Beneficial reuse of flare gas recovers freshwater

A novel produced water treatment technology recovers freshwater for reuse using natural gas that is typically flared and, thereby wasted, in oil and gas operations. This new approach tackles the growing problem of produced water treatment and disposal. **Ricardo Bernal** of Heartland Water Technology explains.

Produced water from oil and gas operations has increased dramatically over the past 10 years, primarily from unconventional oil and gas. Especially so in the Permian Basin, where an estimated 35 to 60 billion barrels (bbl) of excess produced water is expected over the next 10 years. Managing this volume of water is a technical, logistical, and economical challenge and has given rise to a burgeoning mid-stream water treatment sector to tackle the problem.

The work-horse for produced water management in the Permian Basis is the salt water disposal well. However, emerging issues with this disposal method, such as increasing formation pressures, cross-contamination, and induced seismicity, are gaining attention.

Dealing with these large volumes of produced water will necessarily require a suite of water treatment and management options including salt water disposal, reuse, water volume reduction, and desalination. Another approach using the Heartland Concentrator™, developed by the US company Heartland Water Technology (based in Hudson, Massachusetts), addresses this challenge while also using the natural gas that is currently being flared in large volumes (and otherwise wasted) to evaporate produced water and recover fresh water for reuse.

Projected growth of produced water

The US is the top oil-producing country in the world, producing an average of 7.9 million bbl per day, which accounted for 18 percent of the world's, production in 2018, according to the US Energy Information Administration's calculations of Total Petroleum and Other Liquids Production. A massive increase in oilfield produced water has accompanied the growth in oil production. In some areas of West Texas, reported water cuts (which is the ratio of the water which is produced in a well compared to the volume of the total liquids produced) can be as high as fifteen barrels of water for each barrel of oil produced. The ability to safely, sustainably, and economically manage this tremendous volume of produced water is critical to the long-term viability of many of the US key oil-producing formations. In their recently published White Paper, the Texas Alliance of Energy Producers sums up the situation clearly: "...to keep US production dominance alive, the Texas oil and gas industry must maintain its 'social license' to operate through a variety of activities that include developing good water management strategies and maintaining public support by exhibiting to the public that the industry is using water wisely and sustainably."

Disposal challenges

Currently, more than 90 percent of produced water brought to the surface from the production of oil and gas is disposed of by injecting it underground through Class II Underground Injection Control (UIC) salt water disposal wells, according to the 2019 Groundwater Protection Council Produced Water Full Report. Generally, when plentiful UIC capacity is available, injection becomes the disposal option of choice as it is relatively inexpensive and can handle the large volumes of produced water. However, in areas such as West Texas and New Mexico, there are questions as to the ability for UIC well capacity to expand sufficiently to meet the future produced-water disposal demand. Concerns associated with formation pressures, cross-contamination, and induced seismicity are slowing the process for new UIC well permits and increasing the cost associated with drilling new UIC wells. For example, New Mexico is restricting the number of disposal wells, which could lead to more wells built in Texas. And, the Texas Railroad Commission, the body overseeing drilling and disposal activities in Texas, has recently curtailed the injection pressures for newly permitted UIC wells from 0.5 psi per foot to 0.25 psi per foot.

Adding to these challenges is the increasing volume of produced water. Estimates vary, but one recent Wood Mackenzie study estimated that water disposal volumes in the Permian are expected to double within the next two or three years.

Focus on water volume reduction and reuse

Current and anticipated challenges with disposal coupled with increasing costs of disposal are pushing producers in the Permian to find ways to reuse as much water as possible. By necessity, (because UIC wells are geologically problematic in the area) producers in the US Marcellus Shale have led the industry in reuse. According to the Pennsylvania Department of Environmental Protection, 90 percent of the produced water in the Marcellus Shale was reused in 2013 with the other 10 percent being trucked to UIC wells primarily in Ohio. Based on industry news and company press releases, water reuse across Texas is increasing and, in some cases, producers may even prefer to use brackish water over fresh water. This is a very positive move by the industry and will help to manage the increasing volume of produced water.

Water reuse midstream solutions, where third-party companies invest in pipelines and infrastructure to facilitate transportation of water between operators, are also growing rapidly. According to the Produced Water Report, these solutions require midstream companies to make significant upfront capital investment, but the solutions allow oil producers to significantly reduce transportation, disposal, and reuse costs.

