Water Treatment in Unconventional Gas Production

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1.Theme description

The average $3 million drilling and fracturing process required for each well uses an average of 4.2 million gallons of water, much of which has traditionally been freshwater. The volume of water can vary significantly and is highly dependent on the length of the drilled lateral[1].

More than 99 percent of the fracturing fluid is water and sand, while other components such as lubricants and bactericides constitute the remaining 0.5 percent. This fracturing mixture enters the well bore, and some of it returns as flowback or produced water, carrying with it, in addition to the original materials, dissolved and suspended minerals and other materials that it picks up in the shale[2].

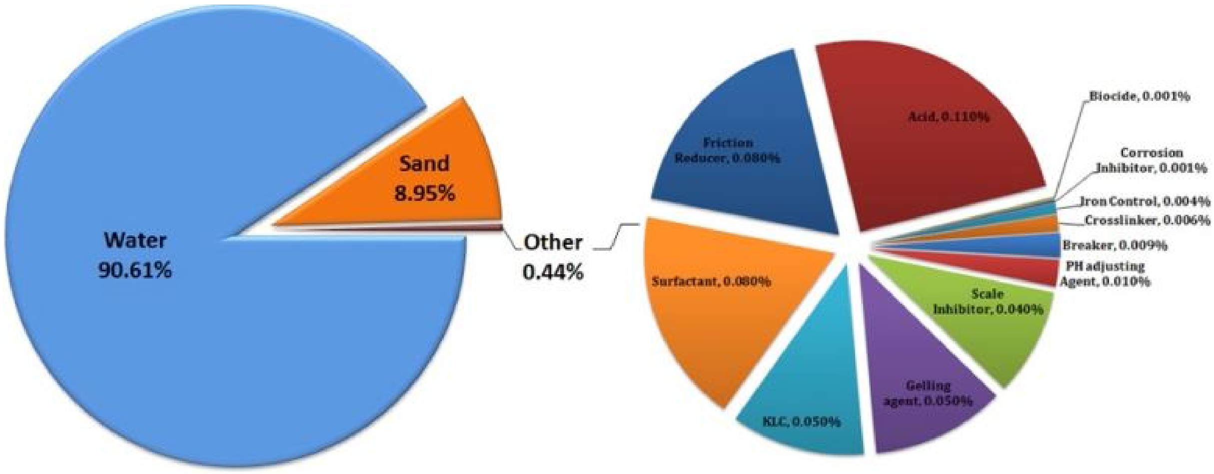

Figure 1 – Volumetric composition of process water in shale gas production.

Once in production for several years, natural gas wells can feasibly undergo additional hydraulic fracturing to stimulate further production, thereby increasing the volume of water needed for each well. Approximately 10-25 percent of the water injected into the well is recovered within three to four weeks after drilling and fracturing a well. Water that is recovered during the drilling process (drilling water), returned to the surface after hydraulic fracturing (flowback water), or stripped from the gas during the production phase of well operation (produced water) must be properly disposed[2].

The recovered water contains numerous pollutants such as barium, strontium, oil and grease, soluble organics, and a high concentration of chlorides. The contents of the water can vary depending on geological conditions and the types of chemicals used in the injected fracturing fluid. These wastewaters are not well suited for disposal in standard sewage treatment plants, as recovered waters can adversely affect the biological processes of the treatment plant (impacting the bacteria critical to digestion) and leave chemical residues in the sewage sludge and the discharge water. Many producers have been transporting flowback and produced water long distances to acceptable water treatment facilities or injection sites. But deep well injection now also meeting challenges.

The water disposal challenge has spurred a new water treatment industry in the region, with entrepreneurs and established companies creating portable treatment plants and other innovative treatment technologies to help manage produced water mainly focuses to water reuse.

