Pumps markets

The potential of gas shale

Robert McIlvaine and Ann James of McIlvaine Company show how extracting gas from shale deposits has become ever more economical, and discuss how pumps can play a role in this increasingly important form of energy, looking at a selection of important wells across the U.S.

The possibility of economically extracting gas from shale has come as something of a surprise to the energy industry. Researchers have known for many years that vast amounts of gas are contained in shale around the world, and in fact, the Eastern United States has five shale areas. However, until the successful extraction in the Barnett Shale play around Fort Worth, Texas, USA during the mid 1990s, this resource was thought to be unrecoverable. ('Play' refers to the area where gas and oil companies are targeting exploration activity.)

The gas is extracted from the shale rocks using a process known as hydraulic fracturing, commonly referred to as fracing. The process creates fractures in the underground formation, allowing natural gas to flow. Water, sand and other additives are pumped under high pressure into the formation, creating fissures. Most of the wells are drilled horizontally once the drill reaches a depth of 5,000 to 9,000 ft, where the shale lies in fields approximately 250 ft thick.

The Barnett shale play deposits in Texas were the first in which gas could be economically extracted. The potential in Pennsylvania is an order of magnitude larger, and the Marcellus shale play is considered the largest in the world – specialist research and consulting firm Advanced Resources International has estimated a recoverable 2100 trillion ft^3 in the Marcellus shale (see Table 1). The Barnett shale play, in comparison, has so far produced 4.8 trillion ft^3 of gas with another 40 trillion ft^3 of expected proven reserves. Since the US consumes a little less than 30 trillion ft^3 annually, the Marcellus play represents a multi-year supply of gas for the US and represents more than half the US potential.

To realize the gas shale potential, drilling activity has seen a tremendous increase recently. Over 12,000 wells have been drilled in the Barnett shale play, while in 2008 the number of wells in the Pennsylvania Marcellus Shale was under 200 but had increased to 800 in 2009. By April 2010, 263 more wells have been drilled in the Marcellus Shale and over 3,000 permit applications have been received in the region by March 2010. But if the Barnett shale is used as a comparison there could easily be 1,000 wells per year drilled at the peak of production. It is possible for these wells to be productive for 30 years.

The drilling life cycle

Each of the wells would initially inject approximately two million gallons of water, sand and additives. Some 25% of this would come back to the surface in the first

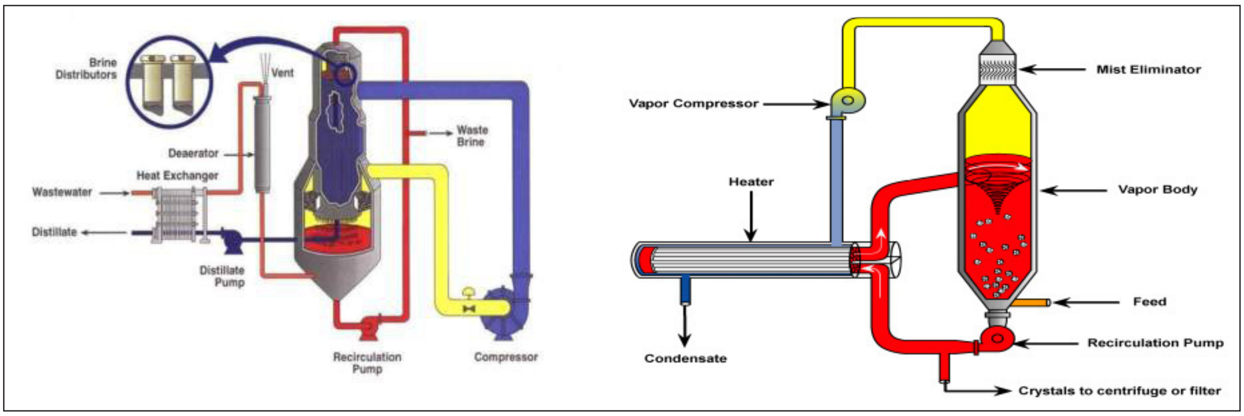

Figure 1. The brine concentrator and crystalliser technology process.

Table 1. General specifications of available floating pumps.

Shale Play	Resource Endowment (by trillion ft^3)
Barnett	250
Fayetteville	320
Woodford	320
Haynesville	790
Marcellus	2100
Total	3700

**2008 Advanced Resources estimate*

Table 2. World Shale gas potential recovery.

Area	Resource endowment (trillion ft^3)*
US	4000
Canada	1500
Europe	1000
China and India	3500
Rest of World	6000
World	16,000

**various estimates*

few days and would need treatment. Then, over the life of the well, smaller amounts of water (about 100 barrels a day) would rise with the gas to the surface. The well may be fraced periodically to restore the gas flow. So you have a new cycle with lots of water pumped down initially, then a large flow back and eventually slow flow back.

