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Technological solution of oil and gas waste disposal

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Technological solutions for the construction of sludge barns at the Pereschepynskoye deposit are considered and analyzed. The authors proposed to arrange a monolithic vertical anti-filtration curtain of the type "wall in the soil" of soil-cement elements. When filling the sludge storage, it is proposed to fill with waste using the following technology: pour a layer of waste about 1 m thick on the bottom of the sludge storage, then pour a layer of soil on top of the construction site (humidity 4-5%) up to 1 m. drying it is offered to add ash of removal of the Mykolaiv thermal power plant. The amount of additive is from 1.5 to 3% depending on the type of soil. The thickness of the layers is selected and calculated to obtain the optimum moisture content of the sludge and soil mixture

Keywords: soil cement, removal ash, strength, soil, cement.

Технологічне рішення утилізації відходів нафтогазової галузі

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Розглянуто та проаналізовано технологічні рішення спорудження шламових амбарів на Перещепинському родовищі у вигляді монолітного вертикального протифільтраційного завісу типу «стіна в ґрунті» з ґрунтоцементних елементів. Ґрунтоцементні елементи запропоновано виготовити за бурозмішувальним методом шляхом механічного руйнування (подрібнення) ґрунту, ін'єкції в ґрунт в'яжучого (стабілізатора) та перемішування ґрунту з в'яжучим робочим органом бурової машини. В результаті перемішування та твердіння цементу в ґрунті сформовано палю з фіксованим діаметром, який визначається розміром змішувальних лопастей обладнання. Подавання в'яжучого здійснюється через отвори (сопла) у буровому снаряді (робочому органі бурової машини). Таким чином отримано циліндричні ґрунтоцементні елементи діаметром 0,3 – 0,8 м і довжиною до 30 м. Протифільтраційну завісу по типу «стіна в ґрунті» з ґрунтоцементних елементів запропоновано заглиблювати у водотрив на глибину не менше 1 м з метою забезпечення відсутності фільтрації. Після твердіння ґрунтоцементних елементів по периметру шламосховища виконано виїмку до 60% масиву ґрунту. Термін тужавіння у зволоженому стані триває 28 діб. З часом міцність та водонепроникність ґрунтоцементу збільшуються. Заповнення шламосховища відходами буріння пропонується здійснювати після тужавіння ґрунтоцементу. До потрапляння у шламосховище відходи буріння зневоднюються. Під час наповнення шламосховища запропоновано виконувати заповнення відходами за такою технологією: на дно шламосховища насипати шар відходів товщиною близько 1 м, потім на нього зверху насипати шар ґрунту майданчика будівництва (вологість 4-5 %) до 1 м. Доведення складеного у відвали ґрунту майданчика до вологості 4-5% запропоновано робити висушуванням на відкритому повітрі з періодичним перемішуванням та спорудженням над місцем складування укриття. Якщо не отримано оптимальну вологість суміші після висушування пропонується додавати золу винесення Миколаївської ТЕС. Кількість добавки дорівнює від 1,5 до 3% залежно від виду ґрунту. Товщину шарів вибрано та розраховано щоб отримати оптимальну вологість суміші шламу і ґрунту. Далі запропоновано здійснення ущільнення шарів шламу та суглинку трамбівками. Після ущільнення операції повторюють. Ущільнення шарів ґрунту запропоновано здійснювати при оптимальній вологості з метою отримання максимального коефіцієнту ущільнення і розміщення у сховищі максимальної кількості відходів

Ключові слова: грунтоцемент, зола виносу, міцність, ґрунт, цемент.

Introduction

One of the priorities of drilling is to preserve the natural state of the environment as much as possible. Drilling rigs are known to be at high environmental risk. Therefore, the impact on the components of the environment during the construction of wells is possible not only as a result of emergencies, but also under normal conditions of the production process.

The practice of drilling in oil and gas production has shown that the most significant problems in terms of their negative impact on the environment is the formation of a significant amount of drilling waste and operation of oil and gas wells. When drilling wells, chemical reagents and substances of hazard classes 3 and 4 are used to prepare drilling fluids. Concentrated solutions of various acids, surfactants, inhibitors, etc. are used in the operation of wells to intensify the production of hydrocarbons [1]. The need for sludge storage is related to the prevention of contaminants in the soil and groundwater. Therefore, special care and professionalism should be shown in the construction of such structures. At construction of similar constructions it is necessary to adhere strictly to stages of construction of sludge storages.

