Originally appeared in World Oil® SEPTEMBER 2018 issue, pg 23. Posted with permission.

EXECUTIVE VIEWPOINT

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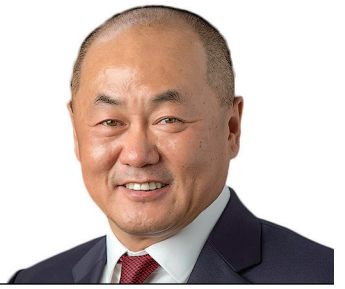

Real-time, tunable technology for operating efficiency

A decade ago, oil prices hit historic highs. The industry was in the early days of what some analysts referred to as the "shale revolution." The combination of horizontal drilling and hydraulic fracturing unleashed production from these unconventional reservoirs, transforming North American shale plays into economically-viable assets.

At that time, fracturing fluids evolved and slickwater became the preferred system. Slickwater typically consists of friction reducers that are designed to provide drag reduction to minimize horsepower requirements during pumping, which enables high-rate pressure pumping to create complex fractured networks.

Extending today's completions. Fast forward to 2018, and even with improved oil prices, operators continue to focus on producing efficiently from their core assets. They're looking to not only increase the production from those assets but, more importantly, lower well costs and decrease the time to completion.

For hydraulic fracturing operations, time reduction can be achieved by reducing NPT, improving completion designs and exploiting more reliable equipment.

One area that cannot be overlooked is the role that chemistry plays in delivering this operating efficiency, particularly friction reducers. Not only are friction reducers among the most economical fracturing fluid systems, they also can improve reservoir performance and productivity, as well as enhance the efficiency of surface equipment.

Almost all friction reducers used today are based on synthetic polymers, such as polyacrylamide or co-polymer of polyacrylamide. They have much higher molecular weight than guar or guar derivatives; therefore, they can be used at very low concentrations to achieve drag reduction, while minimizing horsepower requirements during pumping. The biggest drawback is that they do not have sufficient viscosity for proppant transport.

To address this shortcoming, high-viscosity friction reducers (HVFR) have seen increased usage because of the improved proppant carrying capabilities. Building upon HVFR, the next step is enhanced friction reducers, which are breaking through the barriers of traditional fluids because of the ability to effectively tune the technology. An enhanced friction reducer is a tunable technology, because it has the ability to adapt, and be tuned to perform to a wide-range of operating conditions.

Defining operating efficiency. The purpose of tunable technology is efficiency. For fracturing operations, efficiencies can be grouped into three main areas: wellsite delivery, fracture optimization and fluid design.

Wellsite delivery translates to surface efficiencies. The challenge is to find ways to enable high-rate pumping without requiring more horsepower at the surface. It also includes the ability to mix and pump the fluids easily, with or without the use of specialized, onsite equipment.

Next, there must be efficiency that can be gained within the reservoir. It is important to create an optimized fracture that enables effective proppant transport with control of the fracture geometry. The challenge is to transport proppant into today's more complex fracture networks. Once the proppant is in place, the viscosity must be broken down to allow maximum clean up through a highly permeable fracture.

Finally, the fluid itself must demonstrate efficiencies. The water sources used for fracturing fluid can vary significantly, from location to location and basin to basin. Friction reducers should perform effectively with different water quality. In addition, because the fluid will be pumped at high rates, it must deliver shearing stability.

Thin fluid tunability. To effectively deliver the above-mentioned efficiency gains, enhanced friction reducers are designed to allow fine-tuning of the chemistry. Taking into consideration the operating environment, the chemistry of the polymer enables adjustments to be made on the fly.

For example, enhanced friction reducers are a one-fluid solution. Its concentration level can be tuned to achieve the desired outcome. The product is highly effective in reducing pipe friction at very high loading in low total dissolved solids (TDS) water. At higher concentrations, the friction reducer provides excellent proppant transport capability while maintaining similar surface efficiency. Additional benefits are fewer chemicals on location and reduced logistical complexity.

The tunable friction reducer also allows the use of up to 100K TDS water with increased loading. Recent development with fine-tuned chemistry along the polymer structure enables compatibility of water with more than 250K TDS level.

Also, friction reducers tend to have strong bonds, so they are more difficult to break down into smaller molecules which are critical for flowback. By controlling how the chemistry behaves to precisely break the polyacrylamide-based polymers molecular structure, the small molecules allow for easy flowback after treatment and little to no proppant pack or formation damage.

Looking to the future. Real-time, tunable technology will play an essential role in delivering completions efficiency and technology innovation with the purpose of allowing operators to unlock more of the reservoir. Friction reduction is going to continue to be a major driver in hydraulic fracturing efficacy for years to come. The need for high-viscosity friction reducers that deliver good proppant transport capabilities across a wider range of water sources will continue to transform North American shale plays. WO

■ DR. DAN FU is director of technology for BJ Services. He brings over 20 years of experience in strategic planning and commercializing innovative technologies with specialities in product development, project management, hydraulic fracturing, acidizing and lost circulation control. Dr. Fu holds a BS degree in chemistry from Beijing University, a PhD in chemistry from the University of Southern California, and an MBA from Colorado State University. He is an inventor on more than 50 patents and patent applications, and he has co-authored 40 scientific publications.