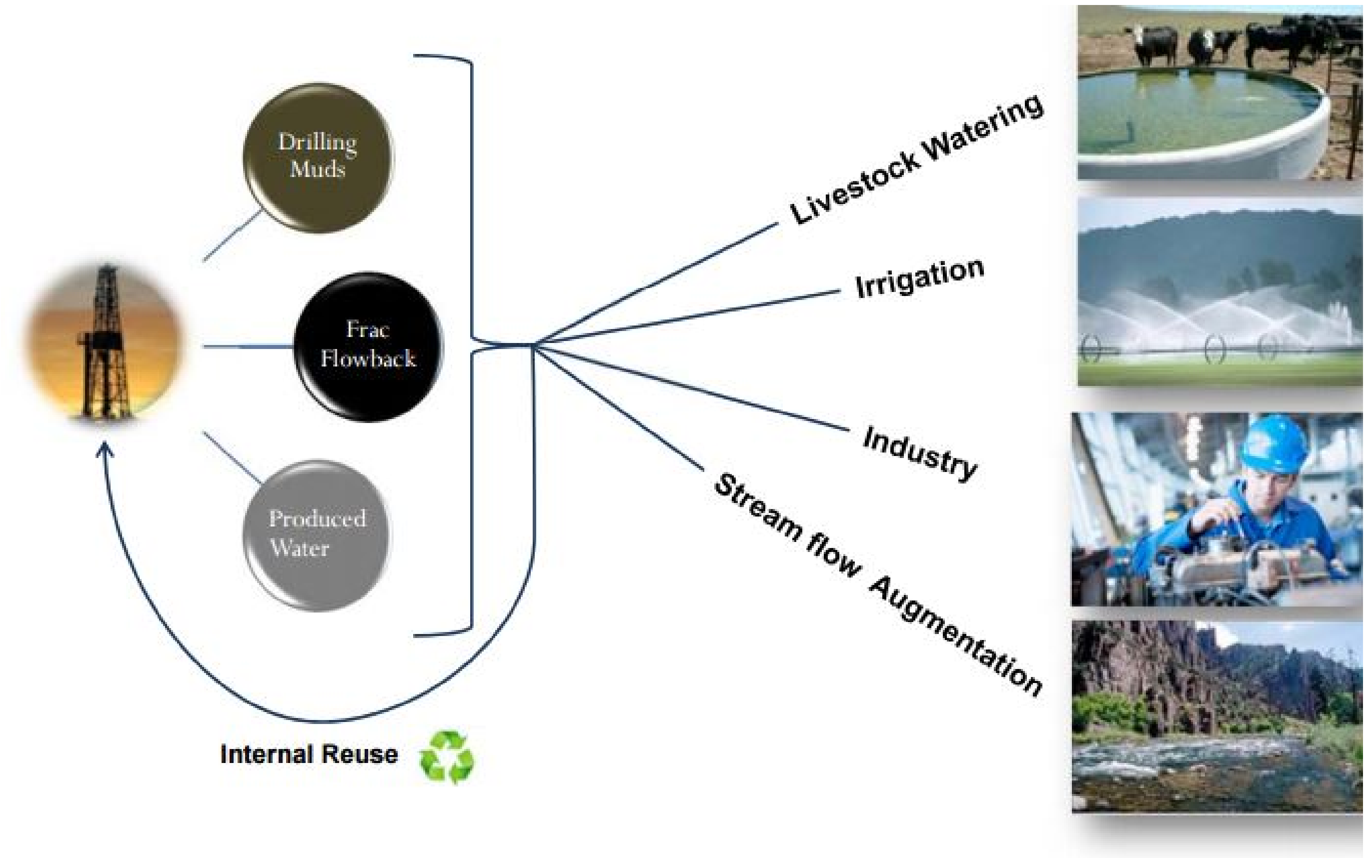

Figure 2 – Potential beneficial reuses of process water in the oil&gas industry.

2.Water Costs and Quality Concerns

Dealing with water scarcity and wastewater (i.e., brine) quality are top priorities in shale and tight gas production. Doing this requires water reuse technology that reduces the waste stream by efficiently separating out salts, heavy metals and nutrients to produce recovered water. Effective filtration must eliminate suspended solids from salt water going to deep well injection.

Cost can be an overriding factor in water treatment and processing decisions. There certainly are environmental considerations involved in using chemicals to perform operations such as frac- water treatment or salt removal and recovery. However, the cost of mitigating chemistry also comes into play. Chemical friction reducers make source water slicker for faster pumping, and then specialty chemicals like biocides, which kill microorganisms, and scale inhibitors, which control deposits, are added to the water. Mobile ultrafiltration technology can reduce the need for biocides – and the cost of treatment.

Slick water fracturing and horizontal drilling were revolutionary developments that made it economically viable to extract unconventional gas on a grand scale. Fracturing lowered the cost of moving the gas to the well bore, while horizontal drilling – which covered a vastly greater expanse of territory than a single vertical probe – exponentially increased the amount of gas that could be withdrawn. It became much more profitable to put wells into shale gas formations, but the cost of doing that business today depends, in no small part, on what ultimately happens to the brine. That, in turn, depends on geography. Chemical treatment is not the challenge so much as affordability; most brine is just discharged to disposal wells, but the fewer of these wells there are, the greater the production expense incurred, and in some parts of the country, geology or the lack of water makes disposal wells unfeasible.

In geographical areas, like Pennsylvania where there are major shale gas deposits, where the geology won't allow disposal wells, the brine has to be trucked out for disposal elsewhere or cleaned for reuse or discharge. Not only is transportation potentially dangerous, it's also expensive; trucking the frac-water from eastern Pennsylvania to Ohio for deep well disposal costs from $1.50 to $2.00 per barrel to dispose of produced water at the injection well plus getting the wastewater to the injection well requires many trucks each costing about $100/hour on an estimated six-hour typical trip in eastern Pennsylvania. Evaporation and crystallization technologies can recover almost all of the produced water as pure distilled water and create a salable salt product for uses such as road de-icing or grey water softening, but that adds another, higher level of costs. In the West, where water often can be inexpensive but scarce, it makes much more economic sense to clean up the wastewater and then sell it for land application[3].

