Development of mobile technology for the disposal of oily waste

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Abstract: Currently, one of the key sectors of the Russian Federation is the fuel industry. Oil and gas production is growing annually; in 2018, 555 million tons of oil and 733 billion m3 of gas were produced. The problem of the oil and gas industry is the negative impact on the environment, namely, the activities of oil and gas companies produce dangerous environmental pollutants, one of which is oil sludge. At the same time, it is a valuable raw material (potential product) that can be used in various industries. Despite the fact that large amounts of oil sludge are formed in specialized facilities (barns), the volume of disposal and the degree of their use are low, which leads to the concentration of oily waste in sludge barns. These factors have an anthropogenic impact on the environment, thereby creating a threat to human health.

1 Introduction

Oil pollution entails a number of environmental factors:

- the complexity of the chemical composition of oil, which is in the process of constant transformation;
- complexity, heterogeneous composition and structure of any ecosystem that is in the process of constant change.

Oil and petroleum products are environmental pollutants. The behavior of oil in the environment depends on its viscosity. Reduced viscosity leads to the fact that oil spreads over the surface of the relief, forming a monomolecular film layer. If the film thickness reaches 10 mm, then the penetration of oxygen is delayed by about 5-10%, which does not have a significant effect on the vital activity of organisms. In the case when the absorption capacity of the oxygen oil film is 80-90%, the photosynthesis process is hindered, which leads to a decrease in oxygen concentration, which contributes to the inhibition of the vital activity of organisms and even to their death[1-3].

Oil pollution (slick) under environmental factors can increase in size, evaporate, absorbed by living organisms, as well as undergo transformation. In a short time, up to 25% of light fractions of oil pollution evaporate. Under the influence of sunlight, the processes of destruction of oily compounds are significantly accelerated. After evaporation of light fractions, the process of destruction of oil pollution slows down. Heavy oil fractions form persistent emulsions over time. The rate of the process of destruction of oil products de-

pends on the temperature of exposure. The lower the temperature, the slower the decomposition reaction. Thus, the degradation of petroleum products occurs as a result of chemical, photochemical and bacterial decomposition, as well as the activity of some organisms and plants. But it is worth noting the fact that the rate of natural neutralization of oil products can be months and years, disrupting the natural balance, leading to pathological changes in tissues and organs, disrupting the functioning of the enzymatic apparatus of living organisms. Waste accumulation is carried out at specially designated sites or in bins without any sorting or classification.

In the process of accumulation and storage of waste in sludge collectors, natural processes occur - the accumulation of precipitation, phase separation, the development of microorganisms, the occurrence of oxidative and other processes.

As a rule, relatively light liquid hydrocarbons are concentrated in the upper layer — low-water oil with a relatively low mass content of solids from 0.5% (for trap oils) to 1.5% (for barn oils). This drive layer is most interesting for recycling. Usually, after dehydration and appropriate post-treatment, it is sent to the feed streams entering the refineries.

The middle layers are characterized by a high water content — a finely divided emulsion of a complex type ("direct" and "reverse") with a mass content of water of 70–95% and mechanical impurities of 1.5–15%. The content of water and mechanical impurities in it can increase monotonically from top to bottom, can be placed randomly in volume, and can be distributed almost uniformly [3,5,6,7,]

The water in the industrial barns is produced in conjunction with the oil produced water, diluted by precipitation. As a result of dilution, its mineralization decreases slightly and the chloride content varies from 7 to 10 g / l, and the total mineralization is from 1 to 16 g / l.

In the lower, near-bottom layer, about 3/4 falls on the wet solid phase saturated with oil products (up to 5-10%) and water (up to 25%); the oil content is relatively constant, the amount of solids increases with depth.

It concentrates heavy hydrocarbon fractions and associated petroleum organocompounds, resins, asphaltenes and particles of the solid mineral phase [8-10].

The aim of this work was to develop a mobile technology for the disposal of oily waste accumulated in sludge collectors, with the further possibility of returning the resulting products to the production cycle.

2 Materials and methods

The following are the most studied disposal technologies today:

2.1 The thermal method

The main thermal disposal method is incineration. Process conditions: t = 800-1200 ° C, excess oxygen [11,12].

As appropriate equipment, chamber, bubbler, fluidized-bed mine installations and rotary kilns are used.

The disadvantage of this method:

- incineration cannot be used for waste treatment if the latter contains phosphorus, halogens, sulfur. In this case, reaction products can be formed, for example dioxins and furans, which are many times more toxic in terms of toxicity.

