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BENCHMARKING HYDRAULIC FRACTURING: THEORY AND NUMERICAL SIMULATION

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ABSTRACT

The stimulation of unconventional reservoirs through the use of hydraulic fracturing techniques is an extremely challenging phenomenon to model numerically. Hydraulic fracture propagation is a highly non-linear moving boundary problem where the solid response is tightly coupled with fluid flow within the newly created fracture(s). The coupling between fluid flow and fracture propagation yields a complex structure of the solution in the near tip region of the fracture front. Near the tip the classical elastic fracture mechanics behavior may shrink to a boundary layer depending on the problem parameters [1]. This is notably the case in the so-called viscosity dominated regime (mostly common in operations) where the dissipation in the creation of fracture surfaces is negligible compared to the viscous flow dissipation.

In order to be relevant for engineering design of hydraulic fracturing treatment, a numerical solver needs to be able to accurately track the fracture propagation over a large range of time and length scales: i.e. injection last up to 2-3 hours, with fracture propagating from a ~10cm wellbore up to a kilometer in length.

Verification and validation of numerical models of hydraulic fracturing have been hindered for a while by the lack of accurate semi-analytical solutions for simple geometries. This is no longer the case. A series of solution know exist for both the plane-strain, radial and height contained geometry [2]. These solutions provide tremendous help in verifying numerical models. Moreover, careful scaled down laboratory experiments with precise monitoring (e.g. [3]) can also be used for model validation.

Verification and validation is especially important in order to be able to attribute differences between field observations and predictions to any missing physical phenomena in the model or uncertainties in rock properties, and not to the poor performance of the numerical solver.

This session aims to engage a constructive discussion and provide impactful insights about the use of theoretical and experimental benchmarking for the validation of analytical and numerical approaches. In particular, the authors are invited to submit their work in the framework of:

1. Innovative analytical techniques to model the hydraulic fracturing process

2. Benchmark studies of numerical simulation with respect to analytical solutions

3. Novel use of laboratory scale experimental tests for the validation of numerical results

4. Constitutive modeling of solid (e.g. cohesive zone modeling, plasticity and continuum damage models, contact mechanics) and fluid behavior (e.g. novel proppant characterization, leak-off modeling, shut-in)

5. Advanced numerical techniques for efficient solid/fluid coupling, poromechanical effects, fracture and fluid front propagation and discretization of complex topologies.

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