3.Guidelines for technology selection

In order the select the more suitable technology for water treatment there are issues related to the condition, as well as the cost, of water that must be addressed. Here are some of the principal ones:

- Most surface water used for fracking is fresh water, and this surface water has variable quality, so ultrafiltration is an effective way to treat this influent source.
- Bacteria, corrosion and the buildup of solids in storage tanks are problems for disposal well management to solve.
- While technical obstacles involved in salt concentration can be overcome through membrane and thermal processes, chemical pre-treatment to remove oil and grease from the brine before it passes through the membranes is a challenge on a case-by-case basis.
- Reuse and recovery options make unconventional gas development sustainable, but they also involve handling

more wastewater, so integrated discharge water management and reuse solutions are necessary for safe and efficient treatment and recycling.

- The presence of Naturally Occurring Radioactive Materials, or NORMs, in frac flowback and produced water can contaminate the salt product created by crystallization. Pretreatment of brine can remove NORMs such as radium.
- Brine disposal into evaporative and wastewater ponds is getting a great deal of critical attention, so it is important to put a cleaner disposal product into the ponds or somehow reduce industry dependency upon them.
- Because industry operators do not just stay in fixed locations, but frequently move from site to site to drill the most promising gas plays, water treatment systems should be mobile[4].

4.Some Research Project

While progress has been made on the water quantity and quality impacts of shale gas development, challenges remain, including the potential cumulative long-term water impacts of the industry. Therefore, additional water research and environmental policy changes will be necessary in order to fully realize the economic opportunity of the region's natural gas wealth while safeguarding the environment.

In the following there are reported some interesting research project focused on water reuse.

Project 1: Advancing a Web Based Decision Support Tools (DST) for Water Reuse in Unconventional O&G Development[5]

The objective of this project is the development of database and a decision support tool (DST) selecting and optimizing water reuse options for unconventional O&G development with a focus on Flowback and Produced Water Management, Treatment and Beneficial Use for Major Shale Gas Development Basins.

- Funding agency: US DOE-RPSEA
- Start date: 1/2012
- End date: 1/2016
- Funding: $286,984

Project 2: Engineered Osmosis for Advanced Pretreatment of O&G Wastewater[6]

The objective of this project is further develop and optimize engineered osmosis membranes and systems for treatment of unconventional O&G wastewater (see figure 3). As main project outcomes there are:

- Field test the engineered osmosis process on drilling and produced waters in the DJ Basin
- Develop process design tools and life cycle assessment
- Funding agency: US DOE-RPSEA
- Start date: 9/2011
- End date: 6/2015
- Funding: $1,323,805

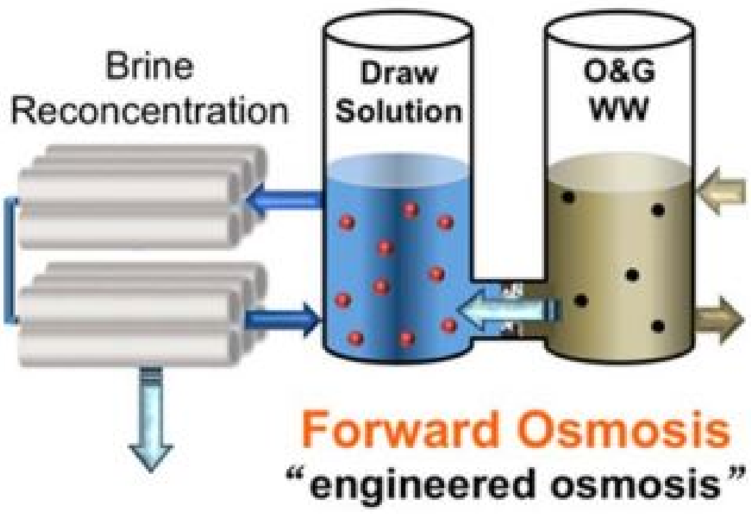

__Figure 3 –__ Engineered osmosis process scheme

Project 3: Advanced Biological Pretreatment[7]

The objective of this project is the development and evaluation of cost-effective pre-treatment technologies for O&G wastewater with emphasis on biological filtration. The major outcomes and outputs are the substantial removal of dissolved organic carbon (96%) and chemical oxygen demand (89%) in produced water from the Piceance and Denver-Julesburg basins

- Funding agency: NSF/SRN
- Start date: 10/2012
- End date: 9/2017
- Funding: $1,400,390 to CSM

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[1] Yoxtheimer, Dave. "Potential Surface Water Impacts from Natural Gas Development." pg.5. http://www.marcellus.psu.edu/resources/PDFs/Halfmoon%208--24--11.pdf

[2] Hammer, Rebecca and Jeanne VanBriesen. "In Fracking's Wake: New Rules are Needed to Protect Our Health and Environment from Contaminated Wastewater,"pg. 11. May 2012. http://www.nrdc.org/energy/files/Fracking--Wastewater-FullReport.pdf

[3] July 2011, Journal of Petroleum Technology, p. 50, "Flowback to Fracturing: Water Recycling Grows in the Marcellus Shale", by Stephen Rassenfoss, JPT Online Staff Writer

[4] https://www.gewater.com/kcpguest/document-library.do/

[5] http://aqwatec.mines.edu/produced_water/tools/

[6] http://aqwatec.mines.edu/produced_water/tools/

[7] http://aqwatec.mines.edu/produced_water/tools/