Treat oily waste with decanter centrifuge plants

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Turning a challenge into an opportunity

Oily wastes are a normal byproduct of many operations carried out by the oil industry between well and pump. The path starts at production and continues on through transport and refining. Although the waste quantity is small compared to the industry's overall output, the size of the industry means that these oily wastes can add up to a considerable problem. One concern with these wastes is the loss of useable volume in crude oil tanks or emergency lagoons due to the volume taken up by the waste. Another concern is the environmental hazards that the waste may pose. Direct disposal of these wastes without prior treatment is normally not possible, but, apart from the requirement for some form of treatment, today's crude oil prices often provide an additional incentive for treatment, as oil wastes are a valuable resource that can be recovered if desired.

In this context the decanter, or solid-bowl centrifuge, is a very versatile instrument and key component of most advanced oil waste treatment plants.

Due to the variability of the oily waste as feed product (because of different crude properties, different histories and the origin of the waste), treatment systems should be tailored to each project's needs, rather than being a standard unit put to work under all kinds of conditions. The decanter centrifuge along with ancillary and additional equipment, can easily be adapted to such varying technical requirements.

Approaching product and treatment:

Oil waste is not a precisely defined product, but it varies over a wide range with regard to its composition and properties. The hydrocarbon content is typically at the heavier end of the spectrum, but this will depend on the oil field where the crude was produced. The waste may also include light hydrocarbons, or it may represent only a certain fraction of the range. Water is often present, but not always. To offer a common example, the solids could be sand, rust or organic matter. There is also often an emulsion present as a fourth component that comprises hydrocarbons, water and captured fine solids. Some examples illustrate the variety of products that are collectively addressed as oil sludge:

- **Waste oil drilling mud**
- **Oilfield pit sludge waste**
- **Storage tank bottom sludge**
- **Emergency lagoon sludge**
- **Refinery slop**
- **Oily sludge from refinery effluent treatment**

Similarly diverse are the primary treatment targets, depending on the project specific background. While, in one case, the only target may be to achieve a product that can safely be disposed in a landfill, another project may require a final product that is good for incineration. Then there might be a project that requires good quality oil for recycling into the refining process, or needs good water phase for re-use in the process. Naturally, the product properties, together with the primary treatment targets, will determine the basic process steps, as shown in a few examples in Table 1 and Table 2.

TABLE 1. Examples for treatment targets and basic process requirements

Primary treatment target	Basic process requirements
Solids to landfill	Minimize oil and water content in solids. Simple liquid-solid two-phase separation sufficient.
Solids to incineration	Minimize water content and maximize oil content in the solids to minimize fuel import for the incinerator. Simple liquid-solid 2-phase separation sufficient.
Recycle oil to refinery	Maximize oil recovery, minimize water content in oil. Liquid-liquid-solid three-phase separation required.

TABLE 2. Product examples and associated basic considerations for process layout

Product	Considerations for process layout
Oilfield pit sludge, lagoon sludge	Very high content of coarse debris, sand, etc. Very in-homogenous. Pay special attention to mechanical pretreatment. If treatment target requires three-phase separation, consider two centrifuge steps. Hydrocarbons may entail a very high proportion of heavy hydrocarbons. Heating and splitting of emulsions essential for three-phase separation.
Refinery slop	Typically rather low in solids and high in oil content. Composition may change quickly with regard to hydrocarbon, water, and solids content, and hydrocarbon fractions present. Three-phase separation. Heating and splitting of emulsions essential.
Oily refinery sludge	Oil content may be too low to justify recovery; simple two-phase separation without heating of the product is often sufficient. Refinery explosion protection guidelines may require a higher degree of explosion protection than the product itself.

Due to this vast diversity, laboratory analyses and tests are extremely important in order to determine the product's properties, the results that a particular treatment method is likely to achieve in full scale and the respective process requirements to run the treatment process effectively.

Other parameters that is required as input into the treatment plant design include product and site data (including customer regulations) relevant for explosion protection, available heat sources and general installation requirements.

