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Approaches to produced-water treatment evolving

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Canadian manufacturer's success in California reflecting advanced approach

Heavy-oil fields throughout North America are now fully engaged in utilizing produced water as boiler feed for thermal extraction – a more reliable, environmentally friendly approach compared to using fresh water. However, the methods for treating produced water are swiftly evolving in interesting ways, presenting operators in the U.S. and Canada with a greater range of options that are safer, more efficient, and able to significantly cut down on many operational costs, compared to conventional counterparts.

In California, a Canadian company's higher-performing micro-media filtration and ion-exchange softening reflect such a progressive approach. Eco-Tec, Inc. has provided seven heavy-oil operations in California with new treatment systems in a span of just over two years – softening water at a total capacity of about 81,500 barrels/day (13,000 m^3/day).

The most recent produced-water treatment project for an operator in Placerita Canyon, California, at a flow rate of 35,000 BPD, represents the largest in terms of capacity to be built by the company and, compared to previous systems by Eco-Tec, will handle water with the highest level of hardness (2,600 ppm as $CaCO_3$) so far. "The water the new Eco-Tec system will be treating is very high in hardness for the California area, and treating it at this larger capacity is serving as a benchmark for the entire region and Western Canada as well," says Mehdi Surury, Regional Sales Manager for Western Canada.

Just as in Alberta, water-conservation measures and environmentally responsible practices among oil producers are moving forward quickly in California, especially following a period of severe drought that struck the state in 2008. The drought compounded the difficulty of securing freshwater sources from which to generate high-quality steam that thermal-extraction methods require (SAGD – Steam Assisted Gravity Drainage, CSS – Cyclic Steam Stimulation). In an effort to manage the crisis, then-Gov. Arnold Schwarzenegger proclaimed a state of emergency and enacted widespread water-conservation measures.

Much like Alberta, the large amount of agriculture throughout California puts pressure on fresh-water reserves needed for farming. As a result of severe shortages in 2008-2009, oil producers were denied fresh aqueduct water from regional water districts and, instead, had to resort to purchasing its supply from farmers in the area.

Lasting impact

The drought officially lasted until March 2011, but has left a lasting impact on many heavy-oil fields in the state that once relied on affordable fresh water to feed boilers. While many shift to using produced water, some tread cautiously since it is of a much higher hardness and salinity in California; it can cause serious problems for operators engaged in thermal heavy oil applications due to the increased tendency toward scaling and corrosion in equipment. Operators remain cautious, as well, as problematic issues continue to crop up while using conventional treatment systems, namely:

• Safety and costs related to handling acid and caustic often used for regeneration of produced water softeners

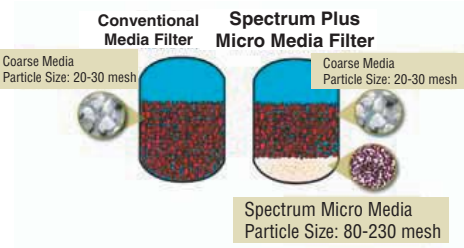
• High chemical (salt, acid and caustic) consumption due to the limitations of conventional ion-exchange softener designs, especially when treating produced water with high hardness or TDS

• Large waste volumes produced during regeneration, requiring disposal

• Large equipment, which requires considerable space and site assembly.

For many operators, among the most important concerns is the need to avoid the use of hydrochloric acid (HCl) followed by caustic soda (sodium hydroxide, NaOH), which is typically used to regenerate the resins in weak-acid-exchange (WAC) softeners. The handling of these products adds substantial costs, safety hazards, greater regulatory requirements, and the need for corrosion-resistant alloys in construction of the processing equipment, which requires considerable space and site assembly.

Operators can employ Strong-acid-cation (SAC) ion-exchange processes, which require only brine regeneration (i.e., no acid or caustic), and are much simpler and less expensive than WAC processes. Yet the SAC process is normally restricted to low-TDS waters (usually less than 3,000 mg/L, and sometimes up to 5,000 mg/L). Instead, WAC resins are typically used for softening high-TDS produced water, such as what the various heavy-oil fields in the California region, and parts of Alberta, must contend with.



A comparison between conventional media filters and micro media filters.

Eliminating the need for acid/caustic

What is driving adoption of the Eco-Tec systems in California is the use of a patented ion exchange process, known as Recoflo, that allows the use of either SAC or WAC resin to soften produced water at TDS levels up to 12,000 mg/L, to levels of residual hardness less than 0.1 mg/L – without the need for acid and caustic, even for regeneration of WAC resins. The technology can also provide a 40 to 80 percent reduction in salt and waste from regeneration compared with conventional softeners.

