Artículo de investigación

Methods of optimizing industry-related oil-ground mixtures from places of accidents on oil pipelines for utilization in road construction in Western Siberia

Способы оптимизации техногенных нефтегрунтовых смесей с мест аварий нефтепроводов для утилизации в дорожном строительстве в условиях Западной Сибири

Métodos para optimizar las mezclas de petróleo y tierra relacionadas con la industria de los lugares de accidentes en oleoductos para su utilización en la construcción de carreteras en Siberia Occidental

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Written by:
Anatoly Nikolaevich Shuvaev [182]
https://elibrary.ru/author_profile.asp?id= 484119
SPIN-code: 6583-6173, AuthorID: 484119
Aleksandr Aleksandrovich Testeshev [183]
https://elibrary.ru/author_profile.asp?id=450349
SPIN-code: 3002-8531, AuthorID: 450349
Anton Pavlovich Smirnov [184]

Abstract

Currently, the problem of utilization of oil-containing grounds from the places of accidents on oil pipelines has not been completely resolved, and its relevance is increasing more and more. The most common methods for collecting and eliminating oil spills do not provide for the disposal of oil and require further measures for its biodegradation. In addition, low cleaning capacity, high cost, and energy intensity are the restraining factors for the use of advanced technologies for processing oil-contaminated grounds.

The article discusses the genesis of industrial oil grounds and their distinctive features. The purpose of the research described in the article is to develop ways to optimize the make-up of industrial compositions, based on industrial and laboratory experiments. Testing the possibility of changing the content of the liquid phase in the oil-ground mixture during storage in the pile has reduced the concentration of the former by 75%, and of oil - by 84%. The proposed methods, depending on the topography and the genesis of the formation, the particle size distribution and

Аннотация

В настоящее время проблема утилизации нефтесодержащих грунтов с мест аварий нефтепроводов окончательно не решена, а актуальность ее все более возрастает. Наиболее распространённые способы сбора и ликвидации разливов нефти не позволяют утилизировать нефть и требуют дальнейших мероприятий по её биодеградации. Кроме того, в качестве сдерживающих факторов применения прогрессивных технологий переработки «замазученных» грунтов выступают низкая производительность очистки, высокая стоимость и энергоемкость. В статье рассмотрен генезис техногенных нефтегрунтов и их отличительные особенности. Целью описанного в статье исследования является разработка способов оптимизации составов техногенных композиций, на основе производственных и лабораторных экспериментов. Апробирование возможности изменения содержания жидкой фазы в нефтегрунтовой смеси при хранении в штабеле позволило снизить концентрацию последней на 75 %, а

[182] Doctor of Engineering, Professor, Expert of the Department of Geotechnics of the Construction Institute, Industrial University of Tyumen, Tyumen, Russia, 625000, email: shuvaevan@tyuiu.ru.
[183] Candidate of Technical Sciences, Associate Professor at the Department of Automobile Roads and Airfields of the Construction Institute, Industrial University of Tyumen, Tyumen, Russia, 625000, email: testeshevaa@tyuiu.ru.
[184] Engineer, Director of Technology Development Programs Function "Capital Construction" Gazpromneft NTC LLC, Moyka embankment 75-79, place 5430, Saint-Petersburg, Russia, 190000.

the purpose of the material, represent the combinatorics of known technological operations. Particular attention is paid to the basic operation of storing industrial oil ground which allows optimizing the technology of storage and production of material with specified properties for the needs of road and site construction.

Key Words: Technogenic oil contaminated soil, liquid phase concentration, composition optimization, stack.

нефти – на 84 %. Предложенные способы в зависимости от топографии и генезиса образования, гранулометрического состава и назначения материала представляют комбинаторику известных технологических операций. Особое внимание уделено базовой операции по складированию техногенного нефтегрунта, позволяющей оптимизировать технологию хранения и получения материала с заданными свойствами для нужд дорожного и площадочного строительства

Ключевые слова: техногенный нефтегрунт, концентрация жидкой фазы, оптимизация состава, штабель.

