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OIL SLUDGE AS SOURCE OF A VALUABLE CARBON RAW MATERIAL

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Abstract

General trends of recovery of oil sludge into the commodity products are presented below. The technology of concentrating of the carbon part of oil waste was justified. The sequence of processes for refining of sludge into the road and construction bitumen, antiseptic and waterproof materials and lubes was presented as a structural scheme.

Keywords: *oil sludge; waste; refining; ecology; bitumen.*

1. Introduction

Oil sludge is the type of the common industrial waste, which considerably pollutes the environment. It appears during the exploitation of oil comprehensive treatment units and directly at the oil processing units. The general direction of the oil refineries development strategy is both decreasing of the harmful influence of the oil waste and increasing of the oil refining level. Therefore, oil sludge can be involved into the technological refining of carbon materials, which aims to the production of the different commodity components and goods.

Oil sludge is very hazardous due to its high toxicity (it pollutes rivers and ground water, soil and plants, atmosphere). It appears as a result of technological equipment exploitation (in vessels, pump stations, pipes etc.) and it is a water-oil emulsion mixed with the various mechanical admixtures (organic and inorganic). The stability of this system depends on its storage duration. During the storage light hydrocarbon fractions may be evaporated from the sludge and the amount of mechanical admixtures, which enter into sludge from the atmospheric dust may be decreased. It should be mentioned that the origin and composition of sludge will define the way of its utilization.

The simplest way of sludge utilization is the burning in the incinerators, which have special construction. A significant amount of ash, carbon dioxide and other dangerous gases appear during the burning. A valuable hydrocarbon raw material is used for production of electrical energy and another technological issues.

Considering the long world experience in the sludge processing, we can present the following perspective directions, which allow to obtain valuable commodity products as a structural scheme (fig. 1)

Shperber [5] describe the fuel composition for boiler, it has low viscosity, high stability, low corrosion activity and includes mazut, oil sludge and the waste of coal refining – pyrogenetic water. The components percentage in this composition is: oil sludge – 30-70 % (mass), pyrogenetic water – 0.5 – 5 % (mass), mazut is all the rest. The oil sludge is taken from the oil tank and contains 10-20 % of water. Vapour at a temperature about 363 – 368 K passes through the fuel composition, which should be emulsificated for up to 20 – 30 minutes. The proposed composition can also be applied as a technological fuel, including at the heating supply companies. The composition includes oil sludge (60 % mass), heating oil (30 % mass), and kerosene or diesel fuel (10 % mass) [6]. There is also well-known a fuel composition, that contains fuel trap product (10 – 70%), heavy gas oil (30 – 90 %) as a product of catalytic cracking or slow coking and heavy pyrolysis tar or fuel additives and home heating oil. The composition is obtained by mixing of fuel trap product with heavy gas oil and heating oil at a temperature about 300 – 325 K.

There is a high-stable fuel for heating room that contains oil sludge and sodium carboxylate in 1: (1-3) ratio in a general part of coal dust (40 – 60 %). Oil sludge can also be applied in the production of fuel briquettes for the communal-general needs, when the peat and the coal dust are mixed up to the homogeneous mass with the following adding of plasticizers in the amount of about 4 % (mass.). After that the mixture is soaked until it gets tight-plastic consistency, then it goes to the press where the fuel briquettes are formed under pressure up to 2.5 MPa. [9]