While reuse is growing dramatically, reuse alone cannot solve the problem. As we can currently see happening in the Marcellus, when drilling activity slows and the demand for water for fracking declines, a supply-demand imbalance occurs because the produced water keeps coming. Additionally, some of the produced water is so saline that it is not desired as a frac fluid. In the Permian, produced-water volume is expected to exceed

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Heartland Concentrator™ integrated with a wellhead gas flare.

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maximum water demand by three to five times if oil prices remain between US$55/bbl and $75/bbl as expected. In this scenario, according to Permian Water Outlook report by B3 Insights, over the next decade 35 to 60 billion bbl of water in excess of water use for hydraulic fracturing will need to be managed beyond what can be reused.

Solving two problems

Globally, a tremendous amount of natural gas is flared and wasted as part of oil production. Total US gas flared increased from 165,928 metal-to-metal charge transfer (MMct) in 2010 to 468,347 MMct in 2018. In the Permian Basin, according to a 2019 *Gas Journal* article, gas flaring reached a record high in the first quarter of 2019, totaling 661 million cubic feet (MMcf). It certainly isn't that the industry doesn't want to recover the value of the flare gas, but the remote locations of the drill sites often make natural gas pipelines impractical. Additionally, the rapid gas peaking and roll-off makes onsite use of the flare gas, such as power generation, challenging.

One solution, offered by Heartland Water Technology, has proven the ability to use flare gas effectively to evaporate produced water and recover fresh water at or near the drill site – solving two problems by offering an important tool for produced water management and an option to beneficially reuse previously wasted flare gas at the same time. Integrating evaporation into an overall water management plan can offer a number of advantages to an operator, such as reducing the volume of produced water, recovering fresh water for reuse, and reducing or eliminating the need for large storage ponds. Ultimately, it all comes down to economics and needs: when UIC well options cannot economically meet the produced water disposal demand, evaporation utilizing available wellhead flare gas can play an important role.

Flare gas case study

The unique evaporation solution developed by Heartland Water Technology reuses thermal energy from wellhead flares to treat, reduce, and reuse produced water. The simple, robust treatment solution for challenging wastewaters also offers processing flexibility that allows for a broad range of wastewater treatment specifications to be met using a single unit operation.

In the following example, a customer located in the Marcellus Shale was seeking a cost-effective treatment solution for the produced water resulting from their natural gas drilling operations. Because its solution can be configured to run on waste heat, Heartland was able to use otherwise wasted thermal energy to treat a produced-water waste stream close to the drill site, reducing truck traffic and costs.

Operational flexibility

The customer selected Heartland to install and operate a LM-HT® Heartland Concentrator capable of processing up to 50 bbl per day of produced water delivering a concentrated brine as well as a true zero liquid discharge (ZLD) solution.

Waste heat integration

The Heartland Concentrator was deployed in two locations, one which used wellhead flare gas and the other which used waste heat taken from six (6) CAT 3615 engines being used to drive six (6) natural gas compressors. Using this waste heat, Heartland successfully operated continuously in Zero Liquid Discharge (ZLD) treatment mode, reducing the produced water to salt, which was disposed of at a local landfill. Later, the customer shifted to Minimum Liquid Discharge (MLD) operating mode, reducing the volume of produced water by over 80 percent while maintaining the residual as a pumpable brine.

Condensate and heat recovery

Heartland also installed a spray condenser to achieve the dual benefit of preheating the produced water feed and condensing a portion of the clean water vapor from the process for beneficial reuse. This technique provided sufficient condensate for all periodic equipment cleaning activities, demonstrating how the Heartland Concentrator™ can operate independently in remote installations with limited utilities available.

Conclusion

As the volume of highly saline produced water continues to rise, the industry will need to continue to innovate in order to safely, sustainably, and economically manage this towering volume of wastewater. The Heartland Concentrator demonstrated that direct-contact evaporation can be an effective part of an overall water management plan. By successfully operating in both a ZLD mode for solid waste disposal and in brine mode for a combination of beneficial reuse and deep-well volume reduction disposal, the Heartland Concentrator successfully demonstrated its operational flexibility and effectiveness across a wide range of treatment specifications. And by utilizing wellhead gas as the source of thermal energy, Heartland beneficially reused a previously wasted energy source. Along with produced water reuse and UIC well disposal, onsite evaporation should be considered as an important tool in managing increasing produced water challenges.

Author's Note

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