2.2 Chemical separation method

It is based on the use of solvents. To disperse oil sludge, low-boiling paraffin hydrocarbons, for example, n-hexane, a wide fraction of light hydrocarbons, gas condensate and some others are used [13,14].

The disadvantages of the method:

- the use of special technological equipment;
- high consumption of scarce and expensive organic solvents.

2.3 The biological method

Biodegradation is carried out by using special strains of bacteria, biogenic additives and air supply [15,16].

The process is characterized by a fairly simple hardware design and environmentally friendly.

The disadvantages of the method:

- low productivity and high cost, the impossibility of implementation at low temperatures.

2.4 Physical and chemical methods

During processing, oil sludge is preheated, the oil-water emulsion is destroyed, and each component obtained is disposed of. To increase the efficiency of separation into the hydrocarbon and aqueous phases, the oil sludge is treated with a specially selected demulsifier [17,18].

Under the influence of temperature, demulsifier and acoustic vibrations, emulsions separate, and when a flocculant is introduced, the process of coagulation of mechanical particles occurs. The treated oil sludge then goes to a two-phase centrifuge, in which, under the influence of centrifugal forces, it is additionally cleaned from the suspension of mechanical particles. The purified centrifuge centrate in pressure mode is passed through a self-cleaning filter equipped with an acoustic system and enters a three-phase self-unloading centrifugal separator with the release of oil and water.

The disadvantages of the method:

- the high cost of the reagents used;
- inapplicability for hard-stratified high-viscosity oil sludge with a high content of paraffins and asphaltenes.

2.5 Processing by centrifugation

It is known that oil sludge for the most part is represented by heavily destructible colloid formations, including oil products, water and mineral components. Their processing is very difficult and requires an integrated approach [19,20].

Centrifugation on decanters is usually carried out through two successive stages. The first part separates the bulk of the solid particles. Coarse mechanical impurities are removed from the apparatus in the form of a solid residue. The liquid phase, consisting of oil and water (and a minimum amount of mechanical impurities) enters the second stage of purification. In a three-phase dishwasher centrifuge, the mixture is separated into oil, water and solids [21].

The nominal capacity of a typical oil sludge processing plant, designed for round-the-clock operation, excluding shutdown time for preventive maintenance, is not more than 15 m3 / hour. The technological complex is designed to process up to 70 - 75 thousand m3 of

oil-containing sludge per year, subject to its uninterrupted supply of raw materials with a certain characteristic:

- free oil content of 10-45 vol. %;
- density of the oil phase up to 950 kg / m3;
- viscosity of the oil phase up to 150 cSt at 50 ° C;
- the permissible presence in the oil of paraffins that completely dissolve at 70 ° C;
- the content of solids is not more than 30 vol. %;
- density of mechanical impurities is not higher than 1.8 g / dm3;
- pH in the range of 5-8.

Changing the parameters of the nominal raw materials will affect the performance and separation efficiency of the separation unit. This can lead to a decrease in its productivity or to a deterioration in the quality of the separated products.

To further reduce undesirable impurities in oil products produced from oil sludge, the use of coalescing separation is practiced. This gives the expected positive results.

The disadvantages of the proposed method:

- increased requirements for the reagents used;
- the need for a constant composition of raw materials;
- complex hardware design of the process.

3 Results

As part of the analysis of advanced technologies in the field of oil-containing waste processing, a search was carried out for equipment that would allow the separation of oil sludge into fractions. One of these equipments is the installation of process activation [22]. The principle of operation of this equipment is as follows:

- a traveling electromagnetic field of high power located in the zone of the installation of process activation, allows for exposure in the form of vibrations of a complex frequency spectrum, which includes ultrasonic vibrations and broadband cavitation components. This allows you to initiate the formation of a process of separation of a stable emulsion (oil, water, gas).

The principle of operation of this technology is as follows (Scheme 1). The first stage of work will be the pumping of the upper 2 and middle layer 3 from the waste disposal facility using a slurry pump with a capacity of 150 m3 / h to the receiving hopper 6. The hopper has a coil inside to heat the incoming raw materials with steam up to 40-50 0C. After that, the heated oil sludge is pumped by the NB-50 pump to the process activation unit 8. This installation creates a powerful ultrasonic field that allows you to affect the incoming raw materials, changing the structure. After processing the raw materials to the process activation plants, the separated fractions are sent to the waterproofing sump 9. This storage tank is a capacity of 2,000 m3, which is located 500 meters from the preparation line. In the waterproofing drive, sedimentation of sediment occurs within 24 hours. After that, the CAA50 mobile pumps are supplied with a liquid fraction to the head of the oil preparation process. After passing the stage of separation of oil from water, oil is sent to the installation for the preparation of oil 12, and water is sent through the production line to the well to maintain reservoir pressure 13 [23,24].

