A fundamental study of proppant behavior in hydraulic fractures using particle based numerical simulations

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Hydraulic fracturing technique has been widely used in the development of unconventional oil reservoirs and geothermal reservoirs. To prevent the induced fractures from closing, supporting materials (proppant) are pumped into the induced hydraulic fractures. The ultimate goal of hydraulic fracturing is to keep high conductive flow paths from the formation to the wellbore. Recently, a new technique has been proposed to improve the fracture conductivity by making open channels throughout the proppant pack. In this technique, fluid with and without proppant is alternately pumped into the well. This treatment creates discontinuous proppant pillars in a hydraulic fracture, and then, the fracture conductivity could be improved significantly. However, proppant slurry behavior inside the fracture still remains poorly understood.
In the present study, we applied a smoothed particle hydrodynamics (SPH) method to the fluid-solid interaction analysis in order to investigate proppant behavior inside the fracture. Our final goal is to establish analysis method for slurry behavior in hydraulic fractures. As a preliminary step toward the final goal, we simulate the Couette flow between coaxial cylinders to investigate the accuracy of the coupled simulation with the SPH method. We evaluate the L2-norm error as a function of the number of particles along the diameter of the inner cylinder. As a result, about 15 and 20 particles are required to achieve less than 15 % and 10 % error, respectively. Based on this result, at least 20 particles along the diameter of proppant grains should be used. In the future study, many effects (viscosity of fluid, grain shape, fracture roughness) on the efficiency of creating open channels will be investigated by using the proposed method.

Keywords: proppant, numerical simulation, particle method

