



National Iranian Oil Refining and Distribution Company  
(NIORDC)



Journal of Farayandno

Review Paper

## Industrial cleaning methods of oil sediments (sludge) from crude oil and products storage tanks

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Received: 16 Mar 2022

Accepted: 21 Jun 2022

### 1. ABSTRACT

This article is written with the aim of investigating the industrial cleaning methods of crude oil and products storage tanks and identifying the most efficient, safe and economical ones. For this purpose, the types of cleaning and recycling methods for oil sludge describe along with their advantages and disadvantages, then three widely used manual, automatic, and robotic methods discuss. The results show that the automatic cleaning system with powerful pumps is the fastest cleaning system, while the robotic method, where the presence of people inside the tank is not required at every stage, is the safest system. In terms of cleaning costs and environmental impact, automatic and robotic systems may be more expensive than manual method, but due to the closed cleaning cycle, the ability to recover up to 95% of the sludge, income from the sale of recycle materials, they are the most cost-effective and environmentally friendly.

**Keywords:** Oil Deposits, Sludge, Storage Tank, Cleaning Method

### 2. INTRODUCTION

Oil industries around the world produce more than 1.4 million barrels of environmentally hazardous oil sludge every day. Oil sludge create great problems at during storage, for example reducing the capacity of tanks, oil pollution and reduction of quality, tank corrosion and repair costs, creating huge clean-up costs, environmental pollution due to waste disposal, reducing oil sales due to the loss valuable oil hydrocarbons. so, the owners of crude oil tanks and petroleum products are obliged to inspect, clean and possible repairs due to corrosion according to the standard rules and regulations.

### 3. CHEMICAL COMPOSITION OF OIL SLUDGE

knowing the percentage of oil sludge compounds is important due to determining the type of solvent and chemicals to liquefy viscous and solid sludge. The chemical composition of oil sludge is never the same. For example, Table 1 presents the oil sludge analysis of Iran and Libya storage tanks [1].

**Table 1.** Analysis of oil sludge's in storage tanks of Libyan and Iranian refineries

Country	Total Hydrocarbon	Hydrocarbon cut%		Water%	Solid%	Solid compounds%
		volatile	non-volatile			
IRAN	26.5	negligible	Diesel fuel 50-60	28.3	45.2	-
			Others 45.2			
LIBYA	42.8	30.7	69.3	2.9	54.3	Organic compounds70 Mineral compounds30

The second point is the analysis of heavy metals in oil sludge, which is related to tank corrosion and waste disposal. Table 2 shows heavy metals in oil sludge of Iran and Oman.

**Table 2.** Heavy metal analysis of oil sludge's of Oman oil development and Tehran oil refinery (mg/kg)

Country	Zinc	Lead	Nickel	Cadmium	Chromium	Mercury
IRAN	6100	850	2700	100	-	-
Oman	278	91	7.5	-	12	3.5

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Please Cite This Article Using:

Hassanzadeh, M., "Industrial cleaning methods of oil sediments (sludge) from crude oil and products storage tanks", Journal of Farayandno – Vol. 17 – No. 77, pp. 91-113, In Persian, (2022).

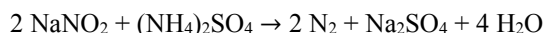


#### 4. OIL SLUDGE CLEANING METHODS

There are many methods for cleaning oil storage tanks, some of which are associated with the recycling of hydrocarbons. The methods with recycling are the most suitable and desirable option from the economic and environmental point of view because it enables the oil industry to reuse hydrocarbons or by reselling them. The cost of cleaning the tanks is also covered. In addition, sludge recycling helps to reduce the volume of oil waste disposal and prevents the increase of environmental pollution and reduces the consumption of non-renewable energy resources. Types of cleaning and recycling methods of hydrocarbons from oil sludge are summarized as follows [2].

**4.1. Manual:** The equipment required for this traditional method is the simplest tool in the market that workers need. Subsequent operations, such as recycling or finding a use for the removed sludge, are not part of the job description of this method. It should be transferred to recycling units. The most important methods of recovering hydrocarbons from sludge are: Centrifuge, Freeze /Thaw, Pyrolysis, Microwave radiation, Foam flotation, Electrokinetic, Ultrasonic, ...

**4.2. Thermochemical:** The process is based on a strong exothermic reaction that takes place between two nitrogen salts. A very large volume of produced nitrogen causes turbulence. The heat released in this reaction melts the sludge and it irreversibly liquefies. After collecting and transferring to the desalination unit, it can be re-refined and recycled. An example of this type of reaction:



**4.3. Biological:** In this method, microorganisms such as fungi, bacteria and yeast are used, all of which are isolated from oil-contaminated soils. These microorganisms produce called bio surfactants. They reduce the viscosity of the sludge and forming a stable W/O emulsion and turn it into a pumpable fluid.

