Results of Preparation of Oil Slime for Primary Processing

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Abstract
Background: L Results of a research on preparation of oil slime for processing are given in article, for dilution of oil slime different types thinners in various ratios are chosen (light and heavy naphtha, gasoline and hydrocarbon solvent). For the purpose of purification of oil slime of mechanical impurity it is used centrifugal cleaning which flow rate is varied within 10÷20 of m/s.
Keywords: oil, oil slime, flow rate, hydroclone, mix, gasoline, centrifugal cleaning

1. Introduction

Oil sludge is a multicomponent stable aggregative system, consisting mainly of oil products, water, sand, clay, etc. The main reason for the formation of oil sludge is the physical and chemical interaction of oil products with moisture, air oxygen and mechanical impurities. As a result of such processes, the initial oil products are partially oxidized with the formation of tar-like compounds. There are no sludges with the same composition and physicochemical characteristics [1]

During the extraction, transportation and processing of oil, oil sludge is formed and accumulated [2]. In general, all oil sludge can be divided into three main groups according to the conditions of their formation: ground, bottom and reservoir type. The former are formed as a result of spills of oil products on the soil during production operations, or in emergency situations. Bottom sludge is formed due to oil spills settling to the bottom of reservoirs, and reservoir-type oil sludge is formed during storage and transportation of oil products in tanks of various designs [3,4,5].

The ratio of oil products, water and mechanical impurities (particles of sand, clay, rust, etc.) varies over a very wide range: hydrocarbons make up 5-90%, water 1-52%, solid impurities 0.8-65%. Such a significant change in the composition of oil sludge, the range of changes in their physico-chemical characteristics is also very wide. Density of oil sludge ranges from 830-1700 kg/m3, pour point from -3oC to +50oC. The flash point lies in the range from 35 to 120°C [6,7,8].

During long-term storage, oil sludge separates over time into several layers, with properties characteristic of each of them: the top layer is a watered oil product containing up to 5% fine mechanical impurities and belongs to the class of water-in-oil emulsions. The composition of this layer includes 70-80% oils, 6-25% asphaltenes, 7-20% resins, 1-4% paraffins. The water content does not exceed 5-8%. Quite often, the organic part of the freshly formed upper layer of oil sludge is close in composition and properties to the original oil product; the middle layer, relatively small in volume, is an oil-in-water emulsion. This layer contains 70-80% water and 1.5-15% mechanical impurities; the next layer entirely consists of settled mineralized water with a density of 1.01-1.19 g/cm3; finally, the bottom layer (bottom silt) is usually a solid phase, including up to 45% organic matter, 52-88% solid mechanical impurities, including iron oxides. Since bottom silt is presented as a hydrated mass, the water content in it can reach up to 25%. In the process of processing sludge, various technological methods can be applied depending on their physical and mechanical characteristics. The collected oil sludge of a liquid-viscous consistency is subjected to separation into oil products, water and solid mechanical impurities. This phase of processing has its own goal - the extraction of oil products with original properties from the sludge and their use for its intended purpose. There are two main methods of phase separation of liquid-viscous oil sludge - mechanical and chemical. For deeper purification of petroleum products, complex technology is sometimes used. The mechanical destruction of stable water-oil emulsions is based on technological methods for artificially changing the concentrations of the dispersed phase of the emulsion, followed by coalescence of small droplets of this phase. To carry out the operation of interfacial separation of liquid-viscous oil sludge, a large number of technological devices have been developed, including separators, centrifuges, hydrocyclones of various designs [9,10,11].

Based on the foregoing, we have carried out a series of experiments on the distillation of dilute oil sludge with various solvents (solvent ratio 30%) under laboratory conditions. The results of the research are shown in Tables 1-4.

Table 1

The output of light fractions from the composition of dilute oil sludge

(light naphtha - 30%, weight of oil sludge - 4000 ml, mixing time - 30 min, mixture density - 900 kg/m3).

