ABSTRACT
Shale reservoirs of North America require a large volume of frac fluid at high pumping rates to allow maximum contact with the reservoir rock to extend the drainage radius. In the early stages of shale play development, these tight low permeability reservoirs were subjected to different types of fracturing techniques to achieve desirable, pre-determined frac designs and post frac cleanups. Crosslinked borate, zirconate, and linear frac fluid systems were attempted with below par post frac performance. However, gas production was improved when a slickwater frac containing a predominantly low dosage friction reducer and surfactant was used. Slickwater is becoming the most popular fracturing fluid in recent years. Today, the industry has adopted slickwater systems as the workhorse of stimulating shale reservoirs due in part to its availability, low cost, and rapid well clean up. With the advent of the horizontal and multi-lateral shale fracturing techniques of up to 40 stages, shale frac fluid requirements have increased volume of up to 900,000 bbls of slickwater per well. In areas like Pennsylvania and western Canada where disposal wells are not an option, recycling and re-using of produced water is becoming an economical alternative method of reducing demands for fresh water while eliminating disposal costs of produced water. Simultaneously, most producing states and provinces are adopting restrictions or limiting the use of fresh water for fracturing proposes. Fresh water consumption issues and environmental regulations surrounding the flowback waters and its disposal have created a challenge for the industry and operators. Operators are adopting means of water treatment to manage water needs by utilizing chemical and mechanical methods of removing unwanted solids and impurities from the flowback water. These techniques, however, do not remove dissolved salts and hardness from the flowback water. In fact, examination of field recycled water shows that most treatments not only increase overall salinity but also increase their multivalent ionic content.

This paper examines the merits of utilizing new high brine tolerant polymers in multivalent high brine waters. Horn River and Marcellus flowback and production waters were analyzed to determine their salinity. Both synthetic brine and produced water representing Horn River production water were then used as a brine source for this investigation.

The objective was to utilize high molecular weight water internal based polyacrylamides as the new friction reducers to examine performance under hostile high brine conditions. Field case studies validate the experimental results which are presented in this study. Test results show that the new high brine tolerant friction reducers significantly improve performance of slickwater fracturing. Experimentally, several friction reducers were tested to evaluate their performance. This study was conducted mainly through using a 50 liter capacity friction loop through one quarter inch stainless steel pipe at a Newtonian Reynolds number of 50,000. Field and experimental results presented in this study show that the new friction reducers exhibits significant performance improvement when produced water is used in shale fracturing treatments. Trends in core flow behavior are also presented.

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