**4.4. Jet wash:** The basis of this method is the use of heat with steam. Using high pressure pumps and special jet washes, rapid mixing of the sludge and dissolution of its waxy compounds is done, after that, the remaining solid materials, including mud, are separated from the refineries and disposed of, and the oil materials also return to the crude oil refining cycle.

**4.5. Automatic:** The general method includes dissolving sludge in petroleum and chemical solvents, suction of softened sludge, separation of materials from each other, recycling, water treatment and safe solid waste burial.

**4.6. Robotic:** In this method, workers are not used inside the very toxic and dangerous atmosphere of the tank. The control of the robotic device equipped with a camera is done with a remote control outside the tank.

#### 5. RESULTS AND DISCUSSION

Among the six explained cleaning methods, manual, automatic and robotic methods have been more popular due to investment conditions, facilities and economic efficiency. In the following, the efficiency, safety, environmental effects and costs of these three methods are discussed [3,4,5].

**5.1. Efficiency of methods:** The efficiency of cleaning methods is defined based on the calculation of the volume of sludge cleaned in hours or days. In general, the operation time from the beginning to the end of cleaning are: transferring equipment to the desired location with a truck, trolley, etc., loading equipment on the ground (separate equipment or assembly of equipment in a container), installation of equipment and piping and..., removing oxygen from the internal atmosphere of the tank with nitrogen gas, the start of the main operations, i.e. recirculation, separation, final washing, collect the equipment and leave the place.

In the manual method, the operation time is longer compared to the other two methods (months), and part of this lengthening time is due to the loading and installation of the equipment, Excretion of oxygen, and using hot solvent to soften the sludge. The efficiency of the automatic method reported by ORECO's BLABO company is 6.6 m<sup>3</sup>/h or 160 m<sup>3</sup>/d. The considered time is 1 to 6 days with the great advantage of simultaneous recovery of about 95% of oil compounds from sludge, which is not present in the other two manual and robotic methods. Of course, in the robotic method, some companies are equipped with recycling devices and equipment. MIRRICOS MARKET reported operating efficiencies from 5.3 to 8 m<sup>3</sup>/h and an average of 6.3 m<sup>3</sup>/h.

**5.2. Safety of methods:** The manual method has the most disadvantages in terms of health and safety; Because it is the only way that workers enter the tank from the beginning to the end of the operation and are directly exposed to the dangers of volatile hydrocarbons, chemical solvents, heavy metals and oil. The automatic method is one step ahead of the manual method in terms of the development of health and safety of operations. All equipment is loaded outdoors without risk of explosion. All solvents, chemicals and cleaning solutions are sprayed on the sludge through jet nozzles and it replaces the direct spraying of these materials by workers in the manual method. In the robotic method, maximum safety and health points are observed compared to other methods.



**5.3. Environmental effects of methods:** The manual method faces serious problems in terms of environmental effects. Because the cleaning system is carried out in the open environment, and the environment is always exposed to pollution such as high-risk oil wastes from all operational departments, such as equipment entering the tank, protective devices, tools, etc., directly or indirectly. The amount of contamination spread in automatic method is less compared to the manual method due to the closed cleaning cycle. In general, the advantages of the robotic method are similar to the automatic method and there is not much difference because it is done in a closed cycle.

**5.4. Cost of methods:** The main costs of the manual method are personnel costs and the management of sludge transferred outside. Compared to the manual method, the cost or price of this method is higher. The cost of managing the cleaned sludge is zero, but in fact, this cost is allocated to the recycling and separation of oil, water, and solids. In addition to this, the many advantages of this method in terms of efficiency, worker safety, environment and technology have made the method more expensive. The cost of the robotic method is lower than the automatic method, but more expensive than the manual method.

## 6. CONCLUSION

The main criteria for evaluating of methods are the four main factors of efficiency, safety, environmental effects and the total price of the operation. 1. In terms of safety, the manual method has the lowest level and the robotic method has the highest level of safety. 2. The efficiency of the traditional method is low and it is considered among the slowest and most exhausting cleaning methods. But automatic and robotic methods are almost similar in terms of time and quality of work. 3. In terms of environmental effects, automatic and robotic methods are performed in a closed flow system and have a good recycling system, but the manual method has the worst condition. 4. The cost of the automatic method is higher than the two robotic and manual methods, but the recycling of materials in this method is more complete and better, and the income from the sale of recycled materials covers at least half of the cost of cleaning.

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