Definition of unsolved aspects of the problem

The most accessible way to eliminate drilling waste and operate wells is to bury them. Waste disposal is practiced in specially designated places, in deep underground horizons, in earth storage facilities directly on the drilling site. To prevent drilling waste from entering the soil and groundwater, it is necessary to provide an engineering system of organized waste collection. For this purpose, special earthen pits in the mineral soil - sludge barns - are installed on the territory of the drilling rig. The size of barns is determined by the project and should correspond to the amount of waste from drilling wells [2]. A feature of the design of sludge barns is the need to waterproof the walls and bottom. Its absence leads to filtration of barn contents into groundwater and subsequent migration of pollutants. Therefore, the problem of liquidation of sludge barns and further reclamation of lands on the territory of drilling rigs is quite relevant at present.

In a number of regions the clay of the bottom and walls of storages is used - artificial filling of cavities and large cracks in the massif of rocks or soil with clay. However, clay does not give the desired result, in addition, this method is quite time consuming and non-technological.

A more environmentally friendly way of disposing of drilling waste involves the construction of ditches in the ground with waterproofing. Waterproofing of such sludge storages protects groundwater from the penetration of toxic waste, provides disinfection and safe disposal of recycled masses. Metal sheets, synthetic film, reinforced concrete slabs, bentonite mats, wooden boards with bituminous coating or compositions based on clay, lime and cement are used for waterproofing [2].

There is a method of waterproofing sludge barns with the use of geotextile membranes. According to this technology, after conducting engineering surveys and appropriate calculations, the Geoflax geomembrane is laid in the sludge storage facility at the project mark. Then the rubble is poured to create a layer of protection against flooding (drainage ditch), then the surface of the lower slope is sown with grass. Geoflax membrane is characterized by lack of toxicity and safety of application, as well as resistance to ultraviolet influences and critical temperatures. Despite the complexity, the work is performed quickly due to the lightness and flexibility of the roll materials, but the force can damage the membranes. The main disadvantage of geomembranes as a waterproofing in the construction of sludge barn is the multi-stage installation.

Review of the research sources and publications

Another common material for waterproofing sludge barns is cement. However, it has a significant disadvantage - unstable, mobile soil can lead to cracks in the cement floor with all the consequences (in the literal sense of the word).

Bochkarev G.P. recommends arranging waterproofing in two stages. In the first stage, a cement-based grout solution is applied to the walls and bottom of the barn, and in the second stage, after the first layer has hardened, a layer based on polyacrylamide and grout cement is applied to reduce the likelihood of cracks [3].

Timofeeva K.A. proposes the installation of sludge barn from soil cement using the technology of manufacturing soil-cement elements by drilling technology without excavation [2]. According to the proposed technology, wells are drilled around the perimeter of the sludge barn. These wells are filled with soil cement, which is a protective shield against groundwater. These methods of making waterproof screens are time consuming, expensive and over time their effectiveness to resist the chemical action of the components of drilling waste is reduced

Problem statement

The purpose of the research is to propose and justify, improve the technology of drilling waste storage (sludge storage).

Basic material and results

It is necessary to investigate the creation of such a method of waterproofing storage barns and disposal of drilling waste in the construction of oil and gas wells, which would provide guaranteed protection of surface, groundwater and groundwater from pollution due to the penetration of harmful drilling waste into the soil. barn method and preservation of the environment. This goal is achieved by performing continuous waterproofing of sludge barns from soil cement.

Soil cement is a mixture of clay soil, cement, and water. It is not a simple mechanical mixture, but a system consisting of two very complex in composition and properties of multicomponent systems - cement and soil. Consider the technological solutions for the construction of sludge barns (storage) at the Pereschepyno field.

Pereschepyno field is an active object under industrial development. The Pereschepyno field is located within the southern part of the Dnieper-Donetsk oil and gas region, where industrial hydrocarbon deposits have been discovered in a wide stratigraphic range from the Bashkir tier of medium coal deposits to crystalline basement rocks.

During 2013-2015, two appraisal and production wells 207, 211 and exploration wells 300, 310 were drilled and put into operation at the Pereshchepyno field. As of September 1, 2017, gas condensate deposits of mountain horizons are under development. C-17, C-15, C-3, B-13b, B-10, B-8b, and B-6 [5].

As of January 1, 2020, there are 7 gas wells (39, 103, 104, 107, 207, 211 and 300) at the Pereschepyno field, and 1 oil well is idle.