Operating principle of decanter centrifuges:

The solid-bowl or decanter centrifuge is the machine of choice for treatment of oil wastes. While other products often leave the option to use belt-filter presses or plate-and-frame presses instead, those types of machines are not suitable for oil waste treatment. Even at low oil contents, the sludge will stick to the filter cloth and will eventually blind it. Similarly, three-phase separation, where the solids are separated from the liquid phase and the liquid phase is split into oil and water, is impossible to achieve with presses.

Contrary to presses, which work on the principle of filtration, decanter centrifuges are separating via the principle of sedimentation by making use of the different specific gravity of the oil sludge's components. The decanter's operating principle is analogous to a continuously fed sedimentation tank with a bottom scraper. In such a tank, solids will settle on the bottom and oil will float on top of the water under natural gravity, provided the hydraulic retention time in the tank is long enough for the separation to take place. This simple principle is also often used in various places in the petroleum industry.

For fine solids and/or viscous hydrocarbons, the time required to achieve separation under natural gravity may be too long to be economical, or the separation result may be less than desired. This is typically the case with oil sludges, and, therefore, sedimentation is enhanced in the decanter centrifuge by increasing the driving force by three orders of magnitude, spinning the product so fast that centrifugal accelerations of up to several thousand times g (= gravitational acceleration; average = 9.81 m/s^2) are created.

Using the analogy of the sedimentation tank again, the tank may be rolled into a cylinder with the tank bottom becoming the cylinder wall, and the water body and scraper being located inside the cylinder. This cylinder, called the cylindrical bowl, is rotated with several thousand rpm around its longitudinal axis to create the required centrifugal acceleration. Feed into this system is continuous via a fixed pipe extending from the outside into the center of the cylinder. In this system, the solids will move radially outward and settle on the inner surface of the cylinder's wall. Water will form a layer sitting on top of this sediment layer, and oil (if present) will form a third layer further inward (toward the center) on top of the water layer. The shape of the bottom scraper will be changed to that of a screw conveyor, also called the scroll, which will rotate with a slightly different speed to the cylinder in order to convey the sediment toward the outlet.

To one end of the cylinder, a truncated cone (also called the beach) is added in order to block this end for the liquids. It is over this beach that the solids are conveyed and discharged out of the bowl. The other end of the cylindrical bowl is closed with a head wall that has outlet openings with adjustable weirs for discharge of the liquid. Further devices can be added to the decanter centrifuge to separately extract a second liquid phase if present. Fig. 1 shows a schematic drawing of a two-phase decanter centrifuge.

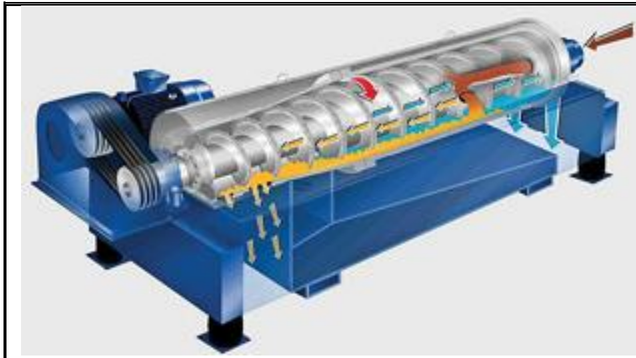

Fig. 1. Schematic drawing of a two-phase decanter centrifuge

Tailoring the decanter centrifuge to the task:

In order to be able to perform most efficiently and economically under site conditions, tailoring the decanter centrifuge to the project specific requirements is required. This includes:

- Materials of construction for wetted parts, taking into account corrosion, abrasion, operating temperatures and operating/maintenance regime

- Wear-protection level and system, taking into account abrasiveness of the product, the size and nature of the solid particles contained in the product, the operating and maintenance regime and available repair capabilities

- Liquid-phase extraction devices, in the case of three-phase separation, taking into account the variability of the content of both liquid phases, quality requirements for the separated liquid phases and downstream plant/equipment

- Explosion protection measures, taking into account ambient conditions and product properties at operating conditions and national and/or customer specific requirements

- Drive system for bowl and scroll, taking into account product and process requirements and site conditions.

While these choices will only marginally affect the capital expenditure for the decanter centrifuge compared to the cost of the entire treatment plant, their effect on the operability, availability and efficiency of the decanter centrifuge as the core piece of the plant can be considerable. Therefore, special care has to be taken that these options in all their breadth are indeed available and considered in depth, and eventually the right choice is made and implemented. Two examples for decanter centrifuges are shown in Fig. 2 and Fig. 3 to demonstrate some of the differences in design.

