TOUGH-GeoFEM : a massively parallel coupled hydro-geomechanical simulator for geologic carbon dioxide storage –current status of the development

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The injection of large amount of CO_2 in subsurface can induce some geomechanical risks, e.g. uplift of ground surface, reactivation of faults and failure of caprocks, which are regarded as results of coupled behaviours of hydrodynamics of pore fluids and mechanics of the rock formations. Then coupled hydro-geomechchanical model is required to predict the geomechanical behaviours during CO_2 injection. For simulations of large-scale geological model with complex and heterogeneous conditions large amount of computation bay be required. To solve such problems computationally demanding, a few numerical simulators capable of massively parallel computations, however, has been developed for geological CO_2 storage.

In this study, a massively parallel coupled hydro-mechanical numerical simulator, TOUGH-GeoFEM has been developed. The numerical simulator couples by one-way method two parallel simulators proven on several massively parallel computers: TOUGH2-MP, which is a non-isothermal multiphase and multicomponent fluid flow simulator in the porous media and fractured media, and GeoFEM, which is a mechanical deformation simulator of the solid originally designed for massively parallel supercomputers. The mass balances for fluid components with the Darcy’ s flow for multiphase fluid flow in the TOUGH2-MP. Calculated an average pressure is transferred as nodal forces to GeoFEM, and the equilibrium equation for rock-fluids mixture is solved in the GeoFEM.

Firstly, overview of formulation and workflow of TOUGH-GeoFEM was presented. Next, as a numerical example, surface deformation due to CO_2 injection was simulated and compared with results from TOUGH-FLAC, which is a well-known hydro-mechanical coupling simulator. It was shown that the result calculated from TOUGH-GeoFEM, a reasonable scalability (i.e. speed-up of computation time against increase in number of processors) was obtained on a parallel computer for a few millions of grids model as an example.

Keywords: Hydro-Mechanical coupled analysis, Massively parallel computing, Subsurface carbon dioxide storage