№	Faction Names	Temperature (exit),⁰C	Temperature (cube),⁰C	Fraction output, %
1	Petrol	84-166	130-250	41,12
2	Kerosene	196	260	2,75
3	Diesel	204-237	298-338	2,62
4	Water	-	-	37,87
5	Remainder	-	-	10,87
6	Losses	-	-	4,75
	Sum	-	-	100

table 2

The output of light fractions from the composition of dilute oil sludge

(hydrocarbon solvent - 30%, weight of oil sludge - 4000 ml, mixing time - 30 min, mixture density - 905 kg/m³)

№	Faction Names	Temperature (exit), ⁰C	Temperature (cube), ⁰C	Fraction output, %
1	Petrol	130-183	175-209	46,12
2	Kerosene	205-239	209-300	6,0
3	Diesel	260	350	3,5
4	Water	-	-	34,25
5	Remainder	-	-	6,39
6	Losses	-	-	3,74
	Sum			100

Table 3

The output of light fractions from the composition of dilute oil sludge
(gasoline - 30%, weight of oil sludge - 4000 ml, mixing time - 30 min, mixture density - 920 kg/m³)

№	Faction Names	Temperature (exit), ⁰C	Temperature (cube), ⁰C	Fraction output, %
1	Petrol	70-170	112-270	44,5
2	Kerosene	179	330	3,5
3	Diesel	260	330	3,25
4	Water	-	-	33,5
5	Remainder	-	-	10,55
6	Losses	-	-	4,7
	Sum	-	-	100

Table 4

The output of light fractions from the composition of dilute oil sludge
(reformat - 30%, weight of oil sludge - 4000 ml, mixing time - 30 min, mixture density - 920 kg/m³)

№	Faction Names	Temperature (exit), ⁰C	Temperature (cube), ⁰C	Fraction output, %
1	Petrol	105-184	170-310	38,83
2	Kerosene	210	336	3,02
3	Diesel	263	341	2,75
4	Water	-	-	42,22
5	Remainder	-	-	8,03
6	Losses	-	-	5,15
	Sum	-	-	100

2. Methods

It can be seen from Tables 1÷4 that different solvents were taken for each experiment in a ratio of 30%. Mixing time 30 min. Light naphtha, hydrocarbon solvent, reformate, and gasoline were used as solvents for the decomposition of oil sludge. To dissolve 4000 ml of oil sludge, 120 ml of light naphtha was added, while the density of the mixture was 900 kg/m3, this indicator in the hydrocarbon solvent was 905 kg/m3, and with further addition of 120 ml of reformate and gasoline, this indicator remained unchanged, i.e. . - 920 kg/m3. The water content in oil sludge when diluted with light naphtha is 37.87%, and in a hydrocarbon solvent - 34.25%, and in gasoline - 33.5%, reformate - 42.22%, i.e. The water content in oil sludge is on average 37%. The yield of gasoline fractions when diluting oil sludge with light naphtha was 41.12%, and with the help of a hydrocarbon solvent 46.12%, in gasoline 44.5%, this figure with the help of reformate was 38.83%. This is due to the fact that the oil sludge in the hydrocarbon solvent dissolves to the limit. Thus, the most suitable fraction for diluting oil sludge is a hydrocarbon solvent.

To determine the effect of the velocity of a diluted liquid flow on the efficiency of cleaning oil sludge from mechanical impurities, we conducted a series of experiments. The experiments were carried out in a hydrocyclone, i.e. in a centrifugal field. In the course of the experiments, the flow rate in the hydrocyclone was varied within 10÷20 m/s. The results of the experiments are shown in table.5.

Table 5

The results of cleaning oil sludge depending on the flow rate (initial concentration of mechanical impurities 25%)

№	Speed of diluted oil sludge, m/s	Light naphtha	Hydrocarbon solvent	Heavy naphtha	Reformate	Gasoline
		Residual concentration of solid particles of mechanical impurities, %				
1.	10	7,18	1,91	4,03	2,96	5,14
2.	11	7,01	1,84	3,88	2,74	4,81
3.	12	6,82	1,77	3,72	2,59	4,39
4.	13	6,56	1,48	3,48	2,37	4,23
5.	14	6,24	1,21	3,12	2,11	3,93
6.	15	5,16	0,92	2,93	1,98	3,52
7.	16	4,62	0,21	2,18	1,86	3,21
8.	17	3,91	0,19	1,92	1,72	2,95
9.	18	3,01	0,16	1,74	1,66	2,57
10.	19	2,87	0,11	1,56	1,59	2,44
11.	20	2,04	0,02	1,43	1,22	2,31

With an increase in the speed of the diluted oil sludge in the hydrocyclone from 10 m/s to 20 m/s, the residual concentration of solid particles of mechanical impurities also changes within 7.18 ÷ 0.02%, and the type of diluent also affects the separation of solid particles from the diluted oil sludge. (light naphtha, heavy naphtha, reformate, hydrocarbon solvent and gasoline).

