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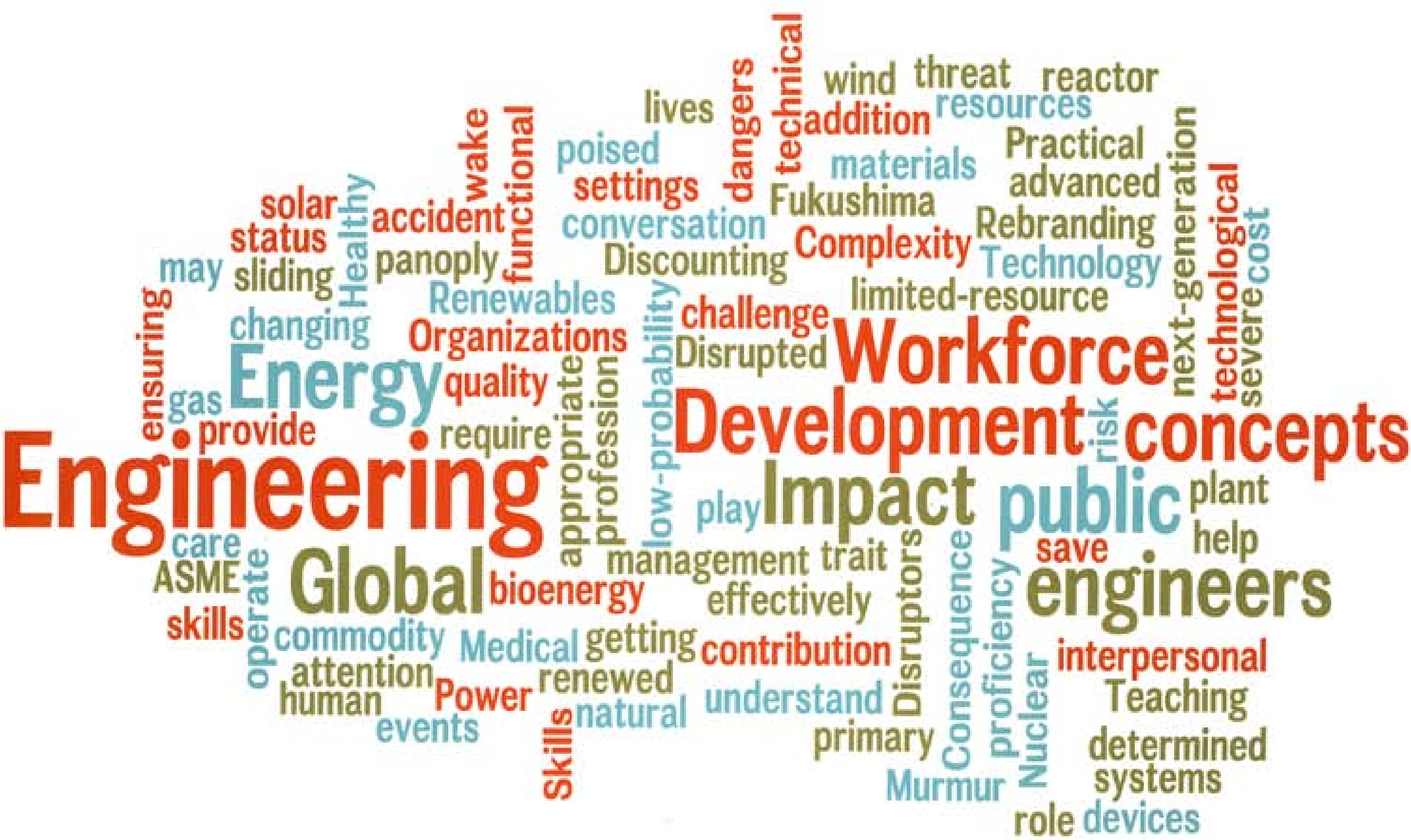

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Fluid Handling & Fluid Power

Recycling Water for Hydraulic Fracturing

BY DAVID GROTTENTHALER

Hydraulic fracturing has unlocked a valuable energy resource: natural gas in the Marcellus shale formation of the eastern United States and other formations throughout the country are now readily accessible. But the fracturing process itself creates environmental concerns and production challenges.

One concern is what to do with water that flows back out of the formation containing down-hole constituents. Treating it for reuse is one option.

Hydraulic fracturing involves injecting several million gallons of water deep into horizontal wells at tremendous pressure, which fractures the shale and releases gas. As the natural gas is extracted, up to 30 percent of the water also returns to the surface.

When it goes into formation, fluid used for hydraulic fracturing is more than 90 percent water, almost 9 percent sand, and less than half a percent chemical additives that serve as friction reducers, scale inhibitors, iron controls, and biocides.

