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New Capacities for Hydraulic Fracturing Studies: A Full Geomechanical Coupling in a 3D Discrete Fracture Networks

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Several unconventional reservoirs have been stimulated using hydraulic fracking to enhance the production. Further, reservoir simulation technology is facing new challenges in providing key information used for long-term strategic decisions.
To understand and optimize shale reservoirs production, one must capture the role of hydraulically induced fractures, natural fractures and their interaction in the formation. New fractures modify the near field stress inducing the fracture network complexity. Taking into account this changing is essential for improving the well stimulation design (rates, perforations and well locations…) or/and for refracturing operations. Mathematical equations and boundary conditions governing this process and the geomechanical laws are very complex, often requiring significant computational performance. Implementation of such approaches is data intensive and time consuming.
In this work, we focus on the mechanical behavior of fracture networks, to investigate enhancement possibilities. For that purpose, we used a 3D Boundary Element Method, where Green functions are formulated with dislocation elements, in order to determine the fracture opening and slip. Then, we proposed a new method to solve sequentially the resulting system of linear equations describing the influence of a fracture on another, with inequality constraints on traction (e.g. static and dynamic Coulomb friction) and displacement (e.g. non-interpenetration of the elements).
Consequently, we developed a hydraulic fracturing simulator where the fractures are explicitly discretized and the flow is coupled with the stresses induced by fracture deformation. This rapid simulator can describe the activation of hydraulic fractures, the opening and the shear stimulations of natural fractures. One of our method advantages is a tailored modeling of the interactions between natural and hydraulically created fractures in 3D.
This method and its performances will be discussed through several synthetic cases that are representative of shale/tight reservoir engineering problems.

References

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Author: BEN GHARBIA, Ibtihel (IFPEN)

Co-authors: BARONI , Axelle (IFPEN); DELORME , Matthieu (IFPEN)

Presenter: BEN GHARBIA, Ibtihel (IFPEN)

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