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Treatment methods of oily sludge and the pertinent processes

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1. ABSTRACT

Oily sludge is a major and common waste material in the-oil industry which is characterized as a concetrated and complex emulsion composed of water, various hydrocarbons, heavy metals, and solid particles. Better understanding of the oily sludge treatment methods is necessary due to its nature, hazards, and large amounts of production around the world. While disposal approaches such as landfilling would pose profound environmental challenges; the problem of wasting valuable materials and inherent energy in disposed oily sludge is highly questionable. Instead, these valuble materials can be recovered in addition to the minimization of environmental footprints by choosing appropriate methods. In this study, different methods of oily sludge treatment have been studied, discussed and evaluated. Moreover, their apllication were compared according to process efficiency, cost, capacity, and complexity. Among those methods for sludge separation and material recovery, the solvent extraction, pyrolysis, air flotation, and methods which use surfactants showed preferable advantages over the others. Nonetheless, the final decision in the selection of separation method should be based on the sludge properties and process limitations. To do so, the operating costs, and energy requirements should be carefully considered. By studying all mentioned parameters, this paper can serve as a guideline for the process and environmental engineers to choose the most suitable method.

Keywords: Energy Recovery, Oily Sludge, Separation, Sludge Treatment, Waste Management.

2. INTRODUCTION

Oily sludge is known as an undesirable and inevitable waste production during different crude oil processes. Generally, it contains emulsion, various hydrocarbons, water, heavy metals, and solid impurities [1]. Traditional disposal methods such as landfilling and incineration would profoundly impact the environment.

However, there are some newer processes that can extract and separate valuable materials and recover water and energy. Some of the most important oily sludge treatment methods and their processes have been described in this paper.

3. OILY SLUDGE TREATMENT METHODS

3.1. Solvent Extraction

Suitable solvents or their blend are mixed with oily sludge at a predetermined ratio to dissolve hydrocarbons. Material separation is the main goal of this process to recover hydrocarbons (Figure 1.a).

3.2. Surfactant

Here, surface-active materials of various types can be added to the oily sludge as pre-treatment to reduce viscosity by dissolving hydrocarbons and separating solids from the new emulsion. The gravitational settling and buoyancy are required in the next step to separate the aqueous and oil phases (Figure 1.b).

3.3. Mechanical Centrifuge

Solids are separated by their higher density when centrifugal force at high rotational speed is applied.

In a two-phase separator, a liquid mixture flowing from the top is separated into oil and water phase.

3.4. Flotation

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Surfactants form a new low stable emulsion from sludge. Using the buoyancy force through air bubbling in the emulsion which causes hydrocarbon separation and flotation due to thinning and bursting the interfacial water-oil layer (Figure 1.d).

3.5. Pyrolysis

The pre-treated sludge is contacted with a hot gas stream in a fluidized-bed reactor, where its large hydrocarbons can break into smaller molecules in the absence of oxygen (Figure 1.e).

3.6. Electrokinetics

A direct electric current is applied to an oily sludge and breaks its colloidal mass by electroosmosis and electrophoresis phenomena.

In this apparatus the charged solids and water-oil emulsion droplets move toward the anode and cathode poles, respectively, and then will be separated.

3.7. Freezing/Thawing

According to the difference in the freezing points of water and hydrocarbons, they can be frozen at different temperatures in the oily sludge. This, in turn, destabilizes water-oil equilibrium, and the following melting helps their stratification and separation (Figure 1.f).

3.8. Ultrasonic

The ultrasonic wave vibration forms vapor bubbles at the solid-liquid interface and reduces the emulsion viscosity. The hydrocarbons are released from the solid surfaces and solids are separated from the liquid. Afterward, the aqueous and oil phases are separated (Figure 1.g).

3.9. Supercritical Fluid

The supercritical fluid environment is suitable for oxidation reactions due to low viscosity and interfacial tension, and high solubility of hydrocarbons. The solvent selectivity is adjustable at the critical point (Figure 1.h).

3.10. Bioremediation

Appropriate microorganisms can consume hydrocarbons as feed in a controlled environment. Their metabolism destroys chemical bonds in the petroleum pollutants in the sludge and produces lower hazardous material.

3.11. Microwave

Microwave radiation increases temperature rapidly and reduces oily sludge viscosity, which helps easier movement of the charged species. Moreover, the resulting magnetic field of the microwave makes apolar hydrocarbons polar and demulsifies and dehydrates the oily sludge (Figure 1.i).

3.12. Cyclone

Fluidized oily sludge and hot steam enter tangentially into the vertical chamber of the cyclone. Air bubbles and emulsion droplets hit, and an aqueous phase containing solids falls while aggregated hydrocarbons flow upward with steam flow.

3.13. Combustion

Burning the dried oily sludge in contact with hot air helps remove hydrocarbons. The flue gas can be used in a gas turbine, and vent to the atmosphere after passing through several absorbents (Figure 1.j).

3.14. Devolatilization

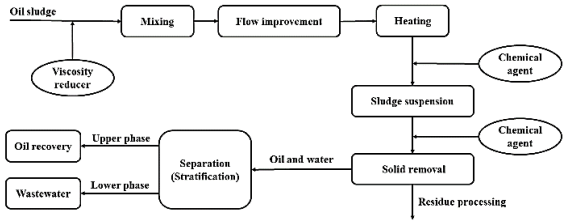
Converting the oily sludge into a bubbling fluidized bed with hot nitrogen gas causes releasing volatile species. More separation happens using condensation and filtration processes (Figure 1.k).

3.15. Photocatalyst

As an advanced oxidation process, ultraviolet radiation is used to release OH radicals in the oily sludge to destroy organic materials, especially polyaromatic hydrocarbons.