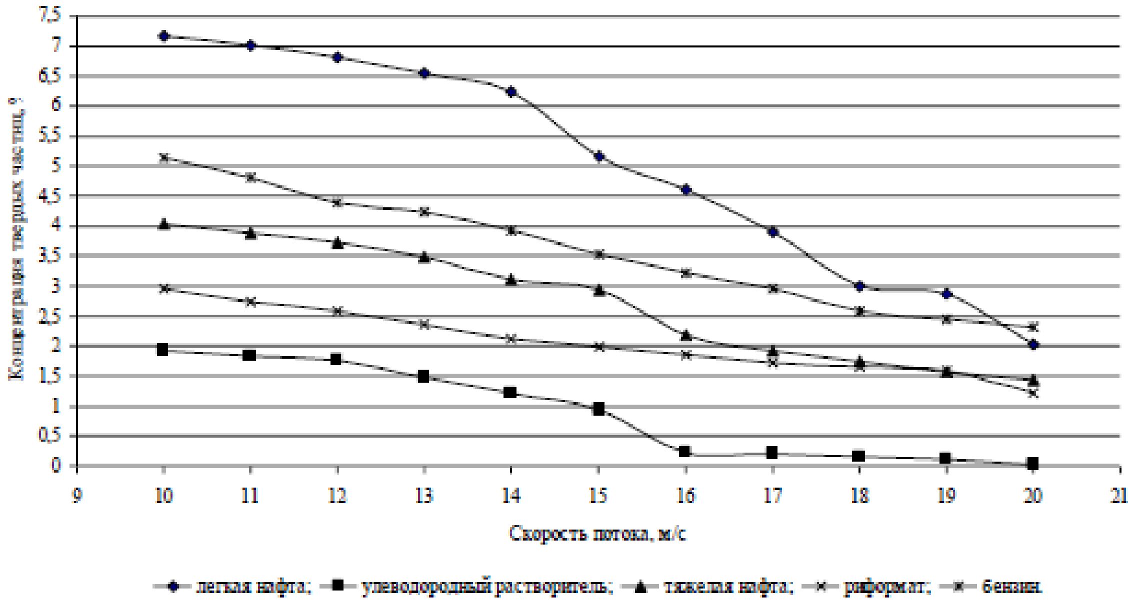

Fig.1. Variation in residual solids concentration as a function of flow rate.

It can be seen from Fig. 1 that at a speed of 10 m/s of a diluted liquid flow with light naphtha, the residual concentration of solid particles of mechanical impurities in the composition of the diluted mixture is 7.18%, and at 11 m/s this figure was 7.01 %, with a further increase in the flow rate to 20 m/s, the concentration of solid particles was 2.04%. At a speed of 10 m/s diluted with heavy naphtha, the concentration of solid particles was - 4.03%, at 15 m/s of diluted this solvent, the residual concentration was - 2.93%, and at 20 m/s, the concentration of solid particles was - 1, 43%. In the course of experiments on the purification of oil sludge from mechanical impurities, it was found that a hydrocarbon solvent was chosen to dilute the oil sludge in order to purify it from mechanical impurities, i.e. at a speed of 10 m/s of a liquid stream of a dilute hydrocarbon solvent, the residual concentration of solid particles was 1.91%, and with an increase in the flow velocity, 11 m/s, the concentration of solid particles was 1.84%, and with a further increase in the flow velocity to 20 m/s, the residual concentration of solid particles in the composition of the diluted mixture was 0.02%. This is explained by the fact that for the dilution of oil sludge in order to easily separate solid particles of mechanical impurities from the composition of the oil sludge, a hydrocarbon solvent was selected.

Further experiments on the purification of oil sludge from mechanical impurities with various diluent ratios by oil sludge were carried out in a centrifugal field at a liquid flow velocity of 20 m/s, the concentration of solid particles of mechanical impurities in the composition of the initial and purified oil sludge was determined in a Soxhlet flask under laboratory conditions. The results of the experiments are shown in table.6.

