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Geomechanical Analysis of Underground Coal Gasification Reactor Cool Down for Subsequent CO_2 Storage

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Underground coal gasification (UCG) is an efficient method for the conversion of conventionally unmineable coal resources into energy and feedstock. If the UCG process is combined with the subsequent storage of process CO_2 in the former UCG reactors, a near-zero carbon emission energy source can be realised.

This study aims to present the development of a computational model to simulate the cooling process of UCG reactors in abandonment to decrease the initial high temperature of more than 400 °C to a level where extensive CO_2 volume expansion due to temperature changes can be significantly reduced during the time of CO_2 injection. Furthermore, we predict the cool down temperature conditions with and without water flushing. A state of the art coupled thermal-mechanical model was developed using the finite element software ABAQUS to predict the cavity growth and the resulting surface subsidence.

In addition, the multi-physics computational software COMSOL was employed to simulate the cavity cool down process which is of uttermost relevance for CO_2 storage in the former UCG reactors. For that purpose, we simulated fluid flow, thermal conduction as well as thermal convection processes between fluid (water and CO_2) and solid represented by coal and surrounding rocks. Material properties for rocks and coal were obtained from extant literature sources and geomechanical testings which were carried out on samples derived from a prospective demonstration site in Bulgaria.

The analysis of results showed that the numerical models developed allowed for the determination of the UCG reactor growth, roof spalling, surface subsidence and heat propagation during the UCG process and the subsequent CO_2 storage. It is anticipated that the results of this study can support optimisation of the preparation procedure for CO_2 storage in former UCG reactors. The proposed scheme was discussed so far, but not validated by a coupled numerical analysis and if proved to be applicable it could provide a significant optimisation of the UCG process by means of CO_2 storage efficiency. The proposed coupled UCG-CCS scheme allows for meeting EU targets for greenhouse gas emissions and increases the coal yield otherwise impossible to exploit.