PARTICLE BASED FORMULATION FOR ANALYSIS OF WEAR IN ROCK CUTTING TOOLS

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The paper presents recent developments of a particle based formulation based on spherical discrete elements for modelling wear in cutting tools operating in rock, soil and granular media [1].

The motion of the spherical elements is described by means of equations of rigid body dynamics. Explicit integration in time yields high computational efficiency. Spherical elements interact among one another with contact forces, both in the normal and tangential directions. An efficient contact search scheme based on oct-tree structures has been implemented. A special constitutive model of the contact interface taking into account cohesion forces allows to model fracture and decohesion of materials.

The discrete sphere model reproduces accurately the behaviour of soil and rock masses as a collection of spheres with frictional and adhesive properties. By calibrating these material properties using an stochastic optimisation procedure for material parameter identification, the model can reproduce the structural behaviour of any rock or soil, including multiple fracture situations typical of excavations, dredging or ripping processes among others.

One of the innovations of the research is the modelling of the cutting tools also by a collection of spheres. Initial tests have shown that the elasticity of the tool is irrelevant for the purposes of modelling the surface wear. Thus a rigid model for the spheres discretizing the tool suffices for accurately predicting the wear of the steel surface. Wear is produced by frictional work due to the contact between the tool and the soil/rock particles. When the surface wear exceeds a certain prescribed value then the corresponding spherical particles are removed from the surface. This reproduces the loss of material in the tool in a simple and effective manner.

The tool model accounts for the internal transfer of heat generated by the frictional work at the surface. Heat is propagated within the tool by means of a thermal conduction model. Thermo-mechanical coupled effects due to the interaction between the frictional work at the wear surface and the heat generated and propagated within the tool are taken into account.

Examples of application of the model to the analysis of the non linear behaviour of rock/soil masses, as well as to the prediction of wear in rock cutting tools for a number of practical situations are presented. Comparisons with experimental data show the accuracy and efficiency of the spherical discrete element model proposed.

References

[1] Rojek J., Oñate E., Zárate F. and Miquel J., "Modelling of rock, soil and granular materials using spherical elements". European Conference on Computational Mechanics (ECCM 2001), Cracow, Poland, June 26-29, 2001.