Resumen

En la actualidad, el problema de la eliminación de suelos aceitosos de los lugares de accidentes de oleoductos no se ha resuelto por completo, y su relevancia está aumentando. Los métodos más comunes para recolectar y eliminar derrames de petróleo no permiten la eliminación del petróleo y requieren medidas adicionales para su biodegradación. Además, el bajo rendimiento de limpieza, el alto costo y la intensidad energética actúan como factores limitantes para la aplicación de tecnologías avanzadas para el procesamiento de suelos "aceitados".
El artículo considera la génesis de los suelos oleaginosos tecnogénicos y sus características distintivas. El objetivo del estudio descrito en el artículo es desarrollar métodos para optimizar la composición de composiciones tecnogénicas basadas en experimentos de producción y laboratorio. Probar la posibilidad de cambiar el contenido de la fase líquida en la mezcla de aceite y tierra durante el almacenamiento en una pila permitió reducir la concentración de este último en un 75% y el aceite en un 84%. Los métodos propuestos, dependiendo de la topografía y la génesis de la formación, la distribución del tamaño de partícula y el propósito del material, representan la combinación de operaciones tecnológicas conocidas. Se presta especial atención a la operación básica para almacenar suelos oleaginosos tecnógenos, lo que permite optimizar la tecnología de almacenamiento y producción de material con las propiedades deseadas para las necesidades de construcción de carreteras y sitios.

Palabras clave: Campo petrolífero tecnogénico, concentración de la fase líquida, optimización de la composición, apilamiento.

Introduction

The long and intensive operation of the facilities of the West Siberian oil and gas complex, and first of all its linear section, led to numerous oil losses throughout the entire production cycle due to imperfect technologies and accidental spills.
The industrial oil grounds that are formed during land spills remain environmentally hazardous for a long time, and require processing hampered by their large volumes and low utilization rates.
A solution to this problem may be utilization of products of accidents - oil ground of industrial origin for the construction of oilfield roads by the method of soil strengthening.

Literature review

The possibility of using oil to strengthen soils and their use in road construction is confirmed by years of research and practical experience (Bezruk & Lintser, 1975; Rakhmatullin, Suleimanov, Valeev & Daukaev, 2018; Testeshev, 2001). The main feature of industrial oil grounds is that the process of material formation occurs uncontrollably, without taking into account the quantitative indicators of the components of water and oil. As a result, the initial properties of the material differ from those required for traditional oil ground, which predetermines the need to optimize the make-up of industrial compositions for use in road construction.

Materials and Methods

The study is based on the physicochemical mechanics of dispersed structures and materials, as well as the theory of packing. A full factorial experiment was performed to determine the optimal dosages of the components of the industrial oil ground.

The production cycle of utilization of industrial oil ground includes methods for controlling the amount of the liquid phase (water + oil) in the mixture and methods for improving the strength characteristics by introducing inorganic binder additives (cement, lime).

At the first stage of optimization of industrial oil-ground mixtures, the possibility of obtaining optimal dosages of oil and water for their further utilization by the method of soil strengthening was determined.

As part of the hypothesis about the possibility of obtaining optimal compositions in the system “ground-oil” due to evaporation and filtration migration of the liquid phase in the porous structure of the soil during the preservation of the mixture, it was proposed to pile up and store industrial oil ground in piles. The presence of surface-active compounds in oil will provide strong adhesive bonds, and the free displaced liquid phase of oil and water under the influence of gravitational forces will flow out of the pile (Testeshev, 2001).

In order to study the nature of changes in the composition of industrial oil ground during storage in the pile, work was carried out in areas of industrial waste of the Prirazlomnoye field of RN-Yuganskneftegaz.

At the site of industrial waste, industrial mixtures with an oil content of 18%, 13% and 8% were stored in three piles, each 2.5 m high.

Since in soils with excessive moisture oil in the presence of water forms water-emulsion solutions, the content of the liquid phase (water and oil) was additionally determined, which was 30%, 25% and 20%.

To exclude evaporation of light fractions of oil in the working area of the site, the piles were covered with a reinforced polyethylene film. Thus, changes in the composition of industrial oil ground (oil and liquid phase) during storage in a pile should occur to a greater extent under the influence of gravitational forces.

Industrial mixtures were not mixed prior to piling-up, which predetermines the non-uniform distribution of oil and water along the height of the pile.

Taking into account this factor and the need for quantitative data on oil migration from the pile over time, samples of oil ground were taken at three levels along the height of the pile: at a depth of 0.2 m, 1.25 m, and 2.3 m.

After 4, 2 and 1 months for oil-ground mixtures stored in piles No. 1, No. 2 and No. 3, the oil content changed to 5.3%, 6.6% and 6.0%, respectively.

Expanding the range of optimal dosages of oil from 4% to 6% and determining the change in the amount of the liquid phase over time, a graphical dependence was obtained (Figure 1).

