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Development of Methods for Extracting Oil in the Purification of Waste Oil with the Use of Solar Energy

Abdibattayeva Maral, Berdikulova Feruza, Beketova Aigul, Umbetbekov Askhat and Kalimbetov Galim

Al-Farabi Kazakh National University, Almaty, Kazakhstan

Abstract: The design solar devices and elements concentrating solar tracking system that ensures efficient use of solar energy in the processing of waste oil from the extraction of oil and refined products soils. Helio device developed by the authors tested for cleaning contaminated soils and sludge oil producing companies. Studied chemical and material composition of waste oil. To assess the feasibility of solar devices and technological regimes cleaning process waste oil heating modes tested waste using solar energy and using more stored energy in combination with solar energy. The research component of contaminated soils and sludges and solid residues after pretreatment using solar energy in the developed device.

Key words: Solar energy · Oily waste · Helio devices · Cleaning of oil wastes

INTRODUCTION

The growth of oil production volumes of its processing and transportation accompanied by increase in oil pollution and other toxic waste. From 3 to 7 % produced and consumed petroleum products lost forever in the form of pollution, or stored as waste. The main sources of environmental pollution are oil producing companies, elements of the pumping and transportation of oil and oil products, oil terminals and storage facilities, rail, river and sea oil tankers, gas station complexes and companies and autos. Currently, the oil companies, refining and petrochemical industries have accumulated several million tons of sludge, which are formed at a wastewater treatment plant in the system of water recycling, drilling for oil, while repairing equipment when cleaning tanks.

The problem of disposal or elimination of oily waste is usually complex technical challenge. The success of its decision largely depends on what principles based theoretical, experimental laboratory and technological development aimed at the destruction, processing or detoxification of the waste.

For the separation of organic and mineral part of oil waste method was developed for thermal processing of oil waste and device for its implementation. Developed a method for thermal processing of oil waste comprises supplying the feedstock into the heating zone and out of the solid residue, wherein a heating zone maintained at a temperature above 150 °C until flow able condition followed by separation of the raw material liquid of the organic part of the solid residue [1, 2].

After preheating the cooled heating zones inner tubular member produce a charge of starting material to the hopper and the feed mechanism includes a feedstock. Raw moving out of the cold portion of the inner tubular member and into a heating zone, where the melting of the organic part. Molten organic phase at this pops up and heavy soil particles coming down. Since the inner and outer tubular members are connected together and mounted at an angle of 10-45° respect to the horizontal plane, the flow of liquid phase occurs in the heating zone in the hoppers for raw materials to the drainage pipe. Organic part flows through the tube into the tank and the solid residue is thrown with a spiral screw the free end in the warehouse for storage. Consumption of propane-butane mixture of 130 cm^3/min, air - 5000 cm^3/min. Temperature in the luminous flame zone reaches 800-900°C. Temperature falling organic part 150-200 °C, the temperature of the solid residue 180 °C. The advantage of this device is the simplicity of the design. The device for the dry thermal processing of waste oil as coolants may be used any heat carrier agents (heat from the gas burner exhaust gases of combustion products, steam, hot water).

Corresponding Author: Abdibattayeva Maral, Al-Farabi Kazakh National university av. al-Farabi, 71, 050040, Almaty, Kazakhstan.

Oily waste relate mainly to moderately toxic and hazardous industrial waste 2 and Class 3 dangerous. According to the chemical analysis of the sludge in the sludge content of oil varies from 2000 to 13870 mg/kg. Oil sludge fraction represented primarily paraffinic- naphthenic hydrocarbons - 41.8 wt. %. Of which 20 % by weight - paraffin waxes, asphaltenes - 5.6 wt. %; resin - 19.2 wt. %. Polycyclic aromatic hydrocarbons - 20.1 wt. %. [3].

The method for extracting hydrocarbons from oily materials [4], including loading of raw materials in a rotating horizontal reactor coolant advancing successive heating of raw materials to the cracking temperature with recirculation in a hot mineral annealed part of the degradation of organic materials, evaporation, condensation and removal allocate gas mixture with separation into liquid and gas phases, the translation for coked mineral part of incineration to form a solid and gaseous coolants. The reactor is charged to 10 % of mineral annealed at a temperature of 200-350 °C, further introduced with vigorous stirring of the organic materials with a content of at least 3 % and 10-20 % by weight of mineral raw coked with temperature 200-400 °C then after reaching to the degradation temperature of the injected 20 % by weight of alumina silicate raw freshly regenerated catalyst at a temperature 500-700 °C.

