Towards the Discrete Element Modeling of Wear in Rock Drilling Bits

A. Wessling*, P. Jonsén* and J. Kajberg*

* Mechanics of Solid Materials
Luleå University of Technology
Universitetsområdet, Porsön, 97187, Luleå, Sweden
e-mail: albin.wessling@ltu.se, web page: http://www.ltu.se

ABSTRACT

Two commonly used methods for rock drilling are the regular rotary drilling method, where the rock is crushed by a weight-on-bit and rotation, and the percussive rotary drilling method, where the rock is initially crushed by the impact energy and experiences further splitting from the rotary motion of the bit. In this study, wear of drill bits, pressure distributions and vibrations in the adjacent soil and rock will be investigated by togehter using FEM, DEM and CFD.

DEM has been used to model rock behaviour where the cohesion between the particles was realized by using the parallel bond model [1] with microscopic parameters [2,3]. Each particle contact was realized by using a penalty-based contact model and friction was included at the perimeters of the particles based on the Coulombs friction law. The drill bit has been modeled using a FEM formulation with steel properties for the drill body and tungsten carbide properties for the cutters. Further, the transportation of drill cuttings via drilling fluid was modeled by coupling DEM and FEM to an incompressible CFD solver. The drill bits were driven by applying torque and weight-on-bit, as well as a percussive force for the percussive drilling method. The fluid dynamics were driven via a pressure difference between the top of the drill bit and the back of the drill. Both air and water has been used as drilling fluids.

Two different wear models have been used, the first one being Archard's abrasive wear law, which relates the removed volume to the hardness of the target material, and the second one being Finnie's wear law for particle impact. Here the erosion due to particle impact is obtained as a function of impact angle and yield stress of the target material.

The preliminary simulations based on rock characteristics from literature show promising results regarding wear and transportation of drill cuttings. Future mechanical characterisation of different types of rocks often encountered during drilling in geothermal applications will be conducted to improve the accuracy of the numerical models. The mechanical properties of the rock materials will be characterized by e.g. unconfined stress test, Brazilian test and Split-Hopkinson pressure bar. Further, the constitutive relationships and wear coefficients for the drill bits will be determined in order to model wear and geometry changes.

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