According to the results of engineering and geological surveys conducted on the drilling site of the well № 309 Pereschepyno field, after removal of the fertile soil layer of chernozems washed light clay to a depth of 0.8 m, the approximate geological section (to a depth of 10.0 m) is as follows:

– soil and vegetation layer: chernozem loam with a thickness of 0.4 m;

– loams dark gray, gray, humus, with plant roots and passages diggers with a thickness of 0.3 - 0.4 m;

– loams light yellow-brown, pale yellow, hard, sagging, with liquid carbonate coatings with a thickness of 2.2 - 2.6 m;

– loams pale-gray, pale, refractory, in a water-saturated state soft-plastic, non-permeable with a thickness of 2.2 - 2.6 m;

– loams yellow-brown, brown-brown, light brown, semi-hard, with liquid nodules of carbonates, in the sole with layers of clay. The power of these loams is 2.1 - 2.8 m;

– sands are fine, multi-grained, yellow-brown, yellow, gray, light gray, medium density, and dense, wet, and water-saturated to a depth of 10.0 m and deeper.

According to the results of engineering and geological surveys conducted at the well site №№ 310, 309 Pereschepyno field, the level of the first aquifer (groundwater) is at a depth of about 7.5 - 9.2 m from the surface. In order to prevent contamination of the first aquifer with fresh water, which lies at depths of approximately 10.0 - 15.0 m from the surface, liquid drilling waste that will be generated during the construction of wells, their storage in earthen waterproof sludge barns, which will be to arrange in soils with filtration coefficient $K_f = 1{,}16 \cdot 10^{-5}$ sm/s.

The volume of storage barns for temporary storage and subsequent disposal of liquid drilling waste and drilled rock is calculated according to regulatory documents and is 5061 m^3. Three earthen storage barns with a volume of 1690 m^3 each have been designed for separate collection of sludge, spent washing liquid and wastewater, and well-test products [5].

The first is for collecting drilled rock, collecting used washing liquid. The second and third are to defend the leachate filtrate, collection of waste technical water and wastewater.

The first settling barn is constructed in such a way that the excess liquid coming through the concrete trays from the cleaning unit and the drilling mud unit and from the wellhead is poured into the second settling barn, and the second is constructed so that the excess liquid coming from the first was poured into the third, from which the settled water will be pumped out for reuse (Fig. 1).

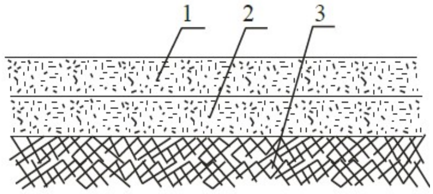

Figure 1 – Technological solution of the colloid-chemical screen:
1 – polymer-clay layer; 2 – diffusion layer; 3 – natural soil

Along the perimeter of the barns it is proposed to arrange an embankment from mineral soil 0.5 m high. and bentonite clay. The width of the bottom of the barn is 10.1 m. The width of the top of the barn, taking into account the slopes is 16.1 m

The surface of the bottom and walls of the sludge barns for the application of the waterproofing layer, taking into account the slopes, is determined to be 2639.2 m^2. Consumption of materials per 1000 m^2 of surface is:

– GPAA	– 30 - 50 kg
– bentonite	– 600 - 800 kg
– technical water	– 10000 - 12000 kg.

The technology of applying the polymer-clay suspension consists of the following measures. Pre-prepare an aqueous solution of HPAA in measuring container cementing unit (mass fraction of GPAA is 0.3-0.5%). After dissolving the GPAA and obtaining a homogeneous solution in the meters are loaded bentonite clay, the mass fraction of which is 6-8%. After intensive stirring for 30-40 minutes, the resulting solution is applied to the prepared surface of the barn using a pump unit CA-320. After drying, re-treatment.

To fix the polymer-clay screen and prevent cracking after drying, it is advisable in 2 - 3 days to perform surface treatment with an aqueous solution of aluminum sulfate, the mass fraction of which is 5%.

The treatment is performed with the help of a cementing unit by spraying the solution through the spray nozzle of the discharge line.

Optimal slope steepness when applying colloid-chemical composition 1:(2-3). The filtration coefficient of colloidal chemical screens based on bentonite and HPAA does not exceed 10-5 cm /s.

The authors propose the design of a sludge storage facility of this design (Fig. 2).

