WATER TECHNOLOGY BRIEF #2008-1

Thermal Distillation Technology for Management of Produced Water and Frac Flowback Water

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Thermal distillation uses heat to turn water containing high dissolved solids into steam. The steam can then be distilled to create clean water. The process also creates a concentrated byproduct stream of much lower volume. The most common use of thermal distillation is desalination of seawater to make drinking water. Historically, the energy input requirements for thermal desalination have been too expensive to treat produced water. However, in some arid areas, the cost of treating produced water minus the recovered value of clean water as a byproduct have made thermal distillation affordable in niche applications. This paper describes one thermal distillation technology already included in Argonne National Laboratory's Produced Water Management Information System (PWMIS; web.evs.anl.gov). It also describes a second thermal distillation technology that has been successfully used to treat flowback water from a hydraulic fracturing job (frac flowback water) in Texas.

Thermal Distillation Technology Already Described in PWMIS

PWMIS includes a technology fact sheet that describes one thermal distillation technology that has been used recently to manage produced water (AltelaRain). The AltelaRain process reduces the energy costs by using counter-current heat exchange technology. The AltelaRain unit is a relatively small, modular technology roughly the size of a home water heater (Figure 1). Each unit processes about 8 bbl/day. When treating larger water volumes, multiple units are deployed in parallel. These may be housed in a large metal cargo container (Figure 2). The AltelaRain units have been used at several locations in New Mexico to treat produced water, generate fresh water, and reduce the volume of wastewater that needs to be transported offsite for disposal.

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Figure 1 – AltelaRain unit.

Source: Altela

Figure 2 – Two shipping containers containing multiple AltelaRain units.

Source: Altela

New Thermal Distillation Technology

Perhaps the busiest shale gas region in the world is the huge Barnett Shale natural gas fields in northern Texas. In order to produce gas from the tight shale formation, each well must undergo a frac job. A frac job requires approximately 3 million gallons of water (~71,000 bbl). Within the first few days following the frac job, most of the injected water returns to the surface as flowback water. The flowback water is sufficiently dirty that it cannot be reused without treatment. Where disposal wells are available nearby, the flowback water often is injected to a deep formation. However, when disposal wells are not available locally, the cost to transport the flowback water can be very expensive.

In addition to paying to dispose of the flowback water, operators must obtain a new water supply for each additional well that undergoes a frac job. In highly active production areas, like the Barnett Shale region, water can become difficult to find and can pose an additional cost to operators.

During March 2008, I visited several sites in the Barnett Shale region. One of the sites I visited was operated by Devon Energy Corporation near Decatur, Texas (40-50 miles northwest of Fort Worth). Devon is running a large-scale pilot test of a new thermal distillation technology to clean the frac flowback water so it can be reused for subsequent frac jobs.

The technology, the Aqua-Pure system, uses a mechanical vapor recompression evaporation (MVR) process. Although considerably larger than the AltelaRain units, the Aqua-Pure system still is portable. It can be broken down into three large skids for truck transport to other sites. In Texas, the evaporator units are owned and operated by Fountain Quail Water Management, a joint venture between Aqua-Pure and the Ellenburg Group of Jacksboro, Texas. Fountain Quail charges a processing fee for each barrel of water processed. Each mobile evaporator unit is capable of processing 2,300 barrels/day of contaminated water and returning approx. 2,000 barrels/day as fresh water.

The following information is taken from the Aqua-Pure website at www.aqua-pure.com.

> *"MVR evaporation is an energy efficient process that produces pure distilled water from wastewater containing dissolved solids. In an MVR Evaporator, a compressor is used to add the energy required to boil water. The feed water passes through two preheat exchangers where sensible heat is absorbed from the distillate and concentrate products leaving the system. The feed then passes through a de-aerator column where dissolved gases are vented. The feed then passes into a recirculation loop where concentrate circulates through an evaporator exchanger and a vapour/liquid separator. A portion of the concentrate is boiled to steam in the evaporator exchanger and separated from the liquid in the separator vessel. A compressor draws the steam off the separator and boosts the pressure, which results in an increase in temperature. The steam is driven through the opposite side of the evaporator exchanger where it condenses to distilled water, releasing its latent heat to the boiling concentrate. The distilled water is then pumped through the preheat exchanger where remaining sensible heat is transferred to the incoming feed. Concentrate is continually pumped from the recirculation loop out of the unit to prevent the solution from reaching saturation. The concentrate also passes*

through a preheat exchanger where remaining sensible heat is transferred to the incoming feed.

