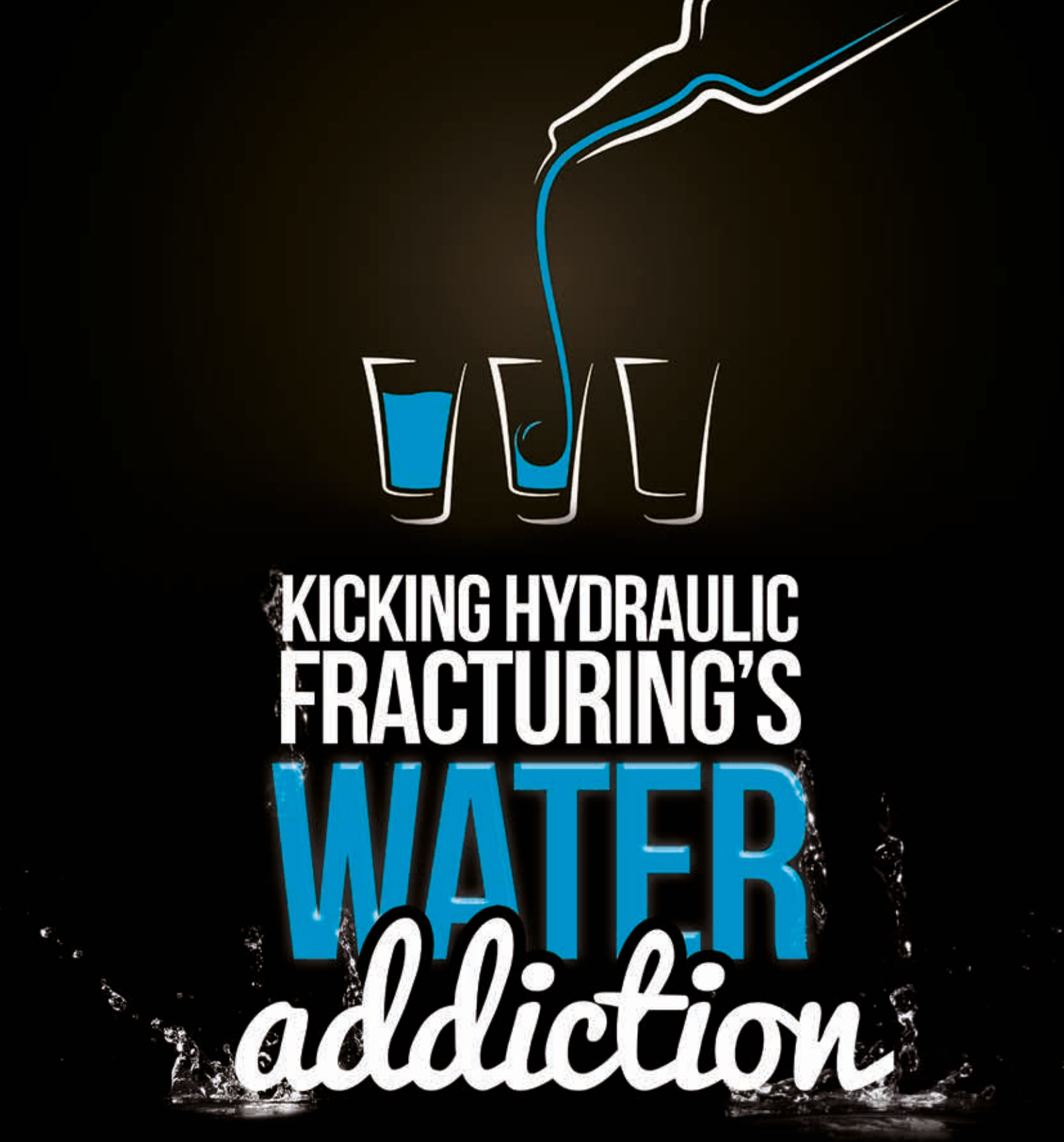

KICKING HYDRAULIC FRACTURING'S WATER addiction

Bill Charneski, OriginOil, USA, looks at how to quench the thirst of the shale industry without putting undue strain on water supplies.

Hydraulic fracturing in the United States offers inexpensive, clean natural gas to power the future and reduce dependency on foreign oil, but it comes at a cost to water supplies. Environment America found in a recent study that 280 billion gallons of wastewater was generated from fracking in 2012, and a recent Ceres report found that nearly half of oil and gas wells recently hydraulically fractured in the US are in regions with high or extremely high water stress. With drought conditions plaguing western states and water management becoming a more critical national issue, the oil and gas industry must own up to its water addiction and devise a path forward.

