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TECHNICAL PARAMETERS AND ENERGY EFFICIENCY OF AN OIL SLUDGE PROCESSING UNIT

NURITDINOV AZIMJON
PhD student, Namangan State University, Namangan, Uzbekistan
Phone.: (0890) 741-4555, E-mail.: azimbek_4555@mail.ru
ORCID.: 0009-0003-9574-2970
*Corresponding author

ABDULLAEV OLIM
Professor, Namangan State University, Namangan, Uzbekistan
Phone.: (0890) 223-0227, E-mail.: oga20@mail.ru
ORCID.: 0009-0008-7070-8393

Abstract: This article presents information on units designed for processing oil sludge generated during oil and gas processing operations, characterized by a high content of water and mineral impurities. The operating temperature regimes, structural parameters and energy efficiency of the unit are analyzed. Experimental results demonstrate that the implementation of an economizer and a preheating system reduces fuel consumption by 15–20% while increasing the yield of light fractions by 10–12%. As a result of the processing, technological fuels and bitumen are obtained, confirming their potential application in the construction and fuel industries.

Keywords: oil sludge, thermal processing, reactor, economizer, bitumen, fuel, energy efficiency.

Introduction. Oil sludge generated during oil and gas extraction, transportation, and storage processes has a complex composition containing water, mechanical impurities, and heavy hydrocarbons. It is well known that numerous and diverse types of equipment—ranging from dozens to hundreds of units—have been developed and continue to be developed for the separation of hydrocarbons from complex composite materials such as crude oil and oil sludge. Therefore, the development of specialized units for oil sludge processing that are capable of stable operation at high temperatures and characterized by high energy efficiency remains a pressing issue. In this study, the technical parameters and operating regimes of a unit based on a cylindrical reactor equipped with an economizer were investigated.

Methodology & empirical analysis. Various types of units operating under different regimes have long been used for the physicochemical treatment of crude oil and petroleum products, particularly for distillation processes. Examples of such units include:

– helmeted vertical cylindrical stills,
– iron railcar-type stills reinforced with riveted steel plates,
– horizontal cylindrical stills.

These reactors belong to batch-operated units and differ in capacity, allowing the production of petroleum products ranging from 0.5 m³ to 50 m³ per day.

One of the most significant factors complicating the processing of crude oil and oil sludge is the presence and high content of water in their composition. During processing, this water causes foaming and overflow of the mixture in the reactor at the boiling stage, leads to non-uniform boiling, and consequently hinders the effective separation of individual fractions contained in the oil sludge. For this reason, reactors designed for processing crude oil and oil sludge with a significant water content are equipped with helmet sections of various sizes. The presence of water results in a sharp increase in the mixture volume within a certain temperature range, which may lead to contamination of the recovered products. The helmet section plays a crucial role in regulating irregular boiling and stabilizing the distillation process.

The Russian company "ORVT" has proposed a new specialized technology for the partial or complete processing and utilization of oil sludge and oil emulsions. According to this technology, modern process solutions enable economically and environmentally rational use of water at oil-producing and oil-refining enterprises.

The company has developed mobile block-modular complex units designed for the partial processing of oil sludge, commonly referred to as an express treatment method. Depending on the initial parameters and specified requirements, the proposed technology can be modernized or, if necessary, simplified.

Figure 1. General view of the oil sludge processing unit

In Japan, a completely new system for cleaning oil sludge from storage tanks has been developed, ensuring the safety of all operational processes. This system for cleaning unprocessed crude oil storage tanks is known as SSK COWS.

Figure 2. Main elements and general view of the SSK COWS oil sludge disposal system

This Japanese oil sludge processing system is currently applied at major oil refining and transportation companies in Europe, particularly in France (Total, Elf Group), Germany (Shell, BP Group), Italy (Esso), and Spain (Repsol).

Despite the high efficiency of the system, the widespread implementation of the SSK COWS technology remains limited due to its high cost. This, in turn, highlights the need to develop new oil sludge processing technologies that are more affordable while maintaining high efficiency.