We propose a method of separating oil from the waste sludge to produce a product suitable for further processing in the refinery [5, 6]. Raw petroleum process includes, water and >5 % solids. Sludge separated by centrifugation of the hydrocarbon fraction and water, after which the residue was heated first at a temperature of 107-227 °C and then at 204-621 °C to evaporate the water and hydrocarbon phases. The solid, which is the current standard in the U.S. is not environmental hazards. The evaporated hydrocarbon phase and water is condensed. From the resulting condensate recovered in a centrifuge hydrocarbon phase, which is sent for recycling. The recovered water is subjected to a standard purification.

The application [7] provides a method for purifying soil contaminated with hydrocarbons, in which the substance to be treated is pulverized and mixed with purge air and irradiated with UV light. Airflow recycled and dedusted. The installation includes a mill, vibrator, feed system and air purification, UV irradiator and compilation.

The organic part of the waste oil is a very complex mixture of hydrocarbons of various structural- group composition and their hetero derivatives having a wide range of physicochemical properties [8]. To extract the hydrocarbon part, most researchers used thermal methods.

Despite the ways [9-12] still not estimate the effect of temperature on the thermal processing. The disadvantages of the proposed thermal methods, despite the high degree of extraction of the organic waste, are the high cost of the units, the complexity of technological schemes and large due to the smoke of burning oil in the combustion zone.

In this regard, we performed research involves the development of technology increases the efficiency of the method with the use of thermal solar energy, requiring little cleanup costs.

We have developed a design solar concentrating device elements, providing maximum focus of direct and diffuse solar radiation and a new method of extracting oil, providing energy savings and traditional fuels, environmental clean environment, free from smoke emissions.

Scientific novelty of this work is to develop the scientific and technical bases of methods of extracting oil in the purification of waste oil in the device equipped with solar concentrating elements, ensuring maximum use of direct and diffuse solar radiation.

We have developed a solar device and the data are then used in the purification of oil pits and disposal of waste oil in a pilot industrial scale in the creation of an industrial prototype solar device. In research studies used oil waste oil producing companies Atyrau region. Experimental work was carried out spring-summer- autumn seasons in Almaty.

In the analysis of oil pollution should pay particular attention to oil pits - places localized accumulation of pollutants accompanying drilling, developing and operating oil wells. Oil has a high melting point and since most of the time the year is in the solid stat, so the technology is its utilization should include melting procedure. The oil must be heated to a temperature (40 - 60)°C, which leads to the mobility sufficient for its transportation. Maximum heating temperature shall not exceed (90 - 100) °C. Otherwise, it may boil off oil fractions and modified oil quality [13].

When selecting flow sheet paraffinic oil heating system, it is first necessary to specify the composition and properties of oil, occurrence phase and changes the state of aggregation and the composition of those components, containing petroleum oils or oils.

MATERIALS AND METHODS

In the analysis of oil pollution should be considered that the composition of crude oil and petroleum products is extremely complex and varies from sample to sample within a wide range.

Table 1: Composition of waste oil

	Composition, wt. %		
Waste oil	Organic Part	Contamination	Water
Oil sludge	76.8	8.0	15.2
Contaminated soils	11.6	85.4	3.0

For research use oil-contaminated soil and oil sludge Atyrau region. Composition as defined in Table 1.

Waste oil were processed to separate the oil components from the bulk waste. Analyzed part of the waste oil for further selection of the conditions being removed from the waste.

RESULTS

Fractional composition of a representative sample of oil was determined according to the method of simulated distillation by gas chromatography with mass spectrometric detection [ASTMD 2887] with modifications as described in the [Roussis, Analytical Chemistry 72, 2000].