Figure 1. *OriginOil CEO Eckelberry discusses the EWS technology at showcase in Delta, Colorado with County Commissioner Mark Roeber.*

Figure 2. *The CLEAN-FRAC was successfully tested by Lizard Labs with water from the western slope.*

Figure 3. *From left: feed water, separated water, final stage clean water and recoverable oil product.*

Two types of wastewater are produced from oil and gas wells – produced and frac flowback water. In the first few days and weeks following a hydraulic fracturing operation, as much as 30% of the water used in the fracturing operation flows back to the surface. That returning water is called frac flowback water. Over time, the chemistry of the flowback water changes to resemble that of the formation water, or the water naturally found within the shale, at which point it is referred to as produced water. The chemistry of the produced water is determined by the chemistry of the shale: if there are toxic elements in the shale, there will likely be toxic elements in the produced water as well. The US DOE reports that an average of eight barrels of water are 'produced' or brought to the surface for every barrel of oil.

Both produced and frac flowback water have traditionally been disposed of in evaporation ponds or disposal wells, which is an expensive process. Energy companies are now paying US$ 3 to US$ 12 per barrel to dispose of produced water, representing a total cost worldwide of US$ 300 billion to US$ 1 trillion per year. Treating and reusing produced water and frac flowback water, rather than trucking it away for disposal, offers well operators the opportunity to incur significant savings and reduce the growing strain on water resources.

What if there was a different way?

Both sourcing new water for hydraulic fracturing and disposing of wastewater has become a challenge for well operators. Water, once considered an abundant resource, is quickly becoming a valuable and limited asset to their operations. There is a strong and growing trend that these waters must be treated and reused instead of using 'new' fresh water. With recycling, operators benefit twofold: first from reducing the cost of fresh water and second from eliminating the logistical costs of water management, such as storage, trucking and disposal. Additionally, by reusing water, hydraulic fracturing's burden on local fresh water resources is reduced, which is crucial in areas experiencing drought conditions.

Recycling technologies are quickly being introduced to the market in order to help oilfield operators maximise the value of their water resources and lessen their impact on the environment. OriginOil has one such technology called Electro Water Separation (EWS) – a continuous, high speed, chemical-free process that efficiently extracts oils, suspended solids, insoluble organics and bacteria from frac flowback and produced water.

Emulsified produced water is fed to the EWS system following free oil or heavy solids upfront

pretreatment, such as a three-phase separator, skim tank or hydro-cyclone. Within the system three distinct mechanisms are used to treat the influent stream; electro-coagulation, electro-flotation and electro-oxidation. Electro-coagulation functions to: de-stabilise the emulsion, neutralise the electro-static charge of non-soluble hydrocarbons as well as suspended solids allowing the dispersed oil and suspended solids to agglomerate and flocculate into large non-soluble particles. Electro-oxidation deactivates biological activity and mineralises dissolved organic materials and soluble hydrocarbons. Following coagulation the influent stream passes through the electro-flotation chamber where the less dense agglomerated particles are lifted from the feed stream and solids are allowed to settle, resulting in an effluent quality ready for re-use as downhole stimulation or additional polishing as required by site specifications.

In contrast to conventional electro-coagulation systems, the EWS technology was designed to incorporate electro-coagulation in-line with downstream electro-oxidation depending on the influent and effluent specifications required for a site. Incorporating downstream electro-oxidation enables a reduction in cost-of-water treated over comparable competitive technologies by providing biological deactivation and dissolved hydrocarbon removal in a single modular system rather than requiring additional stand alone equipment.

Additionally, within the electro-flotation section of the EWS process, a control programme enables the systematic production of a high concentration density of microscopic flotation bubbles. The production of this high concentration density bubble flotation improves the final effluent water quality enabling advanced downstream treatment without additional intermediate treatment steps.

All of these processes are controlled by a supervisory control and data acquisition system (SCADA). The SCADA system can monitor specific water parameters and make real time adjustments to control the electromagnetic pulse characteristics for maximum efficiency and minimum energy usage. It also allows for remote monitoring and control. Integrating these multiple process steps in a single system enables the displacement of up to three pieces of equipment with conventional competitive technologies.

Third party testing

When EWS and a downstream technology are integrated, it falls within the product line under the name CLEAN-FRAC. At ISI Technology in Delta, Colorado the CLEAN-FRAC 1000, embedded with the EWS technology and TriSep's iSep™ ultrafiltration (UF) membranes, was tested on produced and frac flowback water from the western slope. During tests, the system was shown to remove 99% of hydrocarbons and other organics in a single pass.

Lizard Analytical Laboratories, a third party testing organisation, verified the results of the system in the field. The lab concluded CLEAN-FRAC does have a very low energy usage of 0.22 kwh/bbl of water, which amounts to approximately US$ 0.03/bbl. Energy usage could be lowered further in other field applications if the water salinity is higher, which would be typical for most oil and gas plays (ISI has low salinity).