Construction of buildings begins with the removal of the fertile layer of soil and its storage in dumps. Then digging directly into the protective structure and laying the soil for further use in the preparation of soil cement, erection on the perimeter of the structure of the embankment height of 0.5 m to prevent the ingress of meltwater.

A monolithic vertical anti-filtration curtain of the "soil in the soil" type is being constructed from soil-cement elements.

Drilling piles are the most widely used type of piles in the world due to the economy and convenience of manufacturing technology directly on the construction site. With the development of the drilling mixing method of soil cementation in recent years, a new type of drilling pile has emerged - soil-cement drilling piles. They have all the advantages of drilling piles. This completely eliminates the problem of additional stability of the well walls in any engineering and geological conditions of construction

The distance between the centers of adjacent elements should be equal to 0.8d (d is the diameter of the soil-cement elements). Soil-cement elements are made by the drilling method [4]. The main processes of the technology are mechanical destruction (grinding) of the soil, injection into the soil of the binder (stabilizer), and mixing of the soil with the binder working body of the drilling machine.

The cement slurry is mixed in a mortar mixer and pumped with a mortar pump through a swivel into the drill rod and further into the loose soil.

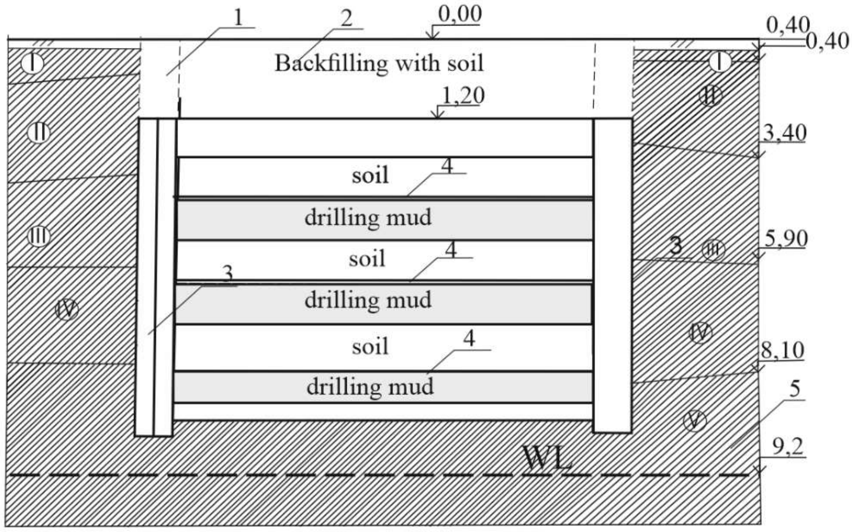

Figure 2 – Type of sludge storage of the offered design:
1 – soil-cement element that can be dismantled; 2 – backfill with the soil of the site;
3 – soil-cement element of the sludge storage; 4 – composition for neutralization and drying;
5 – clay soil (water resistance)

Cement slurry can be made with the help of one of the mortar mixers produced by the industry, provided that the slurry for soil consolidation is uniform.

Construction diaphragm or drill plunger pumps, which create a pressure of at least σ = 0.5 - 0.7 MPa, can be used as mortar pumps. The swivel consists of two parts - movable and immovable. The fixed part includes the body, cover, and branch pipe. The rotating part of the swivel includes the barrel, which is mounted on three bearings to center it relative to the body and obtain the axial and radial loads that occur during operation.

A thrust ball bearing is used as the main middle support. The upper bearing is a tapered roller bearing and the lower bearing is a plain bearing. Swivel body - streamlined steel casting, which is hinged to the earring. The top of the case is closed with a cover, which is attached to it with bolts. The oil seal cover is screwed into the lower part of the case, which prevents oil from leaking out of the swivel body. Upper-pressure seal with V-shaped cuff, which seals the gap between the barrel and the pressure pipe. The inner part of the housing is filled with oil through a hole in the upper part of the housing, which is closed with a stopper with a hole for oil vapors. The soils are loosened at the bottom of the well, impregnated with cement mortar, and moved to a homogeneous state of the soil-cement mixture. The quality of mixing of the soil-cement mixture significantly depends on the speed of immersion of the drill mixer in the soil [8].

A pressure drill allows you to reliably adjust the thickness of the soil chips, with its help it is possible to achieve the smallest thickness. It is recommended to use when passing heavy loams and light clays.

