same time, the problem of freeing huge landfills engaged in waste, representing a danger, for both the water and atmospheric environment, is being solved. The economic effect is also evident, which is reflected in the reduction in the cost of fibrous concrete by using industrial waste.

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