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Physicochemical Properties of Light Ractions Which Released During the Distillation of Diluted Oil Sludge

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Abstract

The article presents the results of the development of an integrated technology for the disposal of oil sludge, research of the characteristics of oil sludge and the physical and chemical foundations of the process. We have determined the physicochemical properties of the distillate after the distillation of diluted oil sludge obtained at various process temperatures. A series of experiments were carried out to determine the density and viscosity, distilled fractions in the process of obtaining bitumen from oil sludge. To do this, the density of the fraction was first determined using a hydrometer and the viscosity of the fraction using a viscometer of the brand "Capillary glass viscometer VPZh-4". The viscosity value depends on the nature of the liquid, i.e. on its chemical composition, chemical structure and molecular weight. With an increase in the temperature of the distillate fraction within 105 ÷ 200 C, its viscosity gradually changes from 0,93 to 2,47 mm2/s. The density of the investigated fraction obtained at a temperature of 105 C is 765 kg/m3, and at a temperature of 110 C this indicator is 775 kg/m3, the change in the process temperature at 170 ºC also changes its density and is 785 kg/m3, with further an increase in temperature to 200 °C, the density index reaches its maximum, i.e. 820 kg/m3. At the same time, the article presents the results of the studies of the fractional composition of the distillate obtained during the disposal of oil sludge. Also, the amount of sulfur in the composition of the obtained fractions was determined during the distillation of a mixture of oil sludge. The results of determining the amount of sulfur in the separated fractions (light naphtha, heavy naphtha, heavy gas oil) are presented.

Keywords: oil sludge, distillate, distillation, density, viscosity, bitumen, viscometer, fraction, sulfur, light naphtha, heavy naphtha, heavy gas oil

Introduction

Currently, oil, gas condensate and natural gas are used as the main sources of raw materials for the oil and gas industry. In the process of production activity during the extraction, processing of crude oil, and transportation, oil sludge is formed. As a result of interaction with environmental conditions, any sludge is formed, and during any period of time there are no sludges with the same physical and chemical characteristics and compositions in nature. And also special attention is paid to the disposal of oil waste. Oil sludge (due to the significant content of petroleum products in it) can be attributed to secondary material resources in the chemical industry. Using it as a raw material is one of the rational ways of its utilization, since it achieves a certain ecological and economic effect [1-7].

One of the most pressing problems in the world is the processing of oil sludge accumulated in the oil traps of oil refineries. The accumulated oil sludge leads to pollution of the soil and vegetation cover, soil erosion, desertification and, as a result, to a decrease in the land fund and its simplification, as well as to local deterioration of ecosystems. At the moment, oil refineries do not process accumulated oil sludge, therefore, processing and obtaining a secondary product from oil sludge of impregnating construction bitumen is an urgent problem [8-14].

Our goal is to study the possibilities of using oil sludge as a secondary raw material and, thus, one more step closer to waste-free production. Slimes are pasty masses with a moisture content of 65-85%. Most of the slimes belong to the 3-4 group of sediments and consist of particles with a size of 10-5-10-7 cm. The slimes of each production have their own characteristics depending on the chemical composition of the generated wastewater and the methods of their treatment used at this enterprise [15-19].

To determine the methods of disposal of oil sludge, it is necessary to know their composition and physical and chemical properties. Based on the above, we carried out a series of experiments to determine the content of mechanical impurities in the composition of oil sludge after dilution with oil fractions with stirring for 30 ÷ 60 minutes in accordance with GOST 6370-83 [20].

Experimental Method

The purpose of our research is to develop an integrated technology for the disposal of oil sludge, to study the characteristics of oil sludge and the physical and chemical foundations of the process.

We carried out a series of experiments to determine the density and viscosity of the distilled fractions in the process of obtaining bitumen from oil sludge. To do this, the density of the fraction was first determined using a hydrometer and the viscosity of the fraction using a viscometer of the "capillary glass VPZh-4" brand.

To measure the flow time of the fraction, a funnel was installed on the knee and the lower part of the viscometer was filled by 1/3-1/2 of the volume. The viscometer was installed in the thermostat so that the expansion was below the liquid level in the thermostat. The correctness of the installation of the viscometer was checked with a plumb line in two mutually perpendicular planes. After holding in a thermostat for at least 15 minutes to establish temperature equilibrium, the liquid was sucked into the knee by about 1/3 of the expansion height using a rubber tube and a pear put on the knee. The rubber tube was removed from the knee and the time of movement of the meniscus of the liquid from the M1 mark to the M2 mark was determined using a stopwatch with the free flow of the fraction with an accuracy of 0.2 s. The results of three consecutive measurements should not differ by more than 0.02%.

The viscosity value depends on the nature of the liquid, i.e. on its chemical composition, chemical structure and molecular weight. We have determined the dynamic viscosity of the distilled fraction in the process of obtaining bitumen from oil sludge according to the well-known formula:

$$V = \left[\frac{g}{9{,}8}\right] \cdot T \cdot K, \tag{1}$$

where K – viscometer constant, mm^2/s^2; T – arithmetic mean time of fraction expiration, s.

