Steadily Moving Semi-Infinite Hydraulic Fracture in a Poroelastic Media

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Linear elastic fracture mechanics has been widely used to describe the propagation of hydraulic fractures in rocks [1]. The embedding material is generally considered to be elastic and permeable, but the fluid exchange between the fracture and the media is often approximated by 1D flow perpendicular to the fracture plane [2, 3]. Only in a few contributions, 3D fluid flow and poroelastic effects were considered in details [4, 5]. Even when considered, additional assumptions for both, the fluid flow or/and the poroelastic effects are made. The work of [5], for example, neglects the mechanical to hydraulic coupling on the poroelastic response and assumes a cake-build up on the fracture interface away from the tip. That leads to a slightly adapted transition between 1D and 3D fluid diffusion. Several contributions (e. g. [6]) did consider the complete poroelastic behaviour but treated only the case of dry fractures (without lubrication flow inside the fracture itself). With this contribution, we intend to solve the complete problem of a steadily moving semi-infinite hydraulic fracture propagating in an isotropic poroelastic solid. The pore and fracturing fluids are assumed to be identical and Newtonian. We recast the poroelastic problem into two coupled boundary integral equations, using fundamental solutions of poroelasticity. We notably use the moving fluid source solution [7] and the one for a moving dislocation density. We then discretize the fracture as an array of moving dislocation densities and fluid sources in a tip-centered coordinate system. Special care is needed to treat the logarithmic singularity of the kernels associated with the flow and mechanics-to fluid flow coupling terms. We isolate the logarithmic singularity and differentiate it to obtain a kernel with a classical Cauchy $(1/x)$ singularity, which can be treated numerically with well-known Gauss-Chebyshev methods.
We test the proposed method against known solutions for the case of a steadily moving crack under simple loading (zero fluid pressure in the crack, known tractions) before moving to the solution of the coupled poroelastic / lubrication problem of hydraulic fracturing.

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