White Paper for DUSEL

Solid Particle Placement in Hydraulic Fracturing

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Proposed Work

We propose to perform hydraulic fracturing experiments with solid transport in complex fluids in DUSEL to investigate the effect of fluid rheology on hydraulic fracture width creation and particle transport pattern.

Backgrounds

Hydraulic fracturing has been widely used as a reservoir stimulation technique, where artificial fractures are created by injecting slurry into the rock mass. The placement of solid particles props the fracture open and creates passages for hydrocarbon flow. Fracture conductivity is therefore one of the most important factors that affect well productivity. Hydraulic fracture width and solid transport pattern are two of the most critical factors in achieving desired conductivity. However, in classical hydraulic fracturing models, fluid rheology and particle transport models have traditionally been kept simple (Newtonian or power law) in order to accommodate the difficulties arising from strong coupling between fluid flow and rock deformation. The final placement is assumed to be uniform in porosity. As hydraulic fracturing fluids evolve from the earlier generation of guar and guar derived fluids to complex polymers and viscoelastic surfactant (VES) based fluids, fluid rheology has become much more complex than simply Newtonian or power law. Strong elasticity and peculiar rheological characteristics such as a flat stress plateau across several orders of time scale or non-monotonic behavior (strain rate softening) in the shear stress vs. shear strain rate curve are not uncommon in those complex fluids. Particle transport pattern maybe also be strongly affected by the shear induced mesoscale structures often observed for such kinds of complex fluids.

Understanding the effect of rheology on hydraulic fracturing width creation and solid particle placement with complex fluids has been a great challenge. The need for field tests in a lab like DUSEL lies in the facts that 1) it is not yet possible to perform theoretical (analytical or numerical) analysis of the transport process in complex fluids with strong elasticity at the particle scale; 2) even large scale parallel plates experiments (meter scale) could be strongly affected by the entrance and exit effect and are unable to mimic many characteristics in hydraulic fracturing, e.g., the leak off process and roughness of the fracture faces; 3) it is also unclear whether those laboratory experiments can be scaled to describe flow in the field treatment with complex fluids.

Approach and Benefit

It is therefore of great value to conduct field scale hydraulic fracturing experiments with particle transport in complex fluids to get a better understanding of how the complex rheology affects the process of width creation and how the transport patterns in a field scale hydraulic fracture differ from parallel plates experiments. Effect of fluid rheology on width creation and particle transport could be analyzed via downhole logging tools and the use of markers (e.g., radioactive tracers). The transport pattern can be examined during the mineback process. Results from such studies would benefit not only our fundamental knowledge of solid transport and behaviors of complex fluid flow in hydraulic fracturing but also the state of practice of the oil and gas industry.