Producing distilled water from direct-fired distillate requires 1000 BTU/lb of heat energy. Due to the sophisticated heat exchanger configuration in MVR evaporation, distilled water can be theoretically produced with only 25-28 BTU/lb, 1/40th the energy."

The Aqua-Pure System at the Devon Site

Devon collects frac flowback water from various wells and hauls it by vacuum truck (Figure 3) to the water treatment facility. The flowback water is unloaded into an aboveground lined impoundment (Figure 4). In addition to high total dissolved solids (salt), the flowback water contains various contaminants, such as organic materials (bacteria present in the rock formation, and fraccing chemicals), polymers (the friction reducers and cross-linked gels), residual hydrocarbons (trace oil, and volatile organic compounds such as benzene and toluene), and suspended solids (clay, iron oxides, and silica). The flowback water cannot be directly reused until these contaminants are reduced.

Pretreatment: The flowback water is dosed with flocculant chemicals (Figure 5) to coagulate and flocculate the solids. Figure 6 shows a sample of the influent following flocculent addition. The sample contains extensive solids flocs. The wastewater is then passed through an inclined plate separator to remove the flocculated solids (Figures 7 and 8). Figure 9 shows two views of the treated wastewater after passing through the separator. Note that the water is considerably clearer.

The solids collected in the separator are sent to a nearby filter press for dewatering (Figure 10). The solids are placed into a dumpster for offsite disposal (Figure 11).

Removal of Total Dissolved Solids: The effluent from the separator looks clear, but still contains high total dissolved solids. It is pumped to the Aqua-Pure MVR evaporator unit for treatment. Figure 12 shows one complete unit. The control room is on the left side. The fully treated water exits on the right side and is stored in tanks for future reuse. A second complete unit is situated to the left of the unit shown in the photo. Figures 13 and 14 show different views of the Aqua-Pure units. It was quite noisy while walking in and around the units so I was unable to learn the identity and location of individual components from the personnel leading the tour.

Economic Issues

According to anecdotal reports, the cost of treating the frac flowback water and reusing it is more expensive than the more traditional approach of hauling the flowback water to a disposal well and purchasing/obtaining new water for each frac job. Nevertheless, Devon has continued to study the Aqua-Pure process for its potential payoffs in the future, both in the Barnett Shale region and elsewhere. They are gaining valuable experience with the technology and can work on improving its efficiency and lowering the cost.

In the Barnett Shale region, natural gas is plentiful, and can be readily obtained as a fuel source to operate the technology. In other applications, such as treating produced water from oil wells, natural gas may not be an affordable energy source.

Figure 3 – Vacuum truck used to haul frac flowback water.

Source: J. Veil, Argonne National Laboratory

Figure 4 – Impoundment for storing incoming flowback water.

Source: J. Veil, Argonne National Laboratory

Figure 5 - Storage tanks for flocculant chemicals.

Source: J. Veil, Argonne National Laboratory

Figure 6 – Sample of influent to separator showing extensive floc formation

Source: J. Veil, Argonne National Laboratory

Figure 7 – Side view of inclined plate separator.

Source: J. Veil, Argonne National Laboratory

Figure 8 – Top view of inclined plate separator

Source: J. Veil, Argonne National Laboratory

Figure 9 – Two views of separator effluent.

Source: J. Veil, Argonne National Laboratory

Figure 10– Filter press used to dewater flocculated solids.

Source: J. Veil, Argonne National Laboratory

Figure 11– Dewatered sludge.

Source: J. Veil, Argonne National Laboratory

Figure 12 – The Aqua-Pure MVR Evaporator Unit

Source: J. Veil, Argonne National Laboratory

Figure 13 – Closer view of the Aqua-Pure unit

Source: J. Veil, Argonne National Laboratory

Figure 14 – Another closer view of the Aqua-Pure unit.

Source: J. Veil, Argonne National Laboratory