Treatment of oil-contaminated water from naval warships

● Membrane bioreactor technology is being used to treat wastewater from warships, with the potential for on-board systems. **TOINE BAKX, SJOERD BOOM** and **HANS RAMAEKERS** present early work with the Dutch Navy.

After a long journey at sea, warships from the Royal Netherlands Navy return home to the Netherlands Naval Base in Den Helder. During the trip, the ships collect wastewater which they are not allowed to discharge. This oil-contaminated water is collected from the engine room, the bilges and from fuel/seawater displacement systems.

Until recently the wastewater was discharged from ship to shore and treated in a flocculation/ flotation unit. When more stringent effluent standards were introduced in a new discharge permit, a new type of wastewater treatment was needed based on currently available, state of the art techniques. A pilot test was conducted to investigate the possibility of treating the wastewater biologically. Compared to domestic wastewater, this water is characterised by a high salt content (sea water) and contamination with phenol, mineral oil, and polycyclic aromatic hydrocarbons. There are hardly any nitrogen components present.

To treat this wastewater requires a bioreactor in which specific bacteria are able to oxidise the various complex components present. Since treatment of wastewater with a high salt content in conventional systems results in sludge wash-out, a different technique is needed to achieve sludge retention. To increase the activity, environmental factors such as temperature, pH, and availability of oxygen and nutrients must be optimised.

Membrane bioreactors can potentially provide on-board treatment (Credit:Visuele dienst Koninklijke Marine)

Membrane bioreactor

An up-and-coming technique for wastewater treatment is a combination of bioreactor and membrane separation technology. The membrane bioreactor technology is characterised by compactness, robustness and high treatment efficiency. Figure 1 shows a schematic view of a membrane bioreactor. Two important elements can be distinguished: a bioreactor and a membrane filtration unit.

The wastewater to be treated flows directly into the bioreactor. In this bioreactor, wastewater and bacteria (biomass) are intensively mixed. The oxygen which is required by the bacteria for degradation of organic compounds is transferred into the bioreactor by aeration. The mixture of the treated water and biomass is continuously recirculated over the membrane filtration unit. In the membrane filtration unit, the purified wastewater and bacteria are separated. The filtrate is drained off as effluent and the concentrate is returned to the bioreactor.

Membrane bioreactor technology differs from traditional biological wastewater treatment. Specific characteristics of the membrane bioreactor technology give the system its ability to treat complex wastewaters. These characteristics are:

High biomass concentration

By using membranes for separation of biomass the treatment is not dependent on settling characteristics of the biomass. Therefore high concentrations of biomass can be achieved: up to 30 g MLSS/l (mixed liquid suspended solids), which is 6 to 8 times higher than conventional systems. This means that the volume of the bioreactor, in comparison with conventional systems, can be reduced six to eight times, or the volume can be reduced until the oxygen transfer becomes limiting.

Full retention of bacteria

By using membranes, bacterial washout is prevented. Consequently the presence of specific bacteria in the bioreactor is guaranteed. Membrane filtration is based on the principle of separation by difference

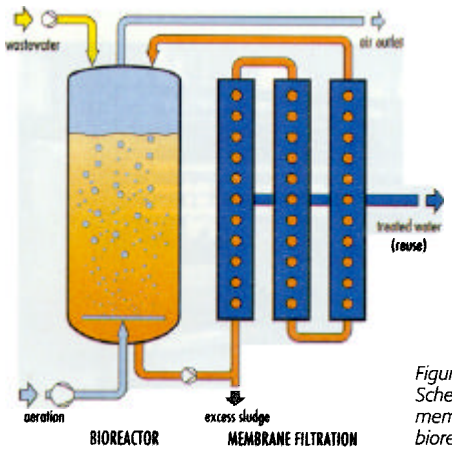

Figure 1 Schematic view membrane bioreactor