The dynamic viscosity of the investigated oil product (μ) in mPa · s was calculated by the formula:

$$\mu = \nu \cdot \rho, \tag{2}$$

where ν – kinematic viscosity, mm^2/s; ρ– density at the same temperature at which the viscosity was determined, g / cm^3.

Results and Discussion

We have determined the physicochemical properties of the distillate after the distillation of diluted oil sludge obtained at various process temperatures. The research results are shown in Fig. 1.

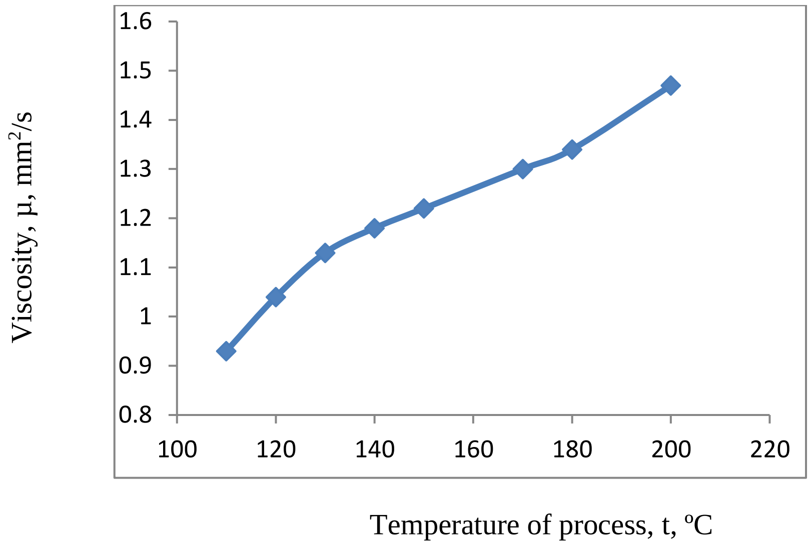

Fig. 1. Change in the viscosity of the fraction obtained during the disposal of oil sludge depending on the temperature of the distillation process

Fig.2 shows that with an increase in the temperature of the distillate fraction within 110 ÷ 200 ºC, its viscosity gradually changes from 0.93 to 2.47 mm^2 / s. In the course of experimental studies, we also determined the density of the investigated fractions. Also, the density of the obtained fractions was determined.

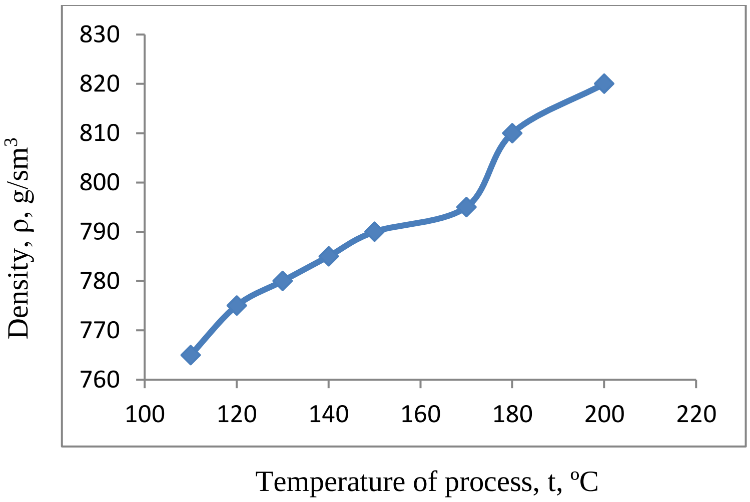

Fig. 2. Changes in the density of the fraction obtained during the disposal of oil sludge depending on temperature

The figure shows that the density of the investigated fraction obtained at a temperature of 105 °C is 765 kg/m^3, and at a temperature of 110 °C this indicator is 775 kg/m^3, the change in the process temperature at 170 ºC also changes its density and is 785 kg/m^3, with a further increase in temperature to 200 °C, the density indicator reaches its maximum, i.e. 820 kg/m^3. From the data in Fig.1, it can be noted that the density and viscosity of the investigated fraction changes depending on the process temperature. The results of the studies of the fractional composition of the distillate obtained during the disposal of oil sludge are shown in tab.1.

Table 1. Fractional composition of the obtained distillate at disposal of oil sludge

Density of oil sludge at 20 ºC, g/cm3	1,2
Water content in oil sludge, %	26
Content of mechanical impurities, %	19
Fractional composition of oil sludge	
Distillation temperature of oil sludge	93
at 95 °C% of the total is distilled.	1
- 105 -	4
- 110 -	11
- 120 -	13
- 130 -	15
- 140 -	20
- 170 -	25
- 180 -	35
- 200 -	45
- 210 -	60
- 230 -	75
- 240 -	86,0

Tab.1 shows that the density of oil sludge at a temperature of 20 °C is 1.2 g / cm^3, the water content in the oil sludge is 26%, the content of mechanical impurities in the oil sludge is 19%. The initial temperature of distillation of oil sludge is 93 °C, at 95 °C 1% was distilled, and at 105 °C - 4%, at 110 °C - 11%, at 120 °C - 13%, at 130 °C - 15% and the experiment continued in this form up to 240 °C, while 86% of the total amount of oil sludge was distilled. Also, the amount of sulfur in the composition of the obtained fractions was determined during the distillation of a mixture of oil sludge.