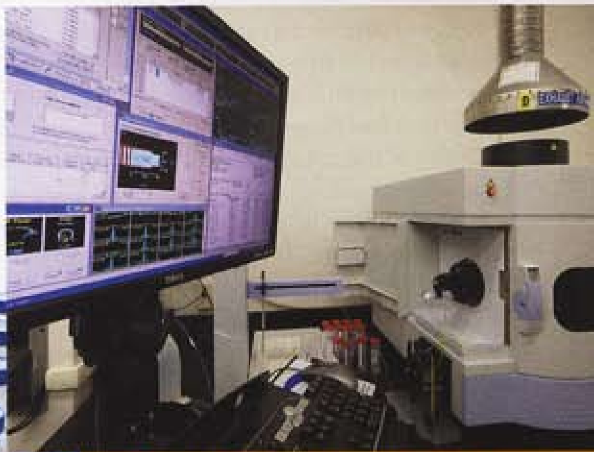
The flowback fluid that returns to the surface contains down-hole constituents that include dissolved solids, hydrocarbons, and heavy metals. These constituents preclude direct discharge into streams because of the hazard to human and environmental health. Untreated flowback water cannot be reused because of high concentrations of barium and strontium, and the potential for calcite precipitation, which could inhibit permeability of the formation and proppant pack, the sand that keeps the fractures in the shale from closing.

To resolve these issues, flowback can be treated to remove potentially harmful constituents, and chemicals can be introduced to ensure optimal production values at the next well site.

Marcellus shale stretches 1,000 miles from New York to Virginia and is 300 miles across at the widest point.

Experts estimate the Marcellus shale contains enough recoverable natural gas to fuel the United States for 20 years, which makes production in this formation one of the best options for creating domestic economic growth and reducing America's dependence on foreign energy.

The largest formation of Marcellus shale lies within Pennsylvania. And much like the processes of the steel and coal industries—which are fresh in the minds of Pennsylvanians—drilling in the Marcellus shale is a risk/reward proposition.



Lab analysis (above) monitors water used in fracturing. Bacteria monitoring (right) optimizes biocide selection and reduces formation fouling.

KROFF WELL SERVICES INC.

Because of elevated levels of dissolved solids and bromides in flowback water and production brines, the Pennsylvania Department of Environmental Protection has ordered a restriction on flowback disposal to publicly owned treatment works. And the industry realizes that disposal is not a sustainable water management strategy.

The challenge for exploration companies and municipalities is to adopt an approach for water management that will contribute to the long-term sustainability of natural gas development in the Marcellus shale.

Two companies, Kroff Well Services Inc. and Superior Well Services Inc., have collaborated to engineer a method to treat flowback water for reuse in hydraulic fracturing. The process reduces consumption of fresh water and addresses the need for disposal of flowback.

The technology was successfully demonstrated at a number of shale-gas production sites in the Marcellus shale, where treated flowback was the source water for the fracturing process fluid.

The processing strategy addresses concerns that any operator will have when reusing water: scale, iron deposition, suspended solids, microorganisms that could form in the proppant pack, and appropriate pH and other water attributes needed to achieve adequate friction reduction.

Various laboratory processes, including inductive coupled plasma analy-

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Patent Watch: The Deep Roots of Fracking

BY KIRK TESKA

Fracking is a timely topic. The idea is to fracture the rock adjacent to a well to increase the extraction of oil and natural gas. Advocates see it as a means for the U.S. to produce more of its own energy. Critics fear it threatens local water supplies.

It's timely, but not new. Fracking has been with us at least since the 1860s. Patent No. 59,936 dated Nov. 20, 1866, names Edward Roberts as an inventor. The patent states: "In my improved method of increasing the capacity of oil-wells, I fracture the rock containing the oil to some distance around the wells, thus creating artificial seams, and enabling me to connect the well thereby with seams containing the oil that would not have been otherwise reached...." The key to the method was to "sink a flask containing gunpowder, or other powerful explosive material or gas, down the well." A column of water above the charge directed the explosion downward. Explosive fracking later used nitroglycerin.

Roberts obtained a royalty not only on the procedure but also on the increased flow of oil—a move that made him wealthy. Infringers worked at night to escape detection and came to be called "moonlighters." The validity of Roberts's patent was litigated at least twice and was upheld.

Today, hydraulic fracturing is the common practice. By some accounts, the Stanolind Oil and Gas Co. introduced hydrofracking early in the 20th century.

