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Penny-shaped hydraulic fracture accounting for shear stress induced by the fluid

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This research focuses on the radial (penny-shaped) model of hydraulic fracture (HF), one of the three classical 1D models (PKN, KGD, radial). The fracture develops in an axisymmetric fashion as a result of a point source activity, making it the only 1D model to approximate a 3D system. As such, numerical solutions can make useful benchmarks to test more advanced 3D computer models. Since it's inception it has seen cyclical updates and revisions [1, 2] (see within).

Recently, it has been demonstrated for the KGD model [3] that the hydraulically induced tangential traction on the fracture walls, previously assumed to be negligible, significantly affects the behaviour of HF. This is of particular importance due to the key role of the near-tip zone in understanding and resolving HF problems. Notably, the energy release rate (ERR) and Irwin fracture criterion no longer coincide, and a new ERR based crack extension condition has been proposed which accounts for the hydraulic shear stress. Its introduction also eliminates several inconsistencies inherent to the classical HF model.

In this work, the effect of hydraulic tangential traction is incorporated into the penny-shaped model. This greatly improves the flexibility and efficiency of the final algorithm, in both the viscosity and toughness dominated regimes. A highly efficient numerical solver is demonstrated, and the level of computational accuracy is verified. The modified HF formulation is compared with the classic radial model. Quantitative and qualitative analysis of the influence of hydraulic shear stress on the HF process is provided.

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