Produced water filtration

An oil well is supposed to give only oil, but in reality it also produces some water. The amount of produced water increases with time, which is partly due to intrusion of water from the surroundings and partly due the that fact that water is injected into the layers below the oil, with the objective to maintain the oil pressure. The injected water can contain gelling agents like xantan gum, which increases the viscosity and that makes it easier to push the water upwards.

Hydro cyclones has for many years been used due to their compact design and low price. However, it is very difficult to remove oil when the concentration gets below 15 mg/l and the processing is not stable. The allowed amount of oil in the discharged water has been lowered to the point where hydro cyclones cannot meet the challenge.

Ultrafiltration can very easily produce permeate with well under 5 mg/l oil, and that has been know for decades. The main obstacle for membranes has been that polymeric membranes handle oil very badly and that ceramic membranes have been quite expensive. The newly developed ceramic membranes from SiC are not affected at all by hydrocarbons. The SiC membranes operate with so high flux, that the OPEX and CAPEX have become acceptable. Furthermore a system with SiC-membranes is very compact compared to yield, meaning that installation on an oil rig is not a major issue. Other advantages include pH-resistance from 0-14 and temperature resistance over 800°C.

CoMeTas has conducted several experiments regarding filtration of produced water, in order to decrease the amount of dispersed oil. The pore size of the CoMem membrane found to be most suitable for this application is 0,04µm. An impressive result is seen in the graph below:

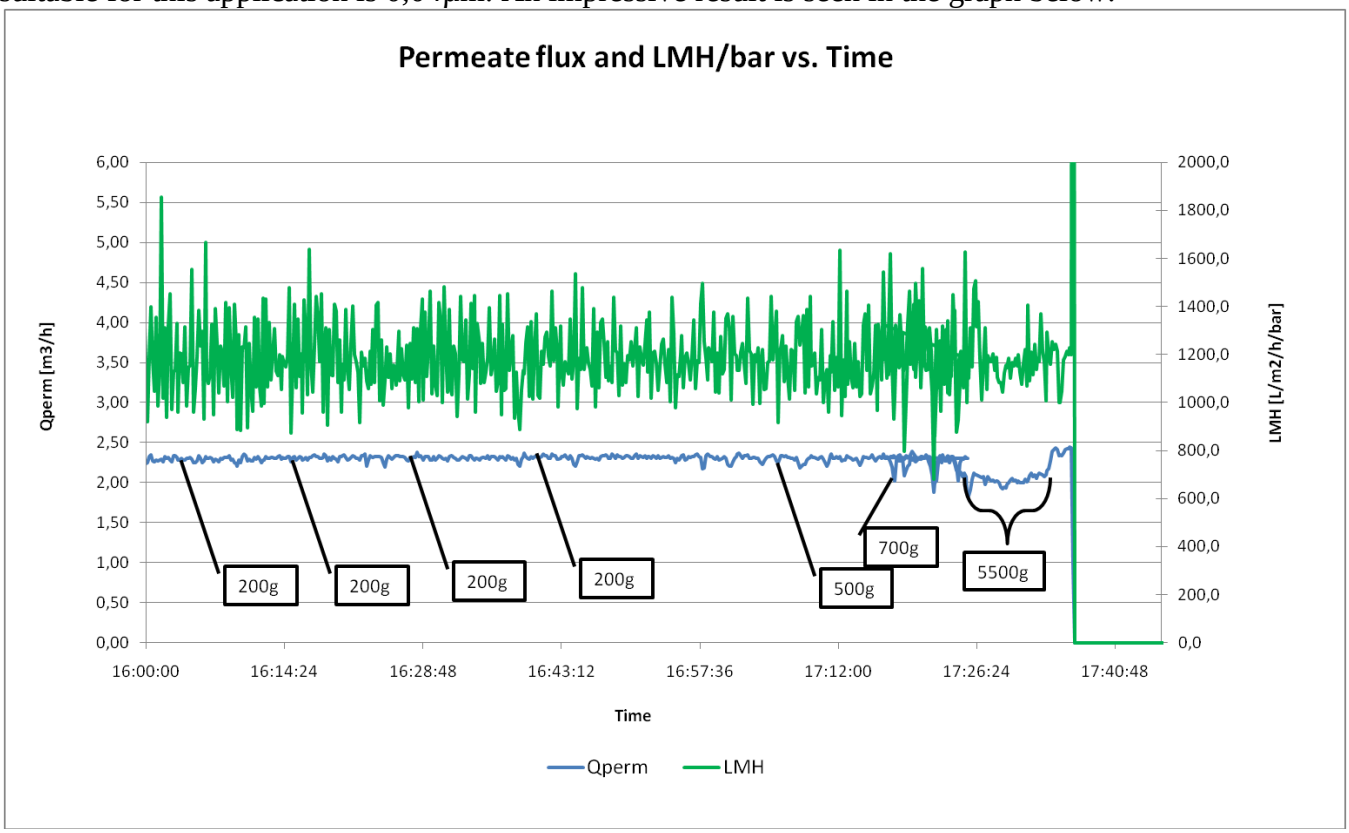

Figure 1 ***Results from produced water experiments. The experiments were performed on a CoMem Ø144x865 membrane with 6,5 m2 membrane area and a pore size of 0,04µm. Cross flow was 2,5 m/s.***

This graph shows corresponding values of permeate flux and LMH/bar vs. time. In this experiment, the membranes were stress tested on artificial produced water. Crude oil was added to real produced water in an attempt to find the limit for the membrane, see the amount added on the graph in the black boxes. We did not find the concentration limit as the permeate flux proved to be independent of the oil content.

Samples taken a while after the last addition of oil showed a reduction in oil content from over 70 g/L (70000 ppm!) to below 10 ppm. This low oil content in the permeate could be reached regardless of oil content in the feed, which shows that the amount of oil in the permeate is virtually independent of oil in the feed.

The fact that SiC-membranes can remove such high amounts of dispersed oil will also mean that hydro cyclones will be redundant in the future, as they can be replaced by CoMem SiC-membranes.

The picture below shows the last sample taken:

In addition to the convincing results in the experiments with oil removal, removal of particles has also been tested. If the particles can be removed, the water can be used for reinjection into the well.

This will result in a large reduction of energy consumption, as there will be no need for pumping and filtering sea water.

The picture below shows the reduction of particles. The oil content in the feed was here around 6ppm, and 1ppm in the permeate.

The results described in this paper show the obvious advantages for using CoMem SiC-membranes in the filtration of produced water. All experiments have been conducted in-house at the premises of CoMeTas in pilot scale, but on an industrial scale membrane. This means that long term on-site testing are yet to be made.

CoMeTas A/S develops, manufactures and globally markets ceramic membranes for industrial processes focusing on micro- and ultra filtration. The ceramic membranes are manufactured from silicon carbide, a superior robust and durable material, which gives the membranes a significantly higher flux offered at competitive prices. The membranes can be manufactured with pore sizes between 0,04 – 33 µm in flexible module sizes having membrane areas up to 15 m^2 per unit. CoMeTas A/S has presently an available production capacity for producing 250,000 m^2 membrane area per year. Furthermore, CoMeTas A/S has a laboratory where pilot tests can be conducted located in newly renovated facilities in Bagsværd, Copenhagen.