The water is collected in open impound pits, then either treated on the spot and pumped back into the well or trucked to a regional wastewater treatment plant. Each well site has many tanks around it for additives, flow back water, and water to drill with. The Marcellus shale wastewater presents a unique problem of very high salt content, so there is a much bigger disposal problem than in the Barnett Shale where the salt content is much lower.

Shale deposits

The US has 25% of the world's shale gas discovered so far, and reserves elsewhere are just now being determined. The estimated potential keeps rising as more effort is expended. Table 2 has the latest forecasts of potential gas reserves from shale.

At the moment, shale gas currently accounts for a negligible percentage of natural gas produced in China. However, the country is believed to have vast amounts of shale deposits, although estimates are uncertain because exploration is in the very early stage. China's National Development and Reform Commission is reviewing a draft plan that would establish a goal to achieve recoverable shale gas reserves of 34 trillion ft^3 by 2020.

In Europe, shale gas exploration is in its infancy with only minimal volumes of gas expected before 2015. One estimate for Sweden is 60 trillion ft^3, Austria 240 trillion ft^3, and Poland 710 trillion ft^3.

Pump requirements

Pumps are used many ways in the shale fields: pulling water from local rivers, filling up tanker trucks to deliver the water to frac tanks at the wellheads, removing water from the wastewater ponds for treatment, and delivering water to surrounding wellheads in PVC pipelines. Pump requirements can be divided broadly into:

- Frac injection fluid pumping
- Frac flowback fluids pumping.

Frac injection fluid pumping can be further divided into pumps required to inject the mix into the well and pumps associated with the additives.

Pumps for downhole delivery

Reciprocating triplex and quintuplex reciprocating piston and plunger pumps are used to deliver the water, sand, and additive mix. Gardner Denver, Weir SPM, Schlumberger, Quinn Pumps, CAT, Ruhrpumpen and National Oilwell Varco are some of the main manufacturers of these pumps, which range in pressure up to 45,000 psi. Weir SPM claims to have more well service pumps operating in the Barnett Shale than any other pump manufacturer. These pumps are mounted on trucks, with each wellhead having many pumps at each location.

Additive pumps

A number of additives are used in water used in fracturing (frac water). These additives are stored in frac tanks at the wellsite and need metering pumps to add them to the injection water. Each additive serves a special purpose and is added in different amounts. Polymers are used to reduce the friction in the injected water, while biocide is used to kill the bacteria in the frac water that can cause corrosion in piping and the generation of H_2S. One supplier reports that 8-25 gallons of biocide may be needed per 1000 gallons of frac water, which amounts to approximately 1 to 2% of the total flow. The estimates for frac fluid additives range considerably, however, and part of the reason for this variation is that the drilling companies regard their additives and amount of each as a trade secret. Table 3 lists most of the additive types and their purposes.

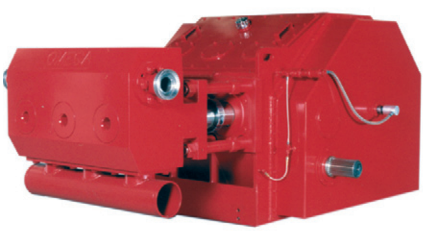

Figure 2. The Mission W-2250 Triplex Plunger Pump by National Oilwell Varco is used for pumping the fracturing fluid down the well to the target zone.

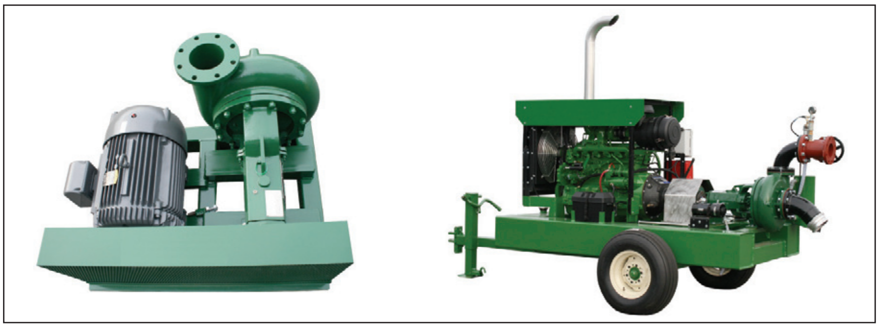

Figure 3. Slurry pump supplied by Integrity Ag Systems.

Frac flowback fluid

Somewhere between 30% and 70% of the water used for hydraulic fracturing of the gas well returns to the surface as flowback. In addition to the frac fluids added by the gas drilling companies, this water picks up other contaminants from deep in the Earth, one of the most notable being salt. These fluids contain sodium and calcium salts, barium, oil, strontium, iron, numerous heavy metals, and other components. Natural radiation has also been found in some of the frac flowback in the Marcellus shale.

Some drilling companies are using 100% of the flowback by mixing it with fresh water and reusing it for fracing. Depending on the specific water characteristics, the ratio may be three to five parts flowback to one part fresh water. The flowback water is impounded and prior to blending a service company provides water conditioning treatment.