Additionally, Lizard Analytical Laboratories[1] concluded that this system, incorporating iSep ultrafiltration (UF) membranes reduces contaminants in the following amounts:

- 99.6% of turbidity.
- 90.3% of total suspended solids.
- 90.5% of oil in water.

Original equipment manufacturers (OEMs) can integrate EWS and downstream polishing solutions, like iSep, into CLEAN-FRAC to provide an end-to-end solution. To date, the company has signed licensing agreements with four companies, including ISI, Pearl H2O, E3 and Burgan One.

Pearl H2O, an oil and gas water treatment spinoff of PACE (Pacific Advanced Civil Engineering), completed the first commercial-scale water treatment system integrating OriginOil's EWS technology. The 1200 bpd system named 'Pearl Blue' processes frac flowback and produced water from California's Monterey Shale formation at a treatment site in the Bakersfield area of California. In addition to OriginOil's EWS, the system utilises EconoPure, a continuously cleaned LFNano™ nanofiltration system.

Pearl Blue achieves the optimal level of treatment for reuse by removing the majority of scaling salts (Ca^{2+},Mg^{2+}, Ba2+, Sr^{2+}, SO_4^{2-}, CO_3^{2-}), resulting in an odourless, colourless, oil-free water. Many other treatment systems over-treat water, which is more expensive than hauling or disposing and removes beneficial monovalent salts, or they under-treat wastewater, requiring excessive maintenance in the long-term due to the damage inflicted on well equipment. The system has been tested and proven to remove:

- 100% of petroleum-based material.
- 100% of suspended solids.
- 75% of salts and scalants.
- 90% of chemicals.
- 100% of all sulfides and biological materials.
- And reduce chemical oxygen demand (COD) by approximately 80%.

Beyond strength of treatment technology, economics are also a key consideration for oilfield operators when determining if recycling makes sense for their operation. For a typical hydraulic fracturing operation, fresh water costs between US$ 0.25 and US$ 1.75 per barrel. Trucking logistics ranges from US$ 0.50 to US$ 14 per barrel, and disposal costs between US$ 0.50 to US$ 3 per barrel. Water technologies that eliminate these line items can reap savings almost immediately. Technology such as that produced by OriginOil, for example, can help generate savings within the first 18 months.

Conclusion

The USA's shale oil resources may be vast, but they are not easy to access. Water is an essential part of the drilling process, placing a great strain on water resources. The costs of sourcing fresh water for oil and gas operations, as well as treating it for disposal, are volatile. If operators can recycle their water supply, both their bottom line and the environment can benefit.

Technologies are available today to recycle large amounts of frac flowback and produced water quickly, efficiently and economically, without the use of chemicals. Integrating these processes into existing hydraulic fracturing infrastructure can help propel the industry forward.

Reference

1. Full results of the Lizard Analytical Laboratories study: http://www.originoil.com/pdf/OriginOil-External-Field-Testing-Report-July-2014.pdf.

NEWS FLASH

OriginOil Receives Order for 5000 BPD CLEAN-FRAC™ System

Los Angeles and Muscat, Oman – October 20, 2014 – OriginOil Inc. (OTC/QB: OOIL), developer of Electro Water Separation™ (EWS), the high-speed, chemical-free process to clean up large quantities of water, today announced Gulf Energy (www.gulfenergy-int.com), an oil service company with major customers across the Arabian Peninsula, has purchased a $1.4M five thousand barrel per day CLEAN-FRAC™ 5000 system for the company's growing oil services business. To alleviate the use of fresh water in oil and gas operations and to comply with strict regional water and environmental regulations, operators are turning to advanced reuse and treatment technologies.

> "Here at Gulf Energy, we are committed to the hydraulic fracture market in the MENA region, which by definition includes the treatment of frac flowback and produced water for recycling. The test results from OriginOil's CLEAN-FRAC system demonstrations in Colorado and Texas were so impressive, we decided to move forward with a commercial scale five thousand barrel per day system," stated Yasser Al Barami, Chief Commercial Officer of Gulf Energy SAOC. "We will be building future units based on the design of this first unit, but we decided it was prudent to purchase the first system which we will mount on a mobile platform."

Gulf Energy currently works with major operators in Oman including Petroleum Development of Oman (PDO), Occidental Petroleum Company (OXY), PTT Exploration and Production Plc (PTTEP), MEDCO, Petrogas E&P and Daleel Petroleum. In addition they have active projects with other operators, such as Aramco and the Kuwait Oil Company.

For more information contact:
Bill Charneski — President, Oil & Gas Division
3300 S. Gessner, Suite 268, Houston, TX 77063
sales@originoil.com 713-425-5355