A phase-field formulation for pressurized and non-isothermal propagating fractures in deformable porous media

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ABSTRACT

The prediction of fluid- and pressurize-driven for the fracturing material in deforming porous media has become an important research interest in recent years. This is a major area of interest in petroleum engineering and commonly refers to the hydraulic fracturing. Hence, a macroscopic continuum phase-field setting is developed for the fracturing response in the porous media [1].

Following the recent work [2, 3], we extend the regularized phase-field formulation for a pressurized fracture through the linkage to a Darcy-Biot-type bulk response towards a non-isothermal setting. This is achieved by adding a balance of internal energy in our system through heat transport equation with an independent temperature field. Accordingly, in the fluid-driven setting, four independent unknown fields namely, temperature, pressure, displacements and phase-field by using alternate minimization approach are solved. The latter subsystem includes displacements and phase-field is solved with a combined Newton approach employing a primal-dual active set method [3] in order to account for crack irreversibility. In particular, stress-based criteria derived from energetic definitions which is embedded in the crack deriving state is formulated. This setting yields towards definition of threshold-based continuum phase-field modeling for the hydraulic fracture setting. The resulting model is augmented with thermodynamical arguments and then analyzed from a mechanical perspective. Due to the dependency of a phase-field formulation to the small length-scale parameter, a predictor-corrector scheme for local mesh adaptivity is employed.

Here, we demonstrate the performance of the proposed model by means of representative numerical examples. We verify our proposed non-isothermal and pressurized phase-field modelling with Tran's et al. [4] test based on Sneddon's setting. The proposed formulation is considered to be a canonically consistent and robust scheme for treating pressurized fractures and non-isothermal setting in porous media.

REFERENCES

[1] Lee, S., Wheeler, M. F., Wick, T. Pressure and fluid-driven fracture propagation in porous media using an adaptive finite element phase field model, Computer Methods in Applied Mechanics and Engineering, Vol. 305, (2016).

[2] Lee, S., Wheeler, M. F., Wick, T. Iterative coupling of flow, geomechanics and adaptive phase-field fracture including level-set crack width approaches, Journal of Computational and Applied Mathematics, Vol. 314, (2017).

[3] Noii, N.,Wick, T. A phase-field description for pressurized and non-isothermal propagating fractures, Computer Methods in Applied Mechanics and Engineering, Under review (2018).

[4] Tran, D., Settari, A. T. and Nghiem, L. Predicting growth and decay of hydraulic-fracture witdh in porous media subjected to isothermal and nonisothermal flow. Society of Petroleum Engineers, vol. 18, (2013).