WATER TREATMENT

Freshening up – towards zero discharge

Testing oil and gas effluents in the laboratory
Source: Suez

Efficient water treatment is a vital component of oil and gas production, from injection to produced water, reinjection or discharge. New and conventional approaches are being applied both on- and offshore, reports *Brian Davis*.

They say oil and water don't mix. But in the face of increasingly stringent environmental legislation, efficient water treatment is of vital importance in oil and gas production both on- and offshore. Furthermore, there are significant challenges in terms of dealing with water scarcity; increasing volumes of produced water, particularly in mature fields; and development of new oil extraction techniques.

Leading water treatment companies like Suez and Veolia have been investing in R&D and pilot projects to optimise water treatment technologies.

Suez operates a global network of research centres based in Paris, France, Melbourne, Australia, and Shanghai, China, as well as working in partnership with customers, universities and research institutes, including the French Institute of Petroleum (IFPEN), BEICIP-Franlab and Solvay.

Work is underway with IFPEN, Solvay and BEICIP-Franlab to optimise the cost of oil extraction in chemical enhanced oil recovery (C-EOR) and minimise its impact on the environment. The water treatment aims to soften water by removing bivalent ions to improve the efficiency of the chemicals injected. However, this is a costly process under current oil prices, which is mostly being applied in China, a few locations in Canada and as pilot projects in the Middle East.

Increasingly oil and gas companies are considering full reinjection of produced water rather than disposal in anticipation of stricter environmental obligations.

Injected water

'Injected water must be free of solids that can plug a reservoir, free of oxygen and certain salts, such as sulphates, that may sour or generate deposits in the formation,' explains Pablo Reali, Oil & Gas Market Director at Suez.

For example, following pre-treatment with cartridge filters, multi-media filtration or ultra-filtration, Suez nano-filtration technology is being deployed by Petrobras on FPSOs to remove sulphates from seawater. Similar pre-treatments can be applied to river water for onshore applications.

According to Reali, there has been a move to use more ultra-filtration offshore. 'Though ultra-filtration is more capex intensive it offers opex savings in the long-term. The trend is to have a whole cycle view, as ultra-filtration can increase the life expectancy of nano-filtration membranes downstream,' he says.

Produced water challenges

'There are probably more challenges with treatment of produced water,' says Bertrand Garnier, Technical Director for industrial water at Suez. Under regulatory pressure, water treatment is required to remove contaminants which include dissolved organics, dissolved oil, salt, heavy metals, and naturally occurring radioactive materials.

Suez has developed a range of options for treating produced water. The de-sander cyclone, Cyclonixx, can be installed in a single pressure vessel located downstream of three-phase separators to remove solids before the fluids undergo further processing to prevent damage to downstream equipment. This compact solution is also suitable for floating systems.

The Pegasus system is designed to treat gas produced water for onshore and offshore gas processing and LNG and FLNG installations. The compact system can treat water suitable for discharge by extraction of BTEX (benzene, toluene, ethyl benzene and xylene) and soluble pollution removal, and a tailored biological treatment combination.

Suez also produces nutshell filters, and is upgrading membrane filters to meet stricter water discharge requirements. The Suez MemLab can handle membrane selection based on a vendor neutral analysis. The Suez Oil and Gas Lab is equipped for testing oil and gas effluents, membrane

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screening tests and hydrocarbon adsorbent media.

Conventional versus advanced

'In gas field produced water the most troublesome components are aromatics, which are hardly biodegradable and accumulate in the food chain. So the operator requires selective ways of reducing the aromatics component,' says Jeroen Boom, Global Account Manager, Water Technologies, Veolia.

A good way of accomplishing this is using the MPPE (macro porous polymer extraction) system, which is a fully automated system that removes dissolved hydrocarbons, like aliphatics, aromatics and polyaromatics. Hydrocarbon-contaminated water is passed through a column packed with porous polymer beads, which contain a specific extraction liquid. The purified water can be reused or discharged. Periodically, the extraction liquid is regenerated in-situ by stripping with low pressure steam. The stripped hydrocarbons are condensed and separated from the water phase by gravity, recovered in pure form and removed from the system. The condensed aqueous phase is recycled. MPPE customers include operators in the North Sea like Shell, Exxon and Statoil. More recently, MPPE is being installed on FLNG ships.