For analysis a sample of crude oil was dissolved in chloroform in a 3:1 ratio and 1.0 mkl of the resultant solution using an auto sampler Combi-PAL (CTC Analytics AG, Switzerland) is injected into the gas chromatograph to input 7890A (Agilent, USA) and heated to a temperature of 300 °C in a stream of division mode of 30:1.

Separation was performed on a column DB-35MS (Agilent, USA) length 30 m, internal diameter 0.25 mm, film thickness 0.25 micrometers. Chromatography temperature programmed from 40 °C (hold 5 min) with a heating rate of 10 °C/min to 320 °C (15 min exposure). Detection was carried out on a mass spectrometer 5973N (Agilent, USA) in registration mode total ion current in the range of mass numbers 10-550. Low - mass spectrometer interface was 300°C. As a comparative sample using chloroform.

To ensure greater accuracy of the analysis of the resulting chromatogram subtracted chromatogram reagent blank, then led data processing. Obtained after subtracting the chromatogram shown in Figure 1.

Petroleum distillation curve obtained is shown in Figure 2. According to the method, taken for 100 % weight of distilled petroleum fractions to a temperature of 530-550 °C.

Group analysis of oil by gas chromatography - mass spectrometry was carried out according to the calculation method described in [Robinson, Analytical Chemistry 43, 1961] with modifications as described in the [Roussiset. al. Energy & Fuels 11, 1997].

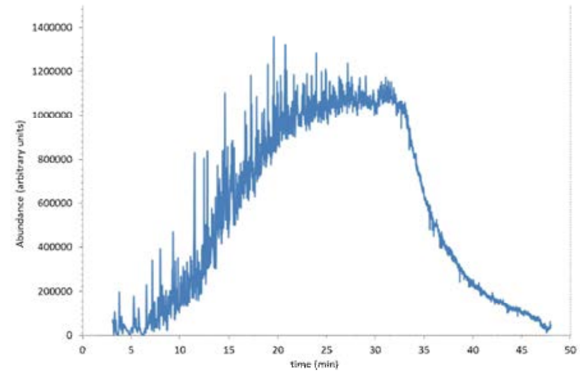

Fig. 1: The chromatogram obtained after subtraction of the reagent blank chromatogram chromatogram oil

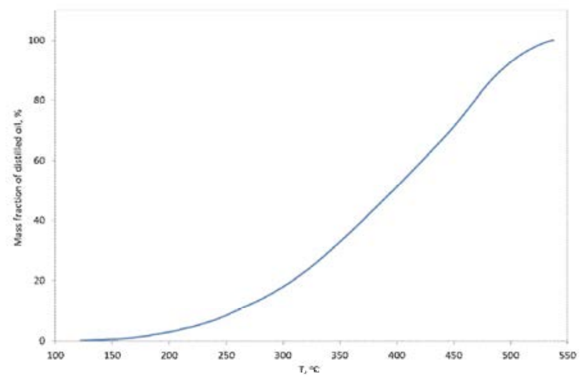

Fig. 2: The curve represented by the distillation of an oil sample

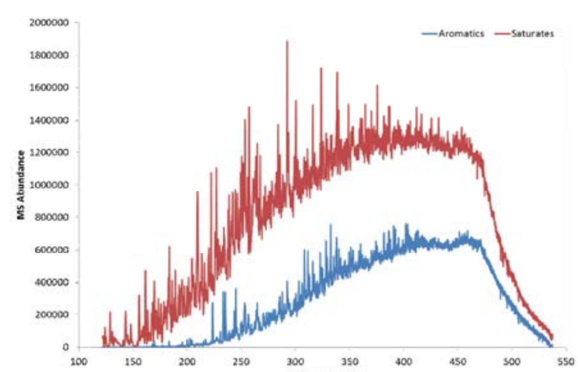

Fig. 3: The distribution curve of saturated and aromatic hydrocarbons in an oil sample under study depending on their boiling

To determine the specific compound classes (Table 2), the characteristic of the signals used for ion mass spectra recorded at each point in the chromatogram.