Table 2. Sulfur content in the composition of distillate fractions obtained during the distillation of a mixture of oil sludge

(ratio of oil sludge to solvent: 70 % oil sludge and 30 % solvent (light naphtha)) (соотношение нефтешлама к растворителю: 70% нефтяных шлама и 30% растворителя (легкая нафта))

№	Received fractions	Sulfur content, %	
1	Light naphtha	0,027	0,029
2	Heavy naphtha	0,030	0,031
3	Heavy gas oil	0,035	0,039

Table 2 shows that in the composition of light naphtha the amount of sulfur is 0,027-0,029%, and heavy naphtha contains 0,03-0,031% sulfur, and also, the amount of sulfur in the composition of heavy gas oil was 0,035-0,039%.

In order to separate mechanical impurities from the composition of oil sludge, several experiments were carried out, dilutions of oil sludge were made with various diluents: light naphtha, heavy naphtha, reformate and gasoline. The results are shown in the following diagrams.

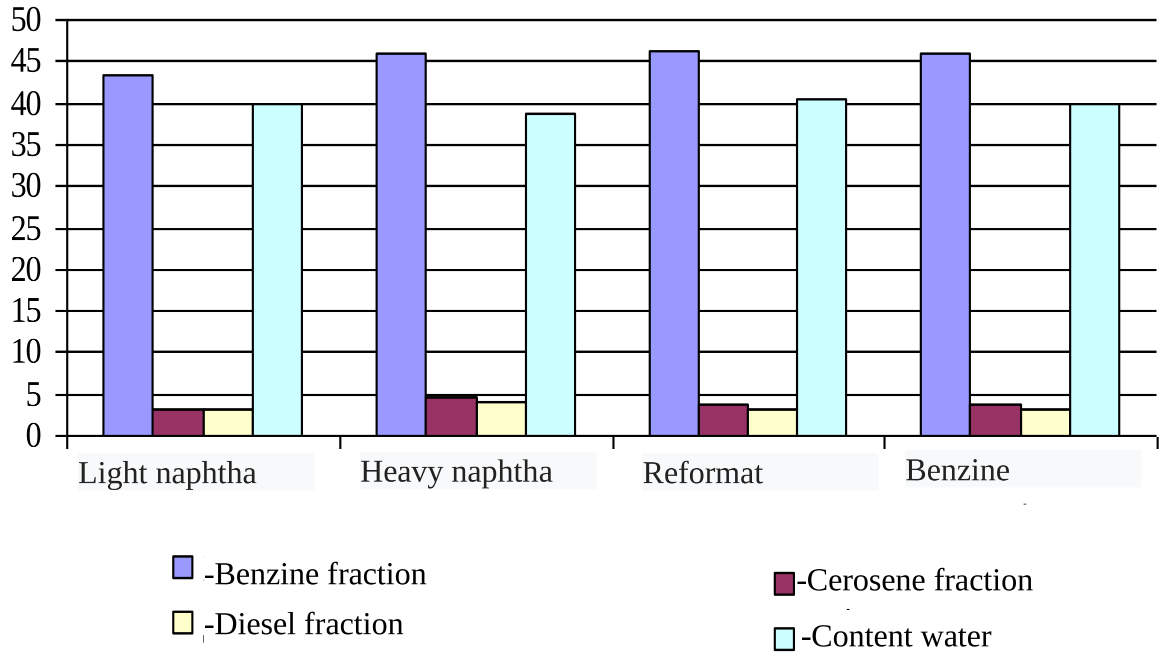

Fig. 3. Yield of light fractions when diluting oil sludge with various diluents

Fig. 3 shows that the duration of stirring for each experiment is 60 minutes, a ratio of solvents is 30%. The water content in the oil sludge when diluted with light naphtha is 39.75%, in heavy naphtha it is 38.73%, and in the reformate 40.4%, in gasoline 39.88%, i.e. the water content in the oil sludge is on average 39.69%, the gasoline fraction is 46.2%, the kerosene fraction is 3.75%, the diesel fraction is 3.05%. It is due to the fact that the most suitable diluent is - with a ratio of 30% reformate and 70% sludge.

Conclusions

Thus, with an increase in the temperature of the distillate fraction within 110÷200 °C, its viscosity gradually decreases from 0,93 to 2,47 mm^2/s. The density of the investigated fraction obtained at a temperature of 105 °C is 765 kg/m3, and at a temperature of 110 ºC this indicator is 775 kg/m^3, the change in the process temperature at 170 ºC also changes its density and is 785 kg/m^3, with further an increase in temperature to 200 °C, the density index reaches its maximum, i.e. 820 kg/m^3. From the data, it can be noted that the density and viscosity of the investigated fraction changes depending on the process temperature. In the composition of light naphtha, the amount of sulfur is 0.027-0.029 %, and heavy naphtha contains 0.03-0.031 % sulfur, and also, the amount of sulfur in the composition of heavy gas oil was 0.035-0.039%.

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