Numerical simulation of hydraulic fracture growth: advances and remaining challenges

Brice Lecampion[1]
[1] *Geo-Energy Lab - Gaznat chair on Geo-Energy, Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland*
E-mail:brice.lecampion@epfl.ch

Keywords: Fracture, Multi-physics, Model validation

Development of numerical methods for the simulation of hydraulic fracture propagation has accelerated significantly over the past fifteen years. These advances have been driven on the one hand by an industrial need to account for more complex behaviors associated with heterogeneous and naturally fractured formation, and on the other hand an improvement of our understanding of the underlying mathematical model and its intrinsic challenges.

After a description of the basic ingredients of the mechanics of fluid-driven fractures and its intrinsic challenges, I will review some recent advances in the numerical methods for this class of non-linear moving boundary problems [1]. Some of these comprise improvements of classical methods, while others are imported from other fields of mechanics but are completely new in their application to hydraulic fracturing. I will focus mostly the discussion on continuum models although meso-scale approaches will be briefly mentioned.

I will emphasize - via examples - the importance of verification and validation. This is a critical point for this type of problems where a stable algorithm may exhibit a significant drift of accuracy with time due to the nature of the multi-physics processes at play near the fracture front. Careful verification and validation are now possible thanks to an increasing library of carefully performed laboratory experiments and analytical solutions for simple fracture geometries in a number of different propagation regimes (toughness, viscosity). I will also highlight how the use of different schemes is reflected in the convergence rate to analytical solutions [2]. This can notably guide the choice of numerical methods depending on the ultimate aim of the modeling. Finally, the remaining challenges associated with full three-dimensional problems, very permeable rock formation, complex fracturing fluid rheologies as well as the proper treatment of rock heterogeneities will be presented.

References

[1] B. Lecampion, A. P. Bunger, and X. Zhang. Numerical methods for hydraulic fracture propagation: A review of recent trends. *Journal of Natural Gas Science and Engineering*, 49:66–83, 2018.

[2] B. Lecampion, A. P. Peirce, E. Detournay, X. Zhang, Z. Chen, A. P. Bunger, C. Detournay, J. Napier, S. Abbas, D. Garagash, and P. Cundall. The impact of the near-tip logic on the accuracy and convergence rate of hydraulic fracture simulators compared to reference solutions. In *The International Conference for Effective and Sustainable Hydraulic Fracturing, May 20-22, Brisbane, Australia*, 2013.