Economics and applicability of nitrogen for fracking

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General benefits and economics of nitrogen fracking

Better life-cycle economics with nitrogen-assisted fracturing treatments

From a service perspective, nitrogen-assisted fracturing treatments are often thought to be higher cost than baseline slickwater. However, with increased legislation affecting water usage and disposal in fracking operations, operators will likely face increasing pressure to treat, recycle, and re-use flowback water. The technological and financial challenges of dealing with contaminants in flowback water makes nitrogen-assisted treatments very competitive. The same is true for arid locations faced with the escalating cost of fresh water.

In certain shale plays, nitrogen-assisted treatments have offered superior performance when measured as the estimated ultimate recovery (EUR) of natural gas compared to slickwater treatments. This measure means that the cost of nitrogen-assisted treatments is lowered on a normalized production basis. Two cases are described below [1,2].

Table 1: Montney Shale Case

Treatment	Stage Count	Liquid Volume per Stage (m^3)	Proppant Mass per Stage (tons)	Total Fracturing Treatment Cost ($MM)	Total Fracture Cost Increase (%)	Energized Improvement (%)
Slickwater	5	955	177	$1.34		
N_2 slickwater	5	853	196	$1.57	15%	11%

Burke et al. [1] report that energized fracking with nitrogen costs 15% more than slickwater when total fracturing treatment cost is considered. However, that additional cost is offset by an average increase in natural gas EUR of 11% with nitrogen fracking. Under marginal pricing assumptions for natural gas, the paper reports an incremental value of approximately $1.4 MM.

It is worth noting that the analysis performed in reference 1 assumes typical water disposal costs. However, if water recycling costs were taken into account, the comparative economics of the nitrogen slickwater treatment would be enhanced, since the water volume is 11% lower than with slickwater alone and recycling costs are at least 4 times more expensive than the deep well injection disposal assumed in the paper.

Table 2: Devonian Shale Case [see reference 2]

Fluid Type	N2 Volume (scf)	Water Volume (bbl)	Sand (lb)
Pure nitrogen gas	1,000,000	<10	0
Nitrogen foam	800,000	300	40,000
Hybrid	900,000	50	15,000

- Nitrogen fracture treatments outperformed foam fracture treatments by 28 % (EUR)
- Nitrogen fracture treatments outperformed hybrid fracture treatments by 8 % (EUR)
- Nitrogen fracture treatments cost $50,000 less than foam or hybrid treatmentS

Operational advantages of nitrogen fracturing fluids

- Enable rapid cleanup of flowback fluid
- Do not cause water saturation and clay swelling in water-sensitive formations
- Enhance production of natural gas and oil in low-permeability and low-porosity formations
- Are beneficial for shallow formations
- Are highly beneficial in depleted gas reservoirs due to energizing properties
- Provide an excellent alternative to slickwater in geographical regions prone to water shortages and drought, or in areas with strict water regulations
- Significantly reduce water requirements and the use of chemical additives

These results for the Montney and Devonian shale plays make a compelling case for the use of nitrogen-assisted fracturing treatments in other formations across the globe as the life-cycle well economics, rather than service costs alone, become the basis for decision-making in fracturing fluid selection.

Applicability of nitrogen gas, foam, and energized fracking fluids

Nitrogen gas fracking

Nitrogen gas fracking is used for water-sensitive, shallow, and brittle shale formations because it prevents clay swelling that would otherwise be caused by water-based treatments. Nitrogen is an inert and compressible gas with low viscosity, which makes it a poor proppant carrier. Therefore, nitrogen gas treatments produce the best results in brittle shale formations that have natural fractures and stay self-propped once pressure pumping is completed. Due to the low density of gaseous nitrogen, the main applications for nitrogen gas treatments are shallow unconventional formations: coal bed methane, tight sands, and shale formations less than 5,000 ft deep. These formations tend to have low permeability (less than 0.1 md), low porosity (less than 4%), and a reservoir pressure gradient less than 0.2 psi/ft.

Nitrogen foam fracking

Nitrogen foams contain between 53% and 95% volume of nitrogen with the balance composed of water and additives, which gives them similar applicability as pure gaseous nitrogen. The ability to combine water and nitrogen in different mass fractions means that fluid viscosity can be adjusted for best performance.

With all the concerns in local communities surrounding water usage for fracking, nitrogen foam fracking provides the benefit of reduced water consumption. For the same reason, the amount of additives in the aqueous solution is reduced by the equivalent volume proportion of nitrogen used. This means reduced chemical loading to the fracturing treatment, which is environmentally and financially beneficial.

Nitrogen energized fracking

Energized fluids contain less than 53% volume of nitrogen with the balance composed of water and additives. The gas is used to energize the liquid phase to facilitate water unloading in low-pressure formations.

Because of higher liquid volume concentrations, energized fracking tends to be more amenable to deeper formations (up to 8,000 ft) than foam or pure nitrogen fluids. Energized fracking fluids are typically used when the reservoir pressure gradient ranges from 0.2 to 0.5 psi/ft.

References

1. Burke, L.H., G.W. Nevison, and W.E. Peters, *Improved Unconventional Gas Recovery With Energized Fracturing Fluids: Montney Example, in SPE Eastern Regional Meeting*, 2011, Society of Petroleum Engineers: Columbus, Ohio, USA.

2. Wozniak, G.V., R. T; Hina, D., *Completion Optimization in the Lower Huron Shale in Kentucky, in SPE Eastern Regional Meeting*, 2010, Society of Petroleum Engineers Morgantown, West Virginia, USA. p. 17.

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