A New Insight In Fracturing Fluid Rheology And Proppant Transport

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Abstract

Objectives/Scope: Hydraulic fracturing is a key technique for the successful hydrocarbon extraction from low permeability subsurface formations. Deep proppant placement is critical to ensure the induced fracture hydraulically conductive. To effectively suspend and transport the proppant which has significantly higher density than liquid, the fracturing fluid must be viscosified by adding chemicals such as a polymer hence making the fluid Non-Newtonian. Characterizing proppant transport under the dynamic condition normally requires a large scaled and costly experimental setup, which is sparsely available. Therefore, instead of by direct measurement or observation, suitable fluid rheological property for proppant transport is often determined by arbitrary rules derived from previous experiences. This study is an effort to develop a device that combines viscometry and visualization to gain insight into the interaction of solids and non-Newtonian fluids in the dynamic flow condition. This can help formulate customized fracturing fluid composition for maximizing the outcoming of hydraulic fracturing treatments.

Methods, Procedures, Process: A newly design viscometer is used to simultaneously measure the fluid rheological properties and at the same time the proppant settling behavior. The new device has a small footprint and is easy to operate in the laboratory or even on wellsite so that it is not only a good research instrument but also can be used to serve for real time QA/QC purpose during a fracturing job. In the experiments conducted, Newtonian and Non-Newtonian fluids with equivalent viscosity are compared for their solid-carrying capability. The impact of visco-elastic property of the Non-Newtonian on proppant settling is characterized at various shear rates.

Results, Observations, Conclusions: Experiments show when a viscoelastic fracturing fluid is injected through the tubing and fracture, it is continuously sheared, the elasticity characterized by small strain oscillatory tests cannot properly describe its rheological behavior in a continuous flowing process. It is found that the fluid viscosity, not elasticity dominates the proppant transport during the fracturing pumping treatment. In a typical viscoelastic fluid, proppant suspension capacity by fluid elasticity is negated because of its shear thinning characteristics. The elasticity only comes to play when pumping stops during shut-in, either unintentional due to operation issues or at the end of the fracturing job. Under such situations, the static settling is taking place and the fluid elasticity becomes critical to keep proppants suspended.

Novel/Additive Information: The new rheology measurement device provides a cost-effective means to characterize fracturing fluids and its dynamic proppant carrying capability under flowing condition. Experiments using such device revealed that under flowing conditions, fluid viscosity, instead of elasticity, is the most dominant factor for proppant suspension whereas elasticity is more important in static condition. This is a new insight to the conventional understanding among the fracturing practitioners.