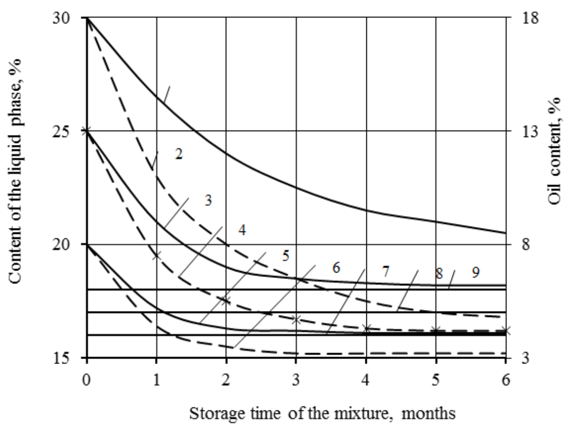

Figure 1 – The dependence of the amount of the liquid phase and oil in the mixture on the storage time: 1, 3, 5 - the content of the liquid phase is 30%, 25%, and 20%, respectively ; 2, 4, 6 - the oil content is 18%, 13%, and 8%, respectively; 7, 8, 9 - the optimal oil content in the mixture No. 1, No. 2, No. 3 (6%, 5% and 4% of oil, respectively)

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The confirmed possibility of changing the amount of oil in the industrial oil-ground mixture made it possible to proceed to the second stage of optimization of compositions aimed at improving the strength characteristics.

When selecting the composition of oil-ground mixtures with inorganic binders, ensuring the achievement of the required physical and mechanical properties (GOST 23558-94, 2005; GOST 30491-2012, 2013), the following quantitative characteristics of the components were obtained.

TABLE The required content of the components of oil-ground compositions, reinforced with inorganic materials

Composition	Amount by weight of dry soil, %		
	oil	cement	lime
Oil ground + cement	6.0	5.0	-
Oil ground + lime	4.0	-	4.0

In general, the results obtained from field and laboratory experiments allow us to proceed to the direct development of methods for optimizing industrial oil grounds based on their storage in a pile.

Results and discussion

Analysis of the actual production conditions, the specifics of the material and the results of the research allowed us to outline several methods of adjusting the total liquid phase (water and oil) and obtaining optimal mixtures of industrial oil grounds (Figure 2).

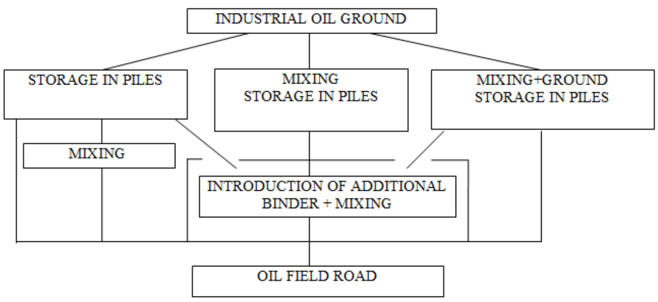

Figure 2 – Methods of obtaining optimal mixtures of industrial oil ground

Due to the fact that each method has its own characteristics, it seems reasonable to consider them in more detail.

The first option is to store the oil-ground mixture in a pile at the technological test site. In the presence of a homogeneous oil-ground mixture with a total content of the liquid phase significantly exceeding the optimum, its immediate introduction into road structures is not possible. In this case, the mixture is placed and stored in a pile at the technological test site. The period of active reduction of the oil content in the mixture, depending on various storage factors, varies from 30 to 120 days or more. The main advantage of this method is the minimum energy consumption and the possibility of extending the construction season.

The second option is most applicable when oil ground is received from various places and with different concentrations of oil, and therefore, to achieve homogeneity, it is pre-mixed with subsequent storage. The advantage of the method is the possibility of obtaining high homogeneity of the material; the disadvantage is the increased consumption of energy resources compared to the first option.

The third option provides for the addition of clean soil to the oil ground with a high content of oil. In this case, at a constant mass of oil in the mixture, a quantitative change occurs in the

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skeletal part, as a result of which it becomes possible to adjust the concentration of oil in the mixture to the required one. The desirable condition is the uniformity of the added soils, and the soils forming the skeletal part of the oil ground. The advantages of this option include the possibility of obtaining a mixture of high homogeneity without a long storage time, and the disadvantage is an increase in energy consumption.