One of the main problems in many oil fields is that the amount of produced water is increasing, because operators are using water flooding or steam flood. In some cases, the water content exceeds 95% water, with less than 5% oil.

For conventional water treatment and coarse oil removal, many operators use a three-phase separator, followed by induced gas flotation (IGF) and walnut shell filtration. Veolia has developed a more compact treatment, which combines pre-treatment (see **Box**) with ceramic membranes. The CeraMem membrane is a 0.2–0.5 µm filter removing virtually all oil droplets and suspended solids. This process line-up makes it ideal for further upgrade of the water quality to produce, for example, boiler feed water.

Three plants are in operation at onshore oilfields in the US using these ceramic membranes. Hardness is also removed from the oil field water using the OPUS process (see **Box**).

In some cases the produced water will have a very high salinity. When this salinity prevents disposal of the produced water it can be reduced by thermal treatment and crystallisation of salts. But this is a more expensive operation and creates a lot of solid waste with mixed salts that could contain contaminants like heavy metals. 'Veolia is researching how to isolate different salts with high purity for beneficial re-use. But this is a difficult process and in many cases is not attractive financially,' Boom says.

Bringing down costs

'There is a huge drive to minimise the cost of produced water treatment', continues Boom. 'There are also challenges around legislation. Moreover, for re-use produced water must comply with a lot of quality conditions, which can sometimes be difficult to meet.'

Boom says Veolia is looking at optimising equipment, new processes and expanding the design limits for different operations, to help cut costs. 'For onshore operations we are also looking DBOM (design, build, operate and maintain) contracts for water treatment plants, combining our design and operational experience for better cost efficiency.'

Towards zero discharge

'In the face of new legislation, there is a move in the industry towards zero discharge,' notes Colin Berry, Technical Manager of John Crane's oil and gas consultancy services team. 'The concept of zero discharge has not yet been universally implemented, but many operators apply their own limits which tend to be more stringent than local legislative limits.'

John Crane frequently considers source waters for injection purposes – seawater, river water, lake water or subterranean aquifers. Berry points out: 'When using seawater, it is important to reduce the solids loading in terms of particle counts and total suspended solids; to remove oxygen to mitigate against corrosion; and to control and manage microbiological populations.'

Bacterial populations should be controlled as strictly as is practically possible, but you will never achieve total eradication,' says Berry. 'However, there may be a desire to encourage the growth of nitrate reducing bacteria at the expense of sulphate reducing bacteria as part of a mitigation programme against reservoir souring.

Treatments vary according to the nature of the water source and the types of suspended solids or dissolved gases for removal. Treatment of a seawater system is a function of coarse and fine filtration followed by de-aeration. Seawater or surface water is de-aerated using vacuum or gas stripping, and chemically treated to mitigate against scale, corrosion and microbiological colonisation.

The main workhorse for filtration is a backwashing dual media filter, typically using anthracite and garnet media, though some (like Saudi Aramco, which has the biggest water injection system in the world) use sand as the filtration medium. Some operators use cartridge filters, but these can be cost prohibitive at current oil prices. There are also ceramic and nano-filtration variant membrane filters 'but these tend to be commonly used for specialised purposes for example where the removal of specific ionic species is appropriate, or perhaps the removal of sub-micron particulates', remarks Berry.

For reinjection, produced water typically requires treatment with a solids-liquids cyclone that separates any large solid particle from liquids. The fluids might then pass through a liquid-liquid hydrocyclone, followed by a flotation device (gas flotation, induced gas or dissolved gas flotation), and finally a bank of nutshell filters; nutshell filters (crushed walnut or pecan shells) are still commonly used to effectively clean produced water, as a precursor to polishing filtration.

'At the end of the day, it's a matter of selecting the right system for the job based on efficiency, required water quality and specified budget,' he says. ●

Water treatment for EOR

Veolia provides water treatment for Chevron's EOR operations in San Ardo, California, where steam is injected to stimulate oil production. Produced water is extracted together with the oil at a ratio of 10~15 to 1. The excess water needs to be treated for re-use as steam or release to the environment. The treatment includes a common pre-treatment step using an induced gas flotation system and a walnut shell filtration system to reduce the free oil to less than 0.5 ppm for removal. Subsequent treatment steps of the OPUS process involve a softening system ready for the once through steam generator, followed by media filtration, ion exchange softening, and a double pass reverse osmosis system. ●

Walnut shell filtration. *Source: Veolia*