Hydro-Mechanical Phase-Field Modelling of Hydraulic Fractures for Carbon Capture and Storage

Isa Kolo*[†], Clemens V. Verhoosel[†] and Karin de Borst[‡]

[†]Department of Mechanical Engineering
Eindhoven University of Technology
P. O. Box 513, 5600MB, Eindhoven, Netherlands
Email: {i.kolo, c.v.verhoosel}@tue.nl

[‡] Shell Global Solutions International B.V.
Grasweg 31
1031 HW Amsterdam, Netherlands
Email: Karin.deBorst@shell.com

ABSTRACT

Carbon Capture and Storage is a technology for mitigating CO_2 emissions which contribute significantly to global warming. However, a major public concern is the risk of leakage from storage sites that can potentially contaminate aquifers or lead to the release of the confined CO_2 to the atmosphere [1]. In an injection well, thermal fractures can be triggered as a result of the temperature difference between the injected supercritical CO_2 and the surrounding rock. To ensure the containment of these fractures within the storage unit, an understanding of the operational conditions under which fractures can initiate and propagate within the site is crucial. Hence, modelling capabilities for hydraulically initiated and driven fractures become necessary.

Herein, a coupled hydro-mechanical model for initiation and propagation of hydraulic fractures in permeable rock is presented. Fracture is modelled using the smeared phase-field approach and the Darcy model is adopted for fluid flow [2]. To obtain physically sound numerical solutions, evolution of damage in different straining modes is considered leading to constitutive assumptions for degradation in the stored elastic energy [3]. The advantage of this approach lies in its thermodynamic consistency and ability to handle complex fracture geometries [4]. The capability of the model is demonstrated using a numerical example wherein various leak-off conditions have been considered.

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