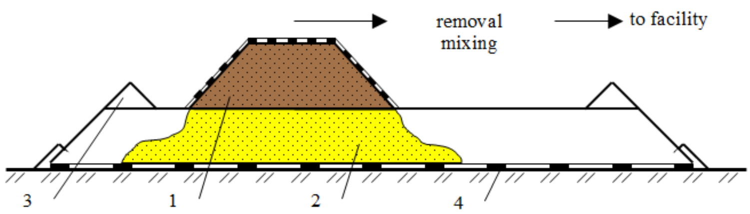
The fourth option involves mixing the mixture after storage. It is used when the oil-ground mixture comes from various places and, for various reasons, it is impossible to carry out mixing before storage. The advantages and disadvantages are the same as in the third option. The fifth, sixth and seventh options associated with the introduction of an additional binder, differ in the sequence of this technological operation in the general chain of preparation of the mixture of the optimized composition.

Technical and economic analysis showed that the most promising method of optimizing is storage in a pile, and therefore, appropriate recommendations were developed.
Depending on the initial oil content, the variety of the mineral part of the oil-ground mixture, and the availability of process equipment, the following technological methods for storing industrial oil grounds in a pile at the site have been developed (Figure 3).

The first method of storage (Figure 3, a) is applicable for the case when the mineral part of the oil ground is represented by soils of optimum particle size distribution and the soils of the site have good oil capacity and permeability. In order to prevent the ingress of oil into the soil-hydrological environment, a layer of geomembrane is arranged under the platform. After aging to achieve the required oil content, the oil-saturated ground of the site is also utilized in road structures.

The second method (Figure 3, b) is characterized by the absence of a bulk pad, so the need for additional work on the disposal of the site's soils is eliminated. The mineral part of the oil ground is also represented by the soils of the optimal composition. The isolation of the pad and the oil-gathering ditch is made by longitudinal overlapping of geomembranes with thermal welding. Oil ground piles stacked on a planned site with a slope of 10‰ in the direction of the oil-gathering ditch. To prevent volatilization of the light fractions of oil, it is pumped daily into the storage tank.

a)



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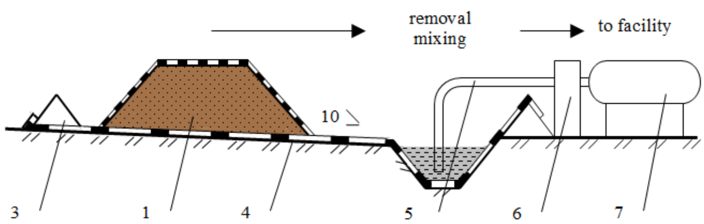

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c)

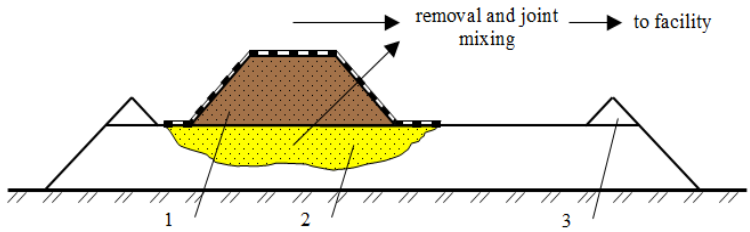

Figure 3 – Schemes of storage of oil ground: a) storage with site soil impregnation; b) storage with subsequent pumping of oil; c) storage with site soil impregnation which improves the granulation; 1 - pile; 2 - impregnation soil; 3 - dike; 4 - geomembrane; 5 - suction hose; 6 - pump; 7 - oil storage tank

The third scheme (Figure 3, c) was developed for the case when the mineral part of the oil-ground mixture is represented by soils of non-optimal composition. In this case, the site pad is made from soils that improve the skeletal part of the mixture. If the site pad is made of soils of heavy mechanical composition (loams, clays), then due to their low oil capacity and depositing properties, the layer of geomembrane is not arranged. After the outflow of free oil from the mixture, the oil ground is mixed together with the impregnated soil of the site, which improves the skeletal composition of the mixture.

Conclusions

Thus, the proposed and tested methods for optimizing industrial oil grounds allow us to bring the amount of oil and water to the required values to obtain a material with high homogeneity and the required physical and mechanical properties for use in the structural layers of roads. In the development of the research, we plan to expand the range of neutralizers of oily substances, including drilling mud waste (Zaitsev, Nikitin & Shuvaev, 2018), in order to reduce the environmental risks of using materials in road construction.

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