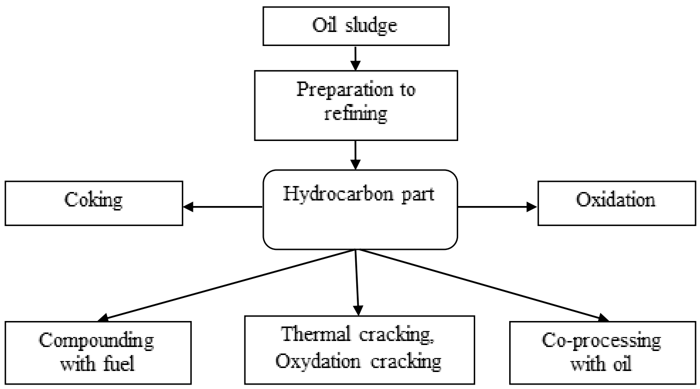

Fig. 1. Perspective directions of sludge processing

Hence, the hydrocarbon part of the oil sludge can be used as a valuable source for thermo-destructive processes of refinery that aim production of high-quality motor and boiler fuels components. Thereby we should consider the thermal cracking of oil sludge [10] which implies feeding of the sludge with an active hydrogen-donor additives as a raw material and its heat treatment in the cracking zone. Water may be applied as a hydrogen-donor additive, the raw material goes to the cracking zone as an oil-water emulsion under the supercritical pressure (about 22.5 – 35 kPa) and temperature about 600 – 750 K. The final products of cracking are gas C1 – C4 (1 % mass); low-boiling component (8 % mass, boiling point – about 430 K): fraction 430 -630 K (64 % mass); fraction 630-770 K (12 % mass); fraction above 770 K (15 % mass). The production of light distillate fraction can be possible through the thermal cracking and consecutive decreasing of the raw material temperature [11]

Then sludge is treated by the gas burner to get heated through the whole volume. Gas burner has a temperature about 780 K and the power density about 20 kW/m^2. The process also implies tanks for sludge and residue, tube furnace for sludge, pumps, reactors and furnace for inert gases. The emanating screen is placed inside the reactor and its surface is parallel to the oil sludge surface, the screen is heated up by the gas burner and the distance between screen and liquid surface is 30 – 300 mm. The sludge can be pretreated by waves through formation of wide frequency spectrum (from acoustic to light range in the treated area).

This process is followed by thermal cracking at 633 K and atmospheric pressure which leads to production of gaseous final products [12]. There is also a way of oil sludge refining through the atmospheric thermal cracking at about 623 – 673 K in the cavitation zone in the electrical field with the strength about 0.5 – 2.0 kV/sm. Then gaseous and liquid products are mixed in the buffer vessel for transportation through the main pipeline.

There is also the technology of oxidation cracking of heavy oil sludge that includes pretreatment of sludge with removing of admixtures and heating up to 723 K. Then sludge is treated by the heated air (T= 800 K) and thermal cracking in the remote reactor (pressure in the reactor is about 0.12 MPa). The further stage is separation of the light oil fractions. Heavy residual product of the thermal cracking goes to the hardening machine or evaporation column [14].

Application of oil sludge as a binding component in the preparation of blend for half-coking of solid fuels [3] of at the slow-coking equipment where sludge is heated up and mixed with a recirculated material (heavy coking gasoil), the obtained secondary product is also heated up to 650 – 660 K and goes to the coking chamber. The coke and distillate are products of coking. Distillate goes to the rectification column for extracting of the light fractions and distillation residues.

Technical literature contains an information about methods of refining through oxidation and compounding which aim the production of components for road, construction and water-proof materials.

There is a technology of bitumen production by pretreatment of oil sludge (water content is less than 5 % mass, mechanical admixtures – less than 16.4 % mass), then raw material is separated into 2 flows, one of those flows is consistently heated up to 470 – 500 K with simultaneous light fractions stripping, then it is oxidized by the air at about 500 K throughout 6 -20 hours for obtaining the oxidized tar. The second flow is heated to 480 – 650 K in the inert gas atmosphere.

The other part of the prepared raw material is heated up in the inert gases (nitrogen, argon *etc.*) to 500 – 660 K. That leads to the obtaining of vacuum tar with the simultaneous stripping of light and heavy petroleum products. Light and heavy petroleum fractions may be applied as a thinner or heating oil and as a raw material for cracking or hydrotreatment at the refineries. Then we calculate numerous indicators of oxidized and vacuum tar for their applying as the raw bitumen according to the RB 20/40. Analyzing these results according to the required properties of the commodity bitumen we can define the proportion of the oxidized and vacuum tar. After that tar will be compounded at 430 – 500 K [16]. Syroezhko [17] propose the composition for production of the cold asphalt concrete. The composition contains binding agent that includes sand (crushed granite), oil sludge (dehydrated, organic part is 60 – 80 % mass, mineral part – 2-4 % mass, sulphur – 3-5 % mass, water –the other) and bitumen. Also the binding agent may contain limestone mineral powder (5-6 % mass). There is also a composition of a cold asphalt concrete that includes bitumen, sulphur-containing fractions and oil sludge in the following ratio: bitumen МГ 70/130 – 6-6.5 %, sulphur-containing fractions 0-5 mm – 98-99 % mass, oil sludge – 1-2% mass [18]. The authors of [19] describe the material, which can be applied for waterfroofing of underground structures, foundations and roofs. It contains of oil sludge (50-65 %), and filler (20 – 40 % mass) - clay or grinded expanded clay

2. Further development of sludge refining processes

Analyzing the foregoing information it should be mentioned that processing of the oil sludge into the road and construction (e.g. waterproof elements) materials is the most reasonable from technical and economical point of view. This kind of processing implies simple equipment and operation practices. The presence of mechanical admixtures and water doesn't make negative effect. Thereby we propose the structural scheme of complex sludge processing (fig. 2) that stipulates particular separation of water and mechanical admixuters.

