TOPIC 06: Temperature-induced effects (THM and C coupled processes)

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Abstract

Clay and claystone are considered as host rocks for the final disposal of spent nuclear fuel and high-level nuclear waste in several countries. However, the disposal of heat generating waste within a clay host rock leads to significant THM responses in the porous medium of clay. The resulting thermal induced stresses and thermal dilation of water may cause a potential risk to the capacity of the clay host rock to limit the migration of the radionuclides within the geology. As a part of the work package HITEC of the European research framework EURAD the modelling of the near-field damage caused by the excavation of the galleries and the effect of thermal pressurisation and of the far-field risk of tensile or shear failure in Clay and claystone is going to be carried out. Thereby a 2D generic model was built to compare the numerical codes and study the behaviour of the different host rocks both in the near-field and in the far-field.

The following work presents a benchmark exercise between two different codes on the numerical modelling of the THM-processes taking place in the near-field of a disposal gallery in BOOM clay. The commercial code FLAC3D in the version 5 and the newest version 7 as well as the open source software OpenGeoSys were used for the modelling activities. The benchmark consists of an excavation phase in the first 24 hours, a waiting phase with drained gallery walls lasting up to six months and a heating phase with impermeable walls and a heat source of 200W/m in the gallery up to the end of the simulation at ten years.

The results of the benchmark using the two codes are presented exemplarily in Figure 1 for the elastic isotropic case. The temperature evolution shows a good conformity in the results between the codes. A small discrepancy occurs over the time between the temperature evolution in OpenGeoSys compared to the FLAC3D counterparts due to the different averaging procedure of thermal conductivity of the porous media assuming in the different codes. The results of the displacement evolution fit well together, too. However a noticeable difference between the two FLAC3D versions is observed during the waiting phase. OpenGeoSys leads to higher displacements compared to FLAC3D in the waiting phase. This may be explained by the different numerical frameworks (finite element for OpenGeoSys and finite difference method for FLAC3D) under which the codes are based. All results fit perfectly in the heating phase.

Most discrepancies can be observed in the pore pressure evolution. One observes some oscillations in the pore pressure evolution in the two FLAC3D versions. The

amplitudes of the oscillations are less important in the latest version of FLAC3D. Further investigations showed that it is possible to avoid these oscillations by decreasing the mesh size. This unfortunately increases the computation time drastically. In the thermal phase, the computed over-pressurization is more pronounced in OpenGeoSys than in FLAC3D. A higher pore pressure is generated over time. This can be due to the different formulations of the over-pressurization used in the two software.

Temperature, displacement and pressure evolution d