The coupling of an enhanced pseudo-3D model for hydraulic fracturing with a proppant transport model

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Hydraulic fracturing (HF) represents the main approach to intensify the production of oil and gas wells during the development of both traditional and hard-to-recover hydrocarbon reserves. The technology of hydraulic fracturing is to create the high-conductivity zone in the reservoir by breaking a material via injecting viscous fluid into it. In order to avoid the closure of the rock under the compressive stress, a wedging agent proppant is added to the fracturing fluid. To ensure effective and optimal fracturing operation during field development, preliminary mathematical modeling describing the total physical process of fracture propagation with proppant transport is required.

This talk describes a coupled model of fracture geomechanics and hydrodynamics of fracturing slurry with proppant within the fracture. Hydraulic fracture growth is described by an Enhanced Pseudo-3D Model (EP3D) [1], which eliminates the primary weaknesses of the classic P3D model: viscous dissipation of energy during fracture growth in height, fracture toughness and non-local elasticity considered around the perimeter of the fracture. The two-dimensional proppant dynamics is described in a single speed approximation using the concept of effective viscosity depending on the proppant concentration. Hydraulic fluid flow through the crack is determined by the mass conservation law in approximation of lubrication theory.

Numerical implementation of the model is discussed. One of the challenges is that the models utilize different meshing strategies: EP3D uses a moving mesh that conforms into the fracture shape, while the proppant transport solver uses a fixed grid. In addition, it is necessary to use a fine grid for proppant transport if one wants to capture small scale effects such as Saffman-Taylor instability. Based on the numerical experiments, examples of typical scenarios for mutual influence of proppant transport and fracture growth are presented. In particular, we describe the cases in which there is a local or complete blocking of the flow due to the proppant concentration increase.

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References

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