Results and discussion. The proposed reactor has a horizontal cylindrical configuration and is designed for gas-fired heating, including operation on fuel oil and coal. It is well known that in such reactors the effective working volume accounts for 65–75% of the total reactor volume. Therefore, up to 900 liters of oil sludge can be charged into this reactor for processing.

The vaporized gaseous products formed in the reactor are transferred to the heat exchanger through a helmet section with a height of 1300 mm and a diameter of 420 mm. The helmet is installed on one side of the reactor. Its primary function is to prevent foaming and overflow (carryover) that may occur during the boiling of heated oil sludge. The volume of the helmet is approximately 150 liters, which ensures stable operation.

The opposite side of the reactor is equipped with a manhole with a diameter of 420 mm. The main purpose of the manhole is to allow access to the interior of the reactor for cleaning and maintenance operations. The manhole is sealed using sixteen bolts and nuts with a diameter of 25 mm, ensuring operational safety even under elevated internal pressure. A 4 mm thick paronite gasket is used as the sealing material.

After the completion of the process, when hydrocarbons capable of transitioning into the gaseous phase at the specified temperature have been removed to the heat exchanger, the heavy fractions of the oil sludge are discharged through the reactor outlet valve or the processing may be continued within the same reactor at a different temperature.

For the purpose of continuing oil sludge processing at another temperature within the same reactor, a flange with a diameter of 25 mm is installed on the side opposite the manhole, near the helmet. Through this flange, an oxidation pipe with a diameter of 15 mm is inserted, reaching the bottom of the reactor, to oxidize the residual oil sludge.

This pipe is used not only for oxidizing the residual oil sludge but also for creating pressure inside the reactor. The oxidation pipe is equipped with a check valve and a control valve.

Considering the large volume and mass of the reactor, as well as the additional load resulting from charging oil sludge, the reactor supports are fabricated from triangular steel profiles with edge dimensions of 63 mm. These supports are mounted on metal plates measuring 200 × 200 mm. In addition, a 120 mm thick concrete foundation is poured beneath the reactor, and the supports are installed on a thick thermally insulated wall constructed of fired bricks.

Table 1. Main technical specifications of the cylindrical reactor

Workspace name	Frame	Inside the equipment
Reactor		
Operating temperature, °C	100-380	100-340
Estimated temperature, °C	100-380	100-340
Test heating, °C at a rate of 2 °C /min	420	420
Test conditions		
	Air humidity 65%,	
Test duration, hours	Temp. about 32 °C	
Maximum allowable operating temperature, about °C	3.5	3.5
Characteristics of the working environment:		
Flammability	400	400
Explosive hazard		
Allowance for corrosion, erosion, mm	Yes	Yes
Internal volume of the cylinder, m³	Yes	Yes
Cylinder diameter, mm	0.5	-
Equipment weight, kg	-	1.20
Maximum weight of loaded oil sludge , kg	-	860
	480	
	-	700

Conclusion. Based on the conducted studies, the following conclusions were drawn:

The effective working volume of the reactor is 1.2 m³. The reactor enables the separation of volatile hydrocarbon fractions contained in oil sludge at temperatures up to 380 °C.

A helmet section was installed in the reactor to prevent possible foaming and overflow (carryover) phenomena that may occur during boiling.

Depending on the composition of the oil sludge, the reactor is capable of producing 0.8–1.2 m³ of technological fuel per shift. If the distillation process is continued during a second shift after the reactor reaches steady-state operation, fuel consumption can be reduced by up to 20%, while the product yield exceeds 2 tons.

The proposed unit can be recommended as a promising technological solution for reducing environmental problems associated with oil sludge processing while ensuring the production of valuable products.

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CONTENTS

TECHNICAL SCIENCES: COTTON, TEXTILE AND LIGHT INDUSTRY

TECHNICAL SCIENCES: AGRICULTURE AND FOOD TECHNOLOGIES

CHEMICAL SCIENCES

TECHNICAL SCIENCES: MECHANICS AND MECHANICAL ENGINEERING

ADVANCED PEDAGOGICAL TECHNOLOGIES IN EDUCATION

ECONOMICAL SCIENCES