I'm not sure that's true. Patent No. 199,488, dated Jan. 22, 1878, is the first I could find for using pressurized water to fracture the rock. Packing (a bag filled with seed) is disposed partway down a well. Water above the packing is pumped out and a ram is placed in the well: "The ram is allowed to fall, striking the seed bag first, thus preventing the water from escaping upward on account of the great pressure of the ram and causing the water, under the heavy pressure applied to it, to be forced out through the openings in the well-tubing and thus opening the crevices in the well."

Stanolind's earliest fracking patent—No. 2,667,224, dated June 29, 1949—is for a fluid used in hydraulic fracturing. The '224 patent itself admits that various hydraulic fracturing techniques and fluids precede Stanolind's invention.

Modern fracking techniques include a "proppant," which must be strong enough to keep the fissures open and also allow the gas or oil to flow. Sand was the proppant of choice through the 1950s. Union Oil Co.'s patent of that era, No. 2,774,431, describes solids that are carried by the penetrating fluid and left behind to keep the fissures open. "Ottawa silica sand of about 20-30 mesh particle size is most widely used," the patent reads.

Patents for proppant materials include Nos. 3,399,727 (ceramics), 4,068,718 (sintered bauxite), and 3,245,866 (vitreous spheres of slag).

But how do you know the process worked? In general, once a crack forms, the pressure of the "frack pump" drops. But there are more sophisticated techniques for mapping the fractures to predict yield: ultrasonic systems, seeding the proppant with radioactive tracers and using gamma ray technology, and using seismic hydrophone arrays. Columbia University has a patent, No. 4,832,121, which provides a good overview of the different mapping and monitoring techniques.

Kirk Teska is the author of *Patent Project Management* (ASME Press) and *Patent Savvy for Managers* (Nolo), is an adjunct law professor at Suffolk University Law School, and is the managing partner of Iandiorio Teska & Coleman, an intellectual property law firm in Waltham, Mass.

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sis, and spectrophotometric and wet analytical titration testing, identify the composition of process water before hydro fracturing. A battery of tests provides data for osmotic pressure, chemical oxygen demand, and microbiological concentrations. Analysis at this stage provides scaling index calculations and frac fluid design recommendations.

Flowback water samples are collected every 500 to 1,000 barrels after fracturing. These analyses are vital for anticipating the geochemical impact throughout the reservoir. Sequential analyses provide the basis for flowback water reuse strategies, water remediation recommendations, and optimization in frac fluid design.

A frac fluid calculator incorporates the pre-fracturing water analysis and historic flowback results from a particular area and provides recommendations for component dosages based on geographic location.

Analysis of fluid design and sequential flowback data are evaluated using sophisticated software unique to downhole applications. Assessments, accompanied by 3-D images, confirm the potential for scale and iron deposition in the proppant pack and in the formation.

Optimized scale and iron control chemistry and feed rates are then applied for a residue-free formation and improved well production.

Downhole performance is determined by advanced friction reduction loops

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to optimize frac water design and to determine the impact of various water conditions and fluid components on performance. This mode of testing can screen environmentally responsible constituent alternatives that will enhance fluid performance to develop improved products.

Conducting thermal stability testing on frac fluid programs allows for maximum performance in cold-weather applications or at high-temperature, bottom-hole conditions. These evaluations are intended to provide optimized fluid design, proper product pour points and fluid properties, and reliable performance of frac water under any seasonal condition.

Adenosine triphosphate testing is performed to give a rapid analysis for microbiological concentrations in a water sample.

More extensive testing is then done for sulfate reducing bacteria, acid-producing bacteria, and total aerobic bacteria counts, to determine the correct microbiocides and application dosage for frac water. Biocide efficacy and deoxyribonucleic acid studies provide additional insight for biocide selection and performance assessment.

When put on production, selected wells were projected to produce at higher rates than traditional wells using only fresh water for the fracturing process.

With treatment technologies that are safe, inexpensive, and effective, those who profit from natural gas can reconcile production with the needs of those who live among the Marcellus shale. Ultimately, this verifiable approach makes good business sense, and protects the environment at the same time.

David Grottenthaler is general manager of Kroff Well Services Inc.

Free Training For Leak-Detection

A manufacturer of leak-detection equipment is offering training sessions to engineers at no charge.

The Houston-based company, Uson L.P., says its sessions are led "by leak test technical support professionals" and cover topics, including basics and instruction on the company's leak detectors. Training sessions are held at its locations.

Uson, a part of Roper Industries, offers products designed to test the seal integrity of products ranging from medical devices to automotive components.

Rudolph Fuentes, a leak-test specialist in the sales department at Uson, said the sessions are open to anyone, but are attended generally by employees of customers. More information about the training sessions is available on the manufacturer's Web site at http://www.uson.com/Support/Training/.