3.16. Combined methods

Some of the introduced methods can be combined to increase the treatment process efficiency. For instance, combining the air flotation with ultrasonic resulted in more hydrocarbon separation from oily sludge or a combination of ultrasonic and Fenton reagent caused higher efficiency.



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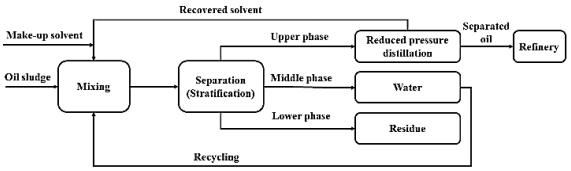

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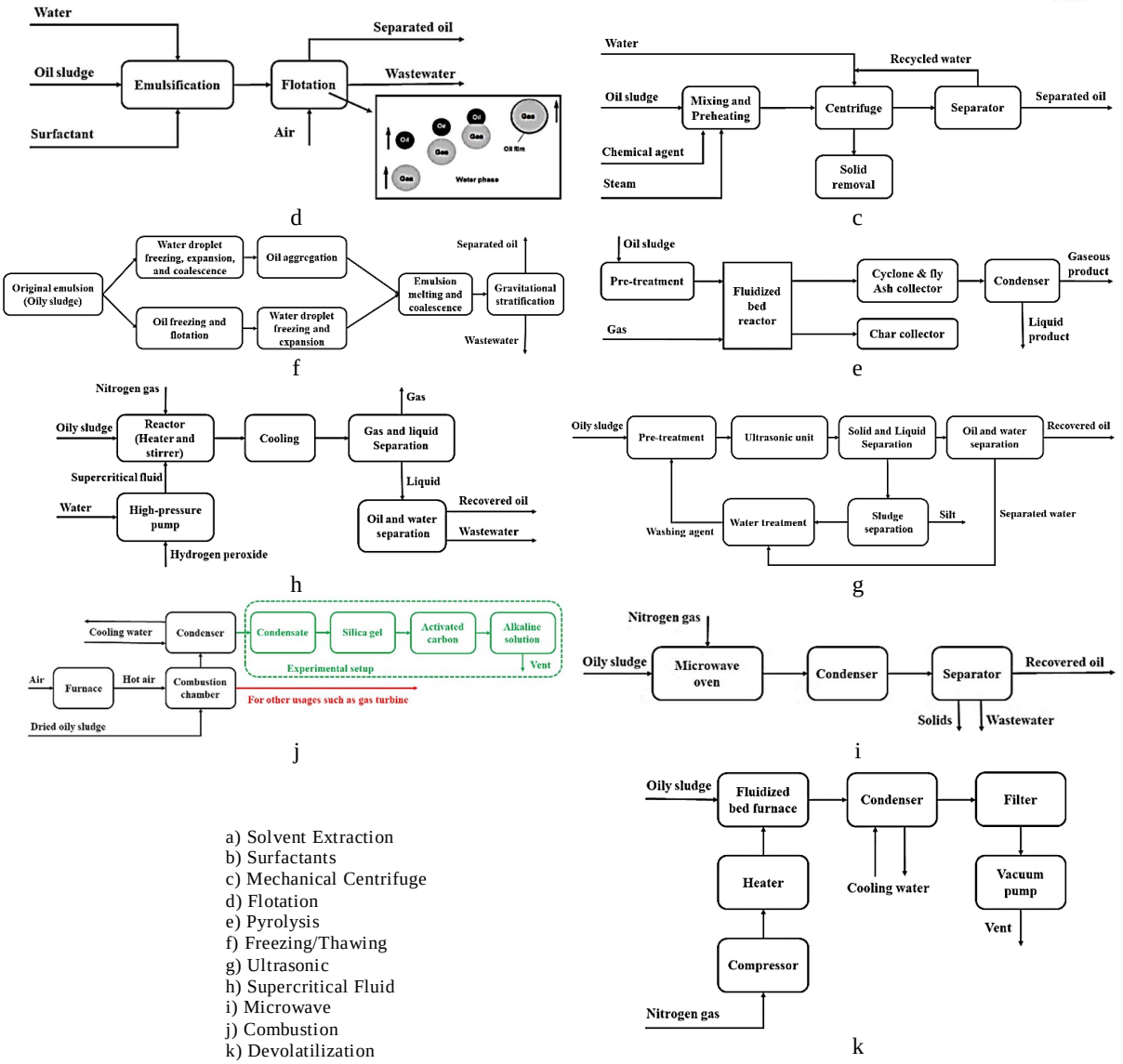

a) Solvent Extraction
b) Surfactants
c) Mechanical Centrifuge
d) Flotation
e) Pyrolysis
f) Freezing/Thawing
g) Ultrasonic
h) Supercritical Fluid
i) Microwave
j) Combustion
k) Devolatilization

Figure 1. Schematic process for oily sludge treatment methods [2-5]

4. COMPARISON OF THE VARIOUS OILY SLUDGE TREATMENT METHODS

Solvent extraction, freezing/thawing, surfactants, and air flotation methods have simple processes while considering the duration, solvent extraction, pyrolysis, microwave, and supercritical fluid are more appropriate. However, cost and material requirements should be considered in applying solvent extraction, pyrolysis, ultrasonic, microwave, and surfactant. On the other hand, more energy is consumed in supercritical fluid, microwave, and flotation methods.

5. CONCLUSIONS

More energy demand causes an increase in fossil fuel production followed by higher formation of hazardous viscous oily sludge. Various treatment methods have been proposed and applied, not only to decrease the amount of oily sludge by product, but also to increase material and energy recovery, and to provide sludge treatment. Their processes have been discussed and compared in this paper.

In this study, technology cost and availability, its simplicity and controllability are some important factors in selection of an efficient method.

6. REFERENCES

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