For reliable mixing of the soil-cement mixture requires more cycles of "deepening - reversal". A paddle mixer is recommended for light loams and sands. When using it, the best mixing of the soil-cement mixture is achieved. This quality of the mixer can be improved by increasing the number of blades by the height of its rod.

As a result of the mixing and hardening of cement in the soil, a pile with a fixed diameter is formed, which is determined by the size of the mixing blades of the equipment. The binder is fed through holes (nozzles) in the drilling projectile (working body of the drilling machine).

Soil cement is prepared on the construction site in a horizontal concrete mixer of continuous action from the soil (loam, sand), Portland cement 400 in the amount of 20% by weight of dry soil and water. Studies show that the strength of soil cement, like concrete, increases over time and this process can take years [8].

The fastest increase in strength is observed in the initial period. Increasing the temperature and humidity of the environment significantly accelerates the hardening of soil cement. Over time, the strength and water Thus, we obtain cylindrical soil-cement elements with a diameter of 0.3 - 0.8 m and a length of up to 30 m [1]. The anti-leakage curtain of the "soil in the soil" type of soil-cement elements is deepened into the water resistance to a depth of at least 1 m in order to ensure the absence of filtration. After hardening of soil-cement elements along the perimeter of the sludge storage, up to 60% of the soil mass is excavated

The period of hardening in the moist state lasts 28 days. Over time, the strength and water resistance of soil cement increase.

Filling of sludge storage with drilling waste is carried out after the hardening of soil cement.

Drilling waste is dehydrated before entering the sludge storage facility.

When filling the sludge storage, it is filled with waste according to the following technology: a layer of waste about 1 m thick is poured on the bottom of the sludge storage, then a soil layer of the construction site (humidity 4 - 5%) up to 1 m is poured on top of it. loam. Bringing the site stacked in the soil dumps to the humidity of 4-5% is done by drying it in the open air with periodic stirring and construction over the shelter storage place [11].

If it is not possible to receive optimum humidity of the mix after drying it is offered to add ash for removal of the Mykolaiv thermal power plant. The amount of additive is from 1.5 to 3% depending on the type of soil [12].

The thickness of the layers is selected and calculated to obtain the optimal moisture content of the sludge and soil mixture. Then perform compaction of sludge and loam layers with rammers. After compaction, the operation is repeated. Compaction of soil layers should be carried out at optimum humidity in order to obtain the maximum compaction factor and place in storage the maximum amount of waste.

In the case of predominantly oil (gas condensate) pollution, a method is used in which neutralization is achieved by accelerating the biological decomposition of organic compounds.

In waterproofed sludge barns is introduced a composition containing phosphogypsum, straw, and organic fertilizers in such concentrations, the mass fraction of which in percent is: phosphogypsum 2.0 – 3.0%; straw 1.0 – 2.0%; organic fertilizers 3.0 – 5.0%

After neutralization, drilling waste is buried in earthen sludge barns [13]. At a high level of contamination with petroleum products and reaching the plastic strength of the soil 0.68 - 1.00 MPa on the surface apply the sorbent and destructor of hydrocarbons oil biological product "Econadin" (or analogue) at the rate of 1 – 2 liters per 1 m^2.

Then the surface is plowed. If the parameters of the treated water do not comply with the norm, it is purified by re-treatment with coagulants and flocculants or by another known and available method (filtration on sand and gravel sites, treatment with adsorbents). Polyacrylamide (PAA) is used as a flocculant.

After wastewater treatment with coagulants, the active reaction of the medium (pH) is reduced. At pH <5.5, wastewater must be neutralized with an aqueous solution of lime or soda ash.

Conclusions

This method of creating a technological solution is relevant in the presence of a waterproof layer at the optimal depth from the surface (8-20 m).

The advantages of sludge storage design with soil-cement coating, which is placed on thickened to a rigid-plastic consistency drilling mud with the addition of soil from the construction site are low cost of production due to the use of waterproof soil layer as the bottom of the structure. After the hardening of the soil cement, the sludge storage cover is covered with a layer of fertile soil. Thus, it is possible to solve the problem of disposal of soil removed during the construction of sludge storage.

It is proposed to fill the sludge storage with a mixture of drilling mud and site soil (in the conditions of Poltava region - refractory loam) with alternating layers. It is also proposed to use a neutralization mixture consisting of phosphogypsum, wood ash, and organic fertilizers to neutralize waste and reduce the negative impact on the environment. This mixture will perform the functions of disinfection and drying of the mixture of drilling mud and soil, as the mixture includes ash.

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