Water may be either applied as a technical circulating agent in the water cooling devices or in the oxidation column for temperature decrease and admixtures may be added to the commodity products as the filler or may utilized on the landfills. The hydrocarbon agent which is released after preparation, contains paraffin-naphtenic hydrocarbons (30 – 50 % mass), cyclic aromatic hydrocarbons (25 – 29 % mass), tar (17 – 27 %), asphaltenes (4 – 14 % mass) [20]. The tar, asphaltenes, aromatic and paraffin hydrocarbons may be oxidized by air and solidified and that obstacle encourage the production of the high-quality bitumen. Thereby hydrocarbon component may be either oxidized in the column for production of commodity bitumen or be concentrated. During the concentration of the hydrocarbon component we can obtain atmospheric or vacuum concentrate (depending of the pressure) with the boiling point about 630-700 K and fuel fractions which can be applied as the components for motor and boiler fuel. During the further processing bitumen enriched by adding the polymer components, fillers and fuel additives to increase its frost and wear resistance.

Then we add polymer component, fillers and fuel additives to the bitumen base, obtained by concentration (T = 420 – 600 K, constant mixing). After the 30 min heat treatment bitumen base turns into bitumen which can be qualified as classical oxidized bitumen.

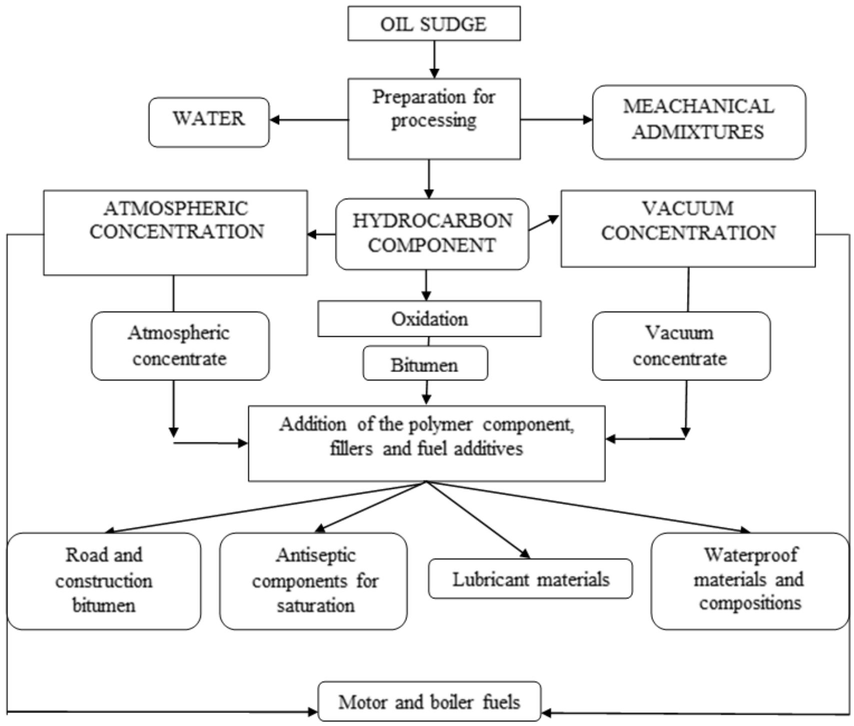

Fig 2. The structural scheme of complex sludge processing

The proposed scheme allows to obtain lubricants, antiseptic and waterproof materials by changing the concentration and chemical formula of the polymer component. It may be also applied for the processing of used motor oil, acid tar, oil fraction waste. The sequence of technological processes should be varied depending of the final products quality.

3. Conclusion

Using the long experience in the processing of oil sludge we have developed the principal scheme for production the antiseptic, waterproof materials and stable construction bitumen with a high adhesive and thermal strength. One of the most important point of the scheme is applying of the non-expensive and simple equipment, soft technological mode which allows to decrease the energy costs and, as a result – the cost price of the commodity product.

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