Eliminating the need for acid and caustic for regeneration was a critical factor for Seneca Resources' heavy-oil operation in Lost Hills, California, which was the first operator in the state to purchase an Eco-Tec system in 2009. To this date, the produced water treatment system installed there, handling a flowrate of about 7,000 bpd (1,090 m^3/day), continues to maintain the desired water hardness level of less than 1 mg/L (as $CaCO_3$).

"What was new about the Eco-Tec project was using a SAC/WAC system that didn't require hydrochloric acid and caustic in the regeneration process. We didn't want the safety concerns in handling those; that was one of the reasons we chose the Eco-Tec technology," said Keith Jones, Senior Technical Advisor for Seneca Resources.

The Eco-Tec Recoflo technology eliminates this through highly efficient features, not found in typical ion-exchange equipment, such as short bed heights (6 to 24 inches/15 to 61 cm in depth) and small resin volume (only up to 15 percent of the resin volume required of conventional ion exchange systems); low resin exchange loading (less than 15 percent of the total exchange capacity of the resin compared to conventional ion exchange processes that use resin to near exhaustion); fine mesh resin with a diameter of one-quarter the size of resin used by conventional systems; compressed resin beds that are at a state of compression at all times, with no freeboard; and counter-current regeneration to ensure that the cleanest, most effective resin is at the bottom of the bed after

Produced water treatment system in Maricopa, California, with Spectrum Plus Micro-Media Filters and RecoPur SAC/ WAC Ion Exchange Softeners.

regeneration.

The highly efficient regeneration and resin rinsing of compressed bed systems result in reduced water and chemical consumption – thus, the elimination of acid and caustic. The equipment also has a smaller footprint than competing systems, is fully automated for simple operation, features easy adjustment to variable feed water conditions and, if needed, effective in-situ resin cleaning.

Two-layer depth filtration

Another issue among heavy-oil producers in the area concerns the use of nutshell media pre-filtration commonly used in advance of softening equipment. Nutshell filtrate typically contains residual oil and suspended solids that can result in downstream operational problems. If allowed to accumulate, these solids can adversely impact water and regenerant chemical distribution, will ultimately increase pressure drop, and degrade water quality and quantity. Furthermore, longer term fouling by solids and residual oil can make subsequent resin cleaning much more difficult, if not impossible.

It's especially true when dealing with today's ion exchange technologies, which require TSS (total suspended solids) of 0.1-0.5 mg/L and turbidities of 0.1-1 NTU (nephelometric turbidity units). Most suppliers of ion exchange resin would advise removal of suspended solids to at least 1 mg/l or better through some form of pretreatment and that some, but not all, of the residual solids that accumulate within resin beds be removed by periodic backwashing of the resin.

Among the reasons operators throughout California have looked to the Eco-Tec treatment system is the advanced micro-media pre-filtration, known as Spectrum, which features a unique two-layer depth media configuration that departs from conventional design. It maintains a coarse media (either anthracite or nutshells) upper layer, a fine micro-media lower layer, and high service flow rates. It can remove virtually all particles > 2 micron while significantly reducing particles < 2 micron, while conventional nutshell filtrate typically contains significant particles in the 0-10 micron size range.

Throughout California, Spectrum micro-media is filtering produced water at a total capacity of 117,894 bpd (18,743 m^3/day), ranging from about 6,000 bpd (1,000 m^3/day) in Lost Hills to about 32,000 bpd (5,000 m^3/day) in Placerita Canyon.

The filters are also handling TSS as high as 25 mg/L in Bakersfield, California. Worldwide, this micro-media technology is filtering 208,460 BPD (33,143 m^3/day).

Since commissioning in Dec. 2009 for Seneca Resources in Lost Hills, softener resin cleaning, as a response to resin fouling by oil and suspended solids, has not been needed in the more than two years since the system has started up – reflecting the efficiency of Spectrum.

The lower, fine micro-media layer of the Spectrum filter is the key feature compared to conventional designs. While dual media filters typically employ silica sand with an effective size of about 0.35 mm, the Spectrum filter uses a lower layer of high density media with an effective size of less than 0.1 mm.

The flow channels through the micro media are extremely small and the tortuous path of fine channels provides excellent retention of solids. It is much heavier in density than coarse media which ensures that it re-classifies (resettles below the coarse media after backwashing) and is virtually impossible to backwash out of the filter vessel.

The top layer consists of coarse nutshells – similar to, but somewhat finer than that used in conventional dual media filters – and provides the bulk of the solids retention and therefore defines the run length.

Eco-Tec, Inc.