The frac flowback fluid can be disposed in several ways. In the Barnett shale play the most common method of disposal is to truck it to distant wells and reinject it back into the ground. Right now in the Marcellus shale play, the water is most commonly is treated by a municipal treatment plant. Due to the high salt content of the Marcellus shale, the municipal wastewater treatment plants are not configured to treat the flowback liquid, so the wastewater is best treated in some other manner. Central wastewater treatment with reverse osmosis or other advanced treatment is being built in Pennsylvania which will result in reusable water and sequestration or sale of the concentrate.

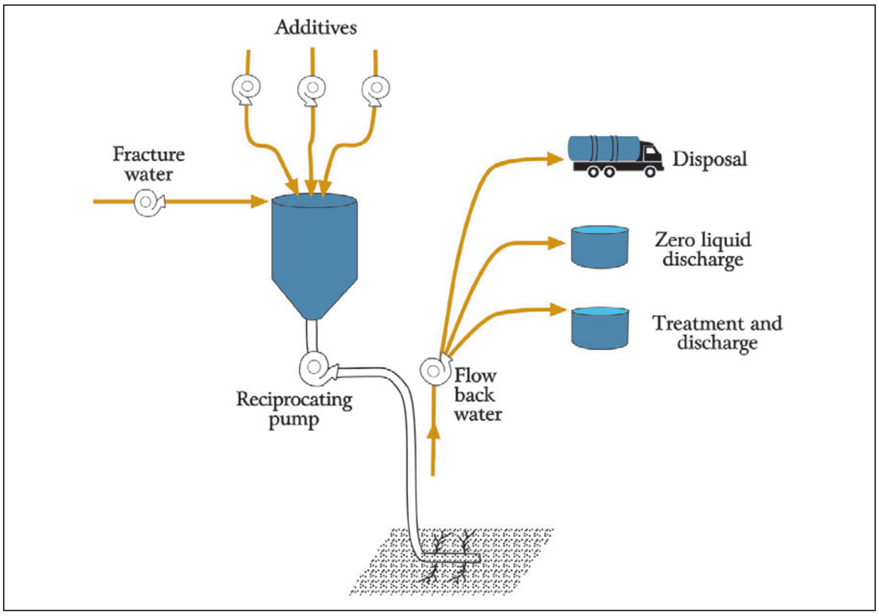

Figure 4. How pumps feature in the gas shale fracturing process.

Zero liquid discharge (ZLD) systems present another alternative to wastewater treatment. The ZLD process creates solid waste using two devices – evaporators and crystallisers. Evaporators, which can concentrate brines up to 250,000 ppm TDS (total dissolved solids), are designed to be extremely energy efficient by using mechanical vapor recompression (VPR).

When the brine concentration exceeds 250,000 ppm TDS, it is pumped under high pressure from the evaporator to a forced circulation crystallizer. The brine is released into a vessel where the pressure falls, the remaining water boils off and the salts crystallize. This salt is still slightly damp but conforms to EPA solid disposal standards. The salt cake, which is a fraction of the original waste stream, is then disposed of in landfill. Some evaporation processes are truck mounted and driven to the wellhead. Centrifugal pumps are then used to move the flowback from the earthen impound pond or holding tanks to the evaporators.

In the Aquapure/Alfa Laval evaporator system, as steam rises to the top of the separator vessel brine sinks to the bottom where it is drawn off and pumped to the blow-down exchanger to transfer its heat to the incoming water.

Table 3. Additive types and purposes.

Additive type	Purpose
Diluted acid (15%)	Hydrochloric or muriatic acid dissolves minerals and cracks rocks
Biocides	Glutaraldehyde eliminates bacteria that produce corrosive byproducts
Breaker	Ammonium persulfate allows a delayed breakdown of gel polymer chains
Corrosion inhibitor	N,n-dimethyl formamide prevents pipe corrosion
Crosslinker	Borate salts maintain fluid viscosity as temperature increases
Friction reducer	Polyacrylamide and mineral oil reduce friction between fluid and pipe
Gel	Guar gum or hydroxyethyl cellulose thickens water to suspend sand
Iron control	Citric acid prevents precipitation of metal oxides
KCl	Potassium chloride creates a brine carrier fluid
Oxygen scavenger	Ammonium bisulfate removes oxygen from the water to prevent pipe corrosion
pH adjusting agent	Sodium or potassium carbonate maintains the effectiveness of other components, such as crosslinkers
Proppant	Silica and quartz sand allows the fractures to remain open so gas can escape
Scale inhibitor	Ethylene glycol prevents scale deposits in the pipe
Surfactant	Isopropanol used to control the rheological of the fracture fluid

Note: The specific compounds used in a given fracturing operation will vary depending on company preference, source water quality and site-specific characteristics of the target formation. The compounds shown above are representative of the materials used in hydraulic fracturing of gas shales.

Conclusion

Pumps play a major role in the gas drilling and water reclamation for all United States gas shale plays. This new development of shale gas is just the start of the process worldwide and may lead to major inventions in the effort to extract more gas economically. Marcellus gas play may turn into the biggest gas producer of all. ■

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