Table 6

The results of cleaning oil sludge from mechanical impurities with various solvents (initial concentration of mechanical impurities 25%)

№	Ratios of raw materials, % (solvent/oil sludge)	Light naphtha	Hydrocarbon solvent	Heavy naphtha	Reformate	Gasoline
		Residual concentration of solid particles of mechanical impurities, %				
1.	30/70	4,62	0,21	2,18	1,86	3,21
2.	40/60	3,91	0,19	1,92	1,72	2,95
3.	50/50	3,01	0,16	1,74	1,66	2,57
4.	60/40	2,87	0,11	1,56	1,59	2,44
5.	70/30	2,04	0,02	1,43	1,22	2,31

Table 6 shows that with a change in the type of solvent, the concentration of solid particles of mechanical impurities in the composition of the diluted mixture also changes, i.e. when diluted with light naphtha at a ratio of 30/70, the residual solids concentration is 4.62%, and at 40/60 the solids concentration was 3.91%, at a ratio of 50/50, the residual solids concentration of mechanical impurities was 3.01 . With the change of solvent to heavy naphtha at a ratio of 30/70, this figure was 2.17%, with a ratio of this diluent of 70/30, this figure was 1.43%. The conducted experiments on oil sludge treatment are also illustrated in Fig. 3 below.

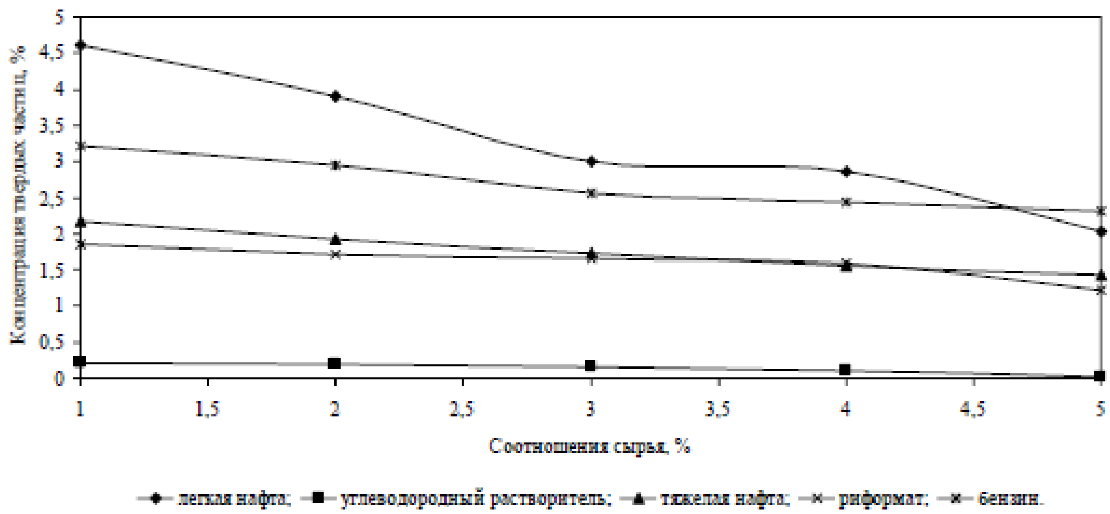

Fig.2. Change in the concentration of solid particles in the composition of oil sludge depending on the ratio of the solvent

3. Results

With a change in the diluent for diluting oil sludge to a hydrocarbon solvent (Fig. 2) at a ratio of 30/70, the residual concentration of solid particles of mechanical impurities in the diluted mixture was 0.21%, and at a ratio of 40/60 this indicator was 0.19%. With a further change in the diluent ratio to 70/30, the residual concentration of solid particles of mechanical impurities in the composition of the diluted oil sludge also decreases to 0.02%. This is explained by the fact that with an increase in the ratio of the diluent to oil sludge, the concentration of solid fine particles of mechanical impurities also decreases, and in order to easily separate solid particles of mechanical impurities from the composition of oil sludge, a hydrocarbon solvent can be selected.

Thus, for the purification of diluted oil sludge in a centrifugal field, the optimal liquid flow velocity of 20 m/s was chosen. The experiments carried out on the preparation of oil sludge for processing indicate that a hydrocarbon solvent was chosen to dilute the oil sludge, while the residual concentration of solid particles in the diluted mixture was 0.02% at a ratio of 70 oil sludge + 30% hydrocarbon solvent. In the composition of oil sludge, the average content of gasoline fractions is 42.6%, the average content of kerosene fractions is 3.8%, and the diesel fraction is 3.03%. To dilute oil sludge in order to isolate valuable components from its composition, the most suitable fraction was chosen - a hydrocarbon solvent.

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