Tracking hydraulic fractures with a fluid lag in impermeable media

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Hydraulic fractures identify a particular class of tensile fractures propagating because of the pressure exerted by an internal fluid, usually in the presence of a preexisting confining stress [1]. They can occur naturally, as for magma transport in the Earth's crust, or they formation can be intentionally promoted for engineering applications such as, among others, hydrocarbon extraction/storage, waste-water injection, CO2 sequestration, geothermal energy exploitation. Nowadays the numerical simulation of fluid-driven fractures continues to be a challenging computational problem, because of the presence of several physical mechanisms affecting the propagation of this class of cracks [2]. The present work focuses on the propagation of a crack in an impermeable linear elastic medium driven by the pressure of an incompressible Newtonian fluid. The fluid front is allowed to lag behind the fracture tip and the tip cavity is considered as filled by fluid vapor under constant pressure with a negligible value with respect to the far field confining stress. The non local elastic relationship between the crack opening and the fluid pressure, together with the non linear lubrication equation governing the flow of the fluid inside the fracture, lead to a non linear system of coupled integro differential equations that has to be solved for each new fracture configuration. The novel presented algorithm is capable of tracking the evolution of the fluid and fracture fronts. In particular, the crack tracking is grounded on a viscous regularization of the quasistatic crack propagation problem as a standard dissipative system. It allows an effective approximation of the fracture front velocity by imposing Griffith's criterion at every propagation step [3, 4].

References

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