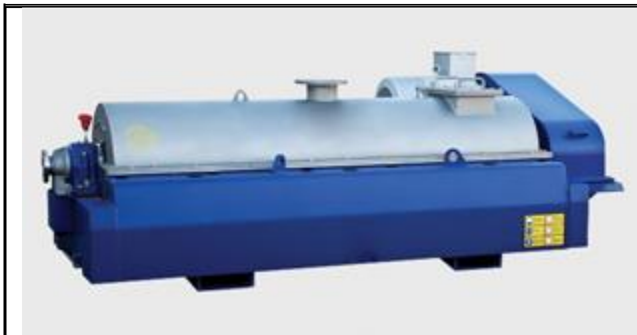

Fig. 2. Explosion-proof (ATEX) two-phase decanter with hydraulic scroll drive

Fig. 3. Explosion-proof (ATEX) three-phase decanter with electro-mechanical regenerative back-drive

Examples for oil waste treatment plants:

The following two examples of oil waste treatment systems are discussed in order to illustrate the aspects outlined above and thus provide the link between theory and practice.

Example 1. A treatment system for lagoon sludge in Siberia was installed in several containers to be placed onsite outdoors (Fig. 4). The core piece is a three-phase decanter for separation of oil, water and solids in one device. The oil is fed back into the refinery's crude stock, while the water phase receives further treatment in the refinery's effluent treatment plant.

Fig. 4. Containerized treatment system with three-phase decanter getting prepared for shipment

Due to the harsh climate and the limited choice of process chemicals (polymeric flocculants and demulsifier), special care has been taken to provide sufficient flexibility and hydraulic retention time (external tanks, built by the customer) for the chemicals to react properly, and to provide sufficient space inside the containers to serve as dry and heated storage, as well as a workplace for maintenance and repairs. The product is heated in several steps using indirect steam heating.

Explosion protection was designed in accordance with potentially explosive atmospheres (ATEX) Directive 94/9/EC. Explosion protection required that all high voltage electrical equipment be installed onsite in a separate container placed outside the hazardous area. The electrical container also included basic laboratory facilities in order to allow the plant operators to assess the properties of the feed and treated products and carry out adjustments as required.

Example 2. A skid-mounted treatment system for oilfield waste in China was placed indoors and connected to an extensive mechanical pretreatment system delivered separately (Fig. 5).

Fig. 5. Skid-mounted treatment system with two-phase decanter plus three-phase separator before shipment to China

This plant had to be designed for a feed product with high sand content, and for the production of high quality oil (sold to a refinery nearby) and water (reused internally as process water). Solid phase quality requirements were also rather strict, as they were to be fed into a soil treatment plant.

In view of these requirements, the separation process was split into two steps. The first step featured a two-phase decanter centrifuge with the sole task of removing solids. The next step utilized a three-phase high speed disc stack separator to separate and clean the oil and water phases. Similar to the decanter centrifuge, a disc stack separator also uses differences in specific gravity for separation. However, it provides even higher centrifugal acceleration and a higher settling area, with the "1xg equivalent" being a lamella settler.

As the treatment facility is situated in a remote location, no steam was readily available and a thermal oil heating system was used instead to provide heat to all parts of the plant. Similar to Example 1, explosion protection is based on ATEX, and all high voltage equipment is installed outside the hazardous area, in the central electrical room of the facility.

Turning challenge into opportunity.

The large quantities of oily waste produced by the oil industry worldwide are a significant economic burden. In order to treat this waste in the most economical way, a detailed study of the product and of the external factors surrounding the project is required. Advanced treatment methods are centered on decanter centrifuges for liquid-solid separation. These machines have proven to be the most reliable and flexible to separate these complex oil-water-solids mixtures under the harsh conditions typically met onsite.

Decanter centrifuges and the treatment plants in which they are operating should be designed to the specific requirements of each project in order to make the best use of the versatility of the decanter and thus achieve optimal performance. By following this groundwork, a refiner can turn a challenge into an opportunity. **HP**

The author

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