The resulting inert material is discharged from the waterproofing sump in the adjacent territory of the accommodation facility, in order to further reduce humidity under the influence of the environment. Also, the obtained inert material is diluted with a 1: 1 structurator, which allows one to obtain soil-organic-mineral soil that meets the requirements for use on industrial lands. The resulting soil can be used for the following purposes:

- filling the bowl of the waste disposal facility;
- restoration of bunches of wells;

- arrangement is expensive;
- as a structurer.

4 Discussion

This approach is the most promising. Indeed, to date, oil producing companies utilize their waste by getting a low-liquid product that accumulates at their production facilities. The proposed method minimizes the negative impact on the environment by several times, and also allows you to highlight a valuable product that, going through the oil treatment unit, will be commercial products in the form of fuel. Industrial water will be directed to the needs of the enterprise in order to create reservoir pressure. Inert material will be additional soil for backfilling of the same object from which the waste was excavated. Thus, this technology will be resource-saving, and most importantly, using it on oil sludge with a high content of oil products, it is possible to achieve the isolation of a valuable product up to 50% of the total waste.

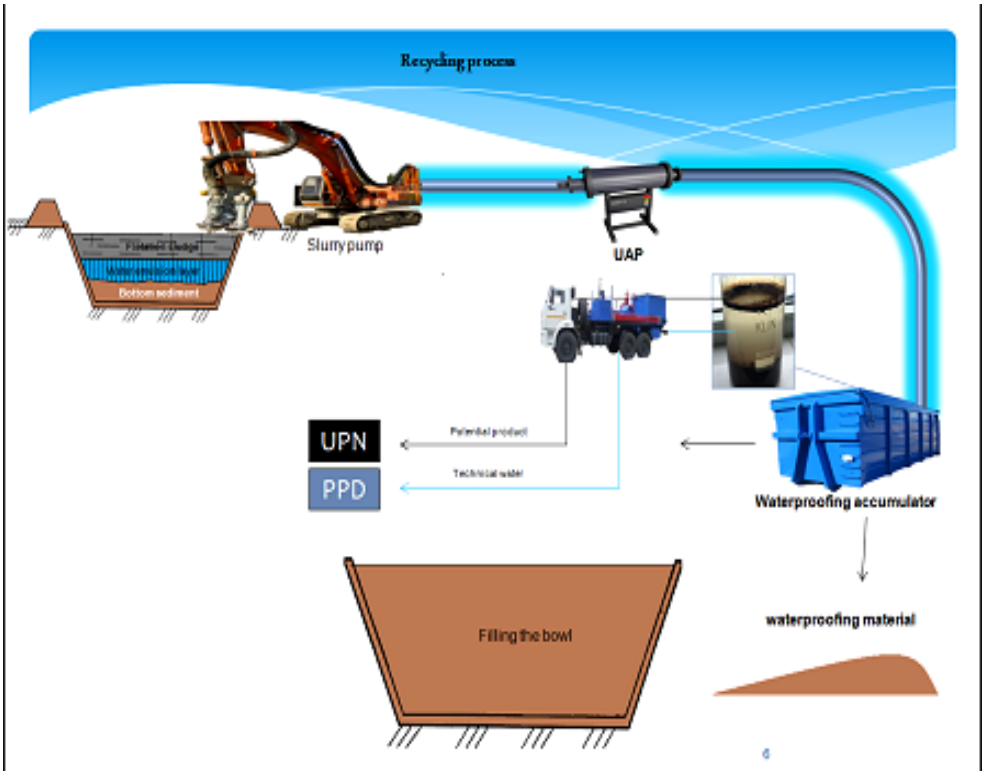

Fig. 1. The technological process of oil sludge processing using a cavitation installation.

5 Conclusion

In the framework of this work, a technological solution was developed regarding the use of a mobile complex for the disposal of oily waste, which is based on the installation of cavitation action. The results of the proposed technological solution will be the effective processing of oil sludge with the further possibility of isolating a valuable product (oil product, water, inert material) and its use in production. The project aims to reduce the negative impact on the environment by reducing the amount of waste disposed of in an open

environment, as well as reducing the financial costs of waste disposal with the possibility of additional profit from the sale of a valuable product.

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