Non-Newtonian rheology and hydraulic fracture growth: the death of the power-law model?

Prof. Brice Lecampion, EPFL

Thursday March 3, 2022, 9 a.m. Central Time

Dr. Brice Lecampion, Associate Professor, and the head of the Geo-Energy Lab at Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland, will speak on Thursday March 3, 2022. The seminar will be at 9:00 Central Time.

The topic is "Non-Newtonian rheology and hydraulic fracture growth: the death of the power-law model?".

Abstract

A large number of fracturing fluids exhibit shear-thinning: namely, their viscosity decreases with shear rate. Traditionally, a power-law rheology has been extensively used in hydraulic fracture (HF) modeling – mostly because of its analytical form for lubrication flows. However, such a power-law model under-estimates, respectively over-estimates, the fluid viscosity at large, respectively small shear rates. More advanced rheological models which capture the proper evolution of fluid viscosity over the wide range of shear rate encountered in a fracture will be discussed and applied to several hydraulic fracture growth problem. We will notably focus on the classical plane-strain (KGD) geometry[1] as well as the steadily moving hydraulic fracture (tip) problem[2].

In particular, we will compare hydraulic fracture growth predictions (in the impermeable limit) obtained with a power-law model against the more physical Carreau rheology. In particular, the results obtained with the power-law model confirm its inadequacy for realistic fluids used in practice: the Newtonian plateau at high and low shear rates just cannot be neglected. As a result, we argue that the power-law rheology should just be plainly abandoned in HF modeling.

[1] L. Pereira and B. Lecampion. A plane-strain hydraulic fracture driven by a shear-thinning Carreau fluid. International Journal for Numerical and Analytical Methods in Geomechanics, 2021.

[2] F. E. Moukhtari and B. Lecampion. A semi-infinite hydraulic fracture driven by a shear thinning fluid. Journal of Fluid Mechanics, 838:573–605, 2018.

Biography

Brice Lecampion is currently Associate Professor and the head of the Geo-Energy Lab at Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland. His research aims at understanding the interplay between the growth of localized discontinuities (in the form of fractures and faults) and fluid flow in geomaterials with applications in the field of environmental, civil & resources engineering, seismology, and tectonophysics. Prior to joining EPFL, Prof. Lecampion worked for Schlumberger in research and development from 2006 until May 2015 - serving in a variety of roles ranging from project manager to principal scientist in both Europe and the United States, working on CO_2 storage as well as unconventional hydrocarbon well stimulation. Brice received his PhD in mechanics from Ecole Polytechnique, France in 2002 and worked as a scientist in the hydraulic fracturing research group of CSIRO (Melbourne, Australia) from 2003 to 2006.