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Characterization of Stimulated Volume Evolution during Multiple Hydraulic Fracturing Stimulation in Naturally Fractured Rocks

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Summary

The mechanism of Stimulated Volume (SV) evolution during multiple hydraulic fracturing treatment in shale formations is not well understood. The interaction of hydraulic fractures often creates complex stress conditions in which the fractures can coalesce, diverge, or propagate asymmetrically to minimize the overall fracturing energy and work. The characterization of the SV can improve the fracture spacing and subsequent well performance. However, the modeling and characterization of the SV is singularly challenging due to uncertainties in natural fracture distribution, reservoir parameters, strong fluid-solid coupling, and stress shadow effects.

In this work, we introduce a non-local poro-elasto-plastic zone model of enhanced permeability for the SV, with a characteristic length scale controlled by the orientation and density of the fracture network. The up-scaled mechanism of fracturing and deformation is described by a non-local Drucker-Prager model with is coupled to a porous media govern by Biot's Theory and implemented within a Galerkin Finite Element Method framework.

First, we consider an example of a single SV evolution for a typical hydraulic fracturing stimulation in a tight formation. We quantify the evolution of the SV and subsequent pressure change in the reservoir. After the creation of a sufficient stimulated volume, the well is shut-in for an extended period of time and the wellbore pressure is allowed to fall-off. We will use the pressure and derivative type curves to calculate the conductivity of the SV and correlate it to the size of the stimulated zone through the non-local length scale.

Next, we will consider an example of a multiple SV propagation in the context of zipper fracturing. We will characterize the SV evolution, pressure change and stress distribution for the system of SVs using the pre-and post shut-in simulation data. The preliminary results confirm asymmetric propagation paths for the SVs in the case of zipper fracturing. The analysis of the post shut-in simulation data also indicates strong pressure communication between the SVs which can ultimately affect the fracturing diagnostic interpretations.