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The Future of Fracturing-Fluid Technology and Rates of Hydrocarbon Recovery

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Abstract

A high percentage of oil and gas wells worldwide are hydraulically fractured in order to allow a reservoir to become economically producible and to improve the rate of hydrocarbon production. Annual global investments for hydraulic fracturing are at one billion dollars. Crosslinked polymer fluids are the most commonly used fracturing fluid because of cost and performance criteria. The crosslinked polymer fluids exhibit exceptional performance features to initiate and propagate a fracture, carry proppant and control fluid leak-off into the reservoir during a treatment. However, crosslinked polymer fluids leave a significant amount of polymeric filtercake material in the fracture once a treatment is completed. Decades of improving oxidative, enzyme and other breakers for the polymer fluids has only marginally improved from about 30% to about 50% by weight the amount of polymer residue left within the fracture. The result has been a continuation of much lower than optimum hydrocarbon recovery rates for many wells.

New surfactant-based fluid technology is being developed that will in many geographic regions replace polymeric-based fracturing fluids over the next decade. This paper will introduce a new fluid technology that uses nanoparticles, special internal breakers and low molecular weight viscoelastic surfactants (VES) to achieve the performance features of crosslinked polymer fluids but leaves little to no gel residue. Unique nanoparticles have been found that "pseudo-crosslink" VES micelles together through electrostatic and van der Waals forces. This micelle-networked fluid property will allow unique "pseudo-filtercake" to form on porous media, like crosslinked polymer fluids exhibit, to control fluid leak-off and improve fluid efficiency. The special internal breakers reside within the micelles and go wherever the fluid goes, including the networked micelles composing the pseudo-filtercake. The internal breakers controllably break the viscosity of the VES-based pseudo-filtercake by rearranging the VES micelles to spherical non-viscous structures and dispersed nanoparticles that readily flow back with producing fluids and do not impair the proppant pack conductivity. The primary result will allow a wide range of hydraulically fractured reservoirs to produce at substantially higher sustained rates than presently achievable, particularly for deepwater and other high investment wells.

Introduction

Crosslinked polymer fluids are the most common type of hydraulic fracturing fluid. These fluids can achieve high viscosities with very low leak-off rates for a wide range of reservoir temperatures and permeabilities. With their efficient leak-off control, crosslinked polymer fluids can be used to generate excellent fracture geometry in most reservoirs. They are also known to have good proppant suspension and placement capability. However, crosslinked polymer fluids have an inherent weakness that decades of developing internal and encapsulated breaker technologies have not been able to resolve: this weakness is the amount of polymer residue that remains within the fracture after a treatment. In most cases residual polymer reduces the proppant conductivity by at least 50%. During the current period of increased global demand for conventional hydrocarbons, a major breakthrough is needed in crosslinked polymer fluid technology where 80% to 100% regained proppant conductivity can be routinely achieved. Without this breakthrough the rates of hydrocarbon recovery will not reach their potential for conductivity-limited reservoirs, and the foremost limitation of crosslinked polymer systems will continue to impact the profitability of oil and gas wells throughout the world.

Over the past decade classical viscoelastic surfactant (cVES) fluid systems have been used for frac-packing and conventional hydraulic fracturing.[1-2] The composition of these fluids systems have typically been fresh water, salt (such as 4% KCl), and VES product. In some cases an organic counterion is used in place of salt to improve the thermal stability of the VES micelle structures. Classical VES fluid has viscosity-dependant leak-off control in porous media, and do not develop or leave filtercake in the fracture. The advantage for this type of leak-off control is that no filtercake damage occurs