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Investigation of fracturing fluid penetration with the Discrete Element Method

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Hydraulic fracturing is a technique well known in oil and gas industry and recently, in geothermal reservoirs, as one which enhances the exploitation and production of hydrocarbons/geothermal water.

Basically, the fracturing fluid is injected into the well under great pressure. This creates number of cracks throughout the impermeable reservoir rock increasing porosity, what raises hydrocarbons or hot water flow. This phenomenon is hard to recreate in laboratory. Hence we decided to recreate it numerically, using the Discrete Element Method implemented in ESyS-Particle Software.

The Discrete Element Method is a numerical technique used for simulating motion of granular material – particles connected together via bonds and interacting with each other. Those bonds have different parameters, which have to be calibrated first in order to simulate real rock behavior. We created a rock sample with great number of particles with different radii. To simulate fracturing fluid, we created a body of water, which is represented by much smaller, not bonded particles. That body was later injected into the rock sample with different velocities and pressures, breaking bonds among the rock sample. We identify broken bond as a new fracture created in hydraulic fracturing simulation.

In this research, we investigated mainly how far and deep fracturing fluid can penetrate the rock, both, in vertical and horizontal direction, what kind of cracks it creates under different simulation setups and also compared how fast bonds were breaking depending on fracturing fluid's velocity.