Table 2: Results of component analysis of a representative sample of fly oil

The class of compounds	Masses. %
Paraffins	15.32
Unfused naphthenes	22.13
Condensed naphthenes with 2 rings	19.45
Condensed naphthenes all naphthenes with 3 rings	14.11
Benzene	6.63
Naphthenbenzenes	3,09
Dinaphthenbenzenes	3.26
Naphthalenes	3.91
Acenaphthene	3.91
Fluorenes	4.88
Phenanthrenes	3.31

Table 3: Physical and chemical properties of the extracted oil from oily waste

Title properties and methods	Density at 20°C. kg/m^3	Density of the delivered oil kg/m^3	Content of chlorides, mg/l	Water cut oil %	Solids content	Sulfur content
norm on ND	830.0	833.7	100	0.5	0.05	0.6
First method	948.0	942.7	127.480	18.0	0.0349	0.168
Second method	852.1	942.7	407.9	35.0	0.0394	0.265

Fig. 4: Experimental area

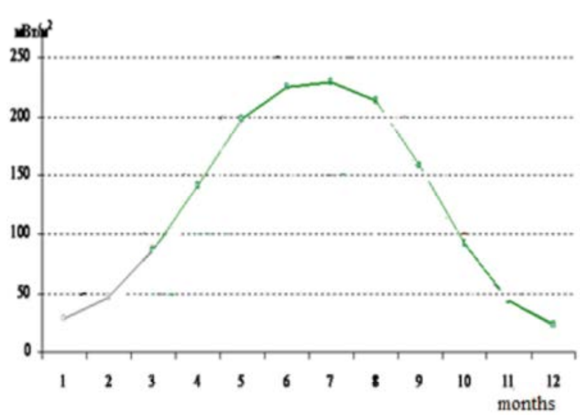

Fig. 5: Annual variations of solar radiation Almaty

Using the capabilities of the method used, the distribution curve was saturated and aromatic hydrocarbons studied sample of oil depending on their boiling points (Figure 3).

The experiments were performed with oily waste in Almaty on the experimental plot of the Almaty Technological University shown in Figure 4.

Annual variations of solar radiation Almaty is shown in Figure 5, which shows the possibilities of solar device in spring-summer-autumn.

For comparative analysis, the experiment was performed two ways: 1) using the solar energy and 2) using the solar energy storage in conjunction with solar energy. The first way is to use solar energy for heating of oily waste. In the second method for heating the oily waste was used more stored energy.

To create conditions for displacing oil from oily waste soil mixed with water and then putting them into the heat produced separately using solar and extra energy storage combination with solar. As a result of heating there was a separation of the hydrocarbon waste from the soil. To elucidate the effect of solar thermal impact on property hydrocarbons was investigated thermal properties of the extracted organic waste. Obtained after treatment with the use of solar energy more hydrocarbon phase, the physic - chemical characteristics significantly different from the hydrocarbon phase extracted using only solar energy [14].

Results of the analysis of the extracted oil from oily waste are shown in Table 3. The table shows that the content of chlorides, oil and water cut sulfur content in the application of additional accumulated solar energy is much higher than normal and also leads to a change in the physic-chemical properties of oil.

DISCUSSIONS

When using solar energy are mild conditions when extracting oil from the ground. As follows from the data cleaning product oily waste is a valuable hydrocarbon feedstock that can be recycled or used for other purposes [15].

To elucidate the effect of the thermal effects of solar energy on the properties of hydrocarbons was investigated component of contaminated soils and sludges and solid residues after pretreatment using solar energy in the developed device. Component composition of contaminated soils and solid residues after pre-treatment using solar energy are shown in Figure 6.

CONCLUSION

Thus, after pre-treatment of waste oil by using the solar energy in the residual solids content of the soil does not exceed 8.65-8.79 %. After purification, molecular weight hydrocarbons close in magnitude to the bitumen and the ratio of carbon to hydrogen varies according to the given row, bitumen (6.29 - 10.7) > or oil sludge contaminated soils (8.56 - 8.79). Advantages of this method of cleaning up oil waste for separating oil and mineral parts are simplicity of the apparatus, its performance and relative cheapness.

Developed a method for purifying oily waste solves an important environmental problem of disposal of oily waste, the recovery and prevention of the degradation of natural systems, reduce pollution soil and water. This will dispose of oil pits and sludge collectors around the oil-producing region. Thus, the technology of oily waste disposal sufficiently reduce the level of the negative effects of pollutants on the environment.

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