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High viscous oil recovery operation in open sea

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Introduction

Oil recovery from open water is challenging, in particular if the oil is viscous and emulsified with water, the ambient temperature is below pour point, the oils have a high wax content, and finally, if the oils have a high specific gravity.

There are many physical factors that influence operations, and these make each operation unique. We will try to address these effects and comment on the consequences for the oil recovery operation.

This subject has become more conspicuous lately as we are experiencing an increased tanker transportation of oil along the Norwegian coast where sea temperatures vary between 10°C and 0°C.

Oil types

What effects will different oil types have on the skimming operation?

If we simplify the picture a little, we may divide these into three categories.

Low-viscous oils, like most of the North Sea crude oils and oil emulsions, are the easiest oils to deal with from a skimming point of view. They flow easily into the skimmer area and cause only moderate friction loss in the transfer umbilical. The technical challenge here is to have a good oil boom with good holding efficiency. During oil recovery we need a minimum towing speed in order to accumulate sufficient oil thickness. Weir skimmers will be best suited for this operation and centrifugal pumps will be the best pumps because of their low weight and high performance.

Medium-viscous oils will typically be some types of emulsified crude oils. Here we may use all three types of skimmers. Weir skimmers may take in more free water, and some efficiency will be lost with a centrifugal pump. Adhesion skimmers will operate where conditions are good. Capacity is here the limiting factor and is proportional to the " rotating" surface. Positive displacement skimmers may also be used with good results.

High-viscous oils come from some emulsified crude oils and from all bunker fuels at ambient temperatures, and when these oils emulsify. These oils must be handled with the positive displacement skimmer system. HF bunker oils and emulsification of these oils are the most challenging operations . Here we have an additional problem, the oil's pour point. If we have to work at temperatures lower than the pour point, we have no control over the viscosity. This is because the oil will stop at the weir edge, water will be drawn under the oil and the skimming process will stop. For this whole family of oils we recommend using the positive displacement skimmer principle. Oil will be moved positively towards the pump well, transferred with the help of positive displacement pumps. The transfer hose will be lubricated with seawater injected through an annulus ring in the hose. A water flow of 5 % to 25 % will be added.

The appearance of the oil on the sea surface

The following elements will have an effect on how the oil appears on the sea surface.

- Inflow rate of oil into the oil boom
- Current or relative towing speed of oil boom
- Specific gravity of the oil
- Viscosity, pour point and wax content of crude oils
- And finally, the state of the sea

All these elements will affect the thickness of the oil on the sea surface as well as skimmer efficiency. During normal recovery operations with standard light crude emulsions, towing the oil boom at 1 knot, oil thickness could reach 0.5 meter at the far end in the apex. These oils are characterized by low specific gravity and low viscosity.

When the waves increase, the oil layer on the sea surface starts to roll into the waves and the water column. This will of course reduce recovery efficiency, but we should be able to recover oil as long as there is any on the sea surface.

High oil flow rates from underneath the seawater surface, high-viscous oil and high specific gravity will result in very substantial oil thickness. During some operations, we have experienced oil thicknesses of about 1 meter. Oil recovery from open sea operations has been performed even without an oil boom. These high-viscous oils have one big advantage, they are easy to keep within the oil boom and boom efficiency is very good, but on the challenging side they are very hard to pump.

Skimmer types

There are many different skimmer types and we may categorize them according to three different principles.

Weir skimmers	with operation viscosity between 1 to 15 000 cst
Adhesion skimmers	with operation viscosity between 1 000 to 100 000 cst
Positive displacement skimmer	with operation viscosity between 10 000 to1 mill cst

In this connection, weir skimmers have the best capacity potential, capacity and size ratio. These are followed by adhesion skimmers, which depend on adhesion within the liquid and also between the liquid and the "rotating surface". Finally we have positive displacement skimmers, which are the most powerful units because of the amount of energy needed to move high-viscous liquid through the transfer hose.

It is clear that the different concepts will have different efficiencies and we must note that the viscosity capability of weir units and positive displacement units have an ample overlap so only two types of skimmer heads are required.

Transfer of oil through umbilical.

It is a well-known fact that as viscosity increases, friction loss also increases and in the end we will loose much of the capacity. If viscosity exceeds 30 000 cst we have to consider viscosity reducing effects. The following elements will reduce friction loss:

- Heating the oil in the skimmer head.
- Using of chemicals.
- Using a water liner in the transfer hose.

The clear winner of these alternatives is the use of lubricating water liner.

Friction loss will be reduced by a factor of 10 by adding about 5% water to the oil flow. This water is relatively easily removed afterwards.

Dewatering, preheating and filtering the recovered oil

As soon as we have the oil and water on board the oil recovery vessel, the free water will be decanted. The total flow will then be heated and it is a waste of energy to heat the water.

If heating is not required due to adequate viscosity, the best dewatering process takes place in the storage tank itself. Discharge from the tank bottom straight into the oil boom is the simplest method. Suction arrangements must be prepared in the tank in such a way as to make it possible to apply suction to the lowest point to drain the water efficiently and continuously.

These oils should be filtered on deck before entering the tanks. The best systems are those we have experienced in connection with the NOFO standard.

For the oil emulsions that are going to be heated, it is an advantage to pre-heat and filter the oil before it is deposited into the tanks. This will ease the circulation of the oil and increase heat transfer to the oil. With this arrangement we are able to use all existing vessels for oil recovery service for heavy bunker fuels and emulsions by arranging all heating facilities on deck with heat exchangers.

Final heating of the oil

We will now have the vessel full of oil at a temperature of about 25°C.

The capacity of the heaters is such that with a recovery rate of about 100 m3/h, this is the temperature at which we will stabilise. Further temperature rises occur through circulation, during the voyage to shore or during preparation for the receiving tanker. The final discharge temperature is expected to be about 60°C. The time needed to ensure this temperature rise is estimated to be 30 h. During preheating and the final heating we expect to consume about 4 tons of steam an hour, saturated at 7 bar pressure, 167° C. All this is based on a total volume of about 1000 m3 total volume.

Dewatering, preheating and filtering the oil may take place in temporary containers installed on deck. The same goes for the steam boiler plant.

Use of emulsion breakers.

During the above-described process we must not forget the use of emulsion breakers.

For many years this has been an effective tool in reducing the water we normally carry back to the receiving station. By adding the emulsion breaking chemical prior to heating and circulate the emulsion through the heat exchanger, we have experienced the same effect as with crude oils, i.e. that the bunker fuels will separate from the water through this process.

Conclusion

Today we must be able to recover oil from the sea surface as long as any oil appears on the surface. We must also be able to handle all kinds of viscosities even without people on deck. Equipment must be automatic or remote-controlled.

Finally equipment must be arranged so that standard oil recovery vessels can deal with heavy oils and oil emulsions.