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Simulations of proppant transport in microfractures

Mateusz Bancewicz, Jakub Poła, and Zbigniew Koza
Faculty of Physics and Astronomy, University of Wrocław, 50-204 Wrocław, Poland (mateusz.bancewicz@uwr.edu.pl)

During the hydraulic fracturing of oil and gas shales a mixture of fracking fluid and solid proppant is injected into the rock fractures. Since this process takes place under physically extreme conditions, a few kilometers under the earth surface, it is practically impossible to obtain detailed, in situ data about the actual proppant transport on the scale of individual fractures and proppant grains. One way to improve our understanding of this technologically critical phenomenon is through numerical simulations.

We use two standard computational fluid dynamics (CFD) solvers, finite volume (FVM) and lattice-Boltzmann (LBM) methods, and couple them with the discrete element method (DEM) in a fully resolved manner [1, 2, 3] to track the fluid parameters and proppant trajectories. This approach allows us to simulate up to about a thousand proppant agents in an arbitrary 3D fracture geometry filled with a fluid, with proppant-proppant, proppant-fluid, and fluid-proppant interactions taken into account.

In this report we focus on two problems crucial for efficient and sufficiently accurate numerical simulations of proppant transport and sedimentation.

1. Is rotation of proppant grains an important factor determining the final distribution of proppants during proppant sedimentation in a realistically narrow, wiggly fracture?

2. Is the lubrication force necessary for the proper reconstruction of collision events between particles and walls as well as between particles themselves [4]?

Our preliminary results show that the answer to the first question is negative. Due to a large number of proppant-proppant and proppant-wall collisions, as well as because of the damping effect of the proppant-fluid coupling, the influence of the proppant rotation on the proppant sedimentation appears to be negligible. However, the answer to the second question is positive: the lubrication force plays an important role in the proper numerical recovery of collisions.

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