A versatile particle fragmentation model using the discrete element model

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ABSTRACT

We report on the development of a discrete fragmentation model (DFM) [1] for spherical brittle particles using the open-source discrete element method (DEM) code LIGGGHTS [2]. Based on the Weibull distribution our model allows for different breakage criterions such as the von Mises stress or the accumulated damage caused by a number of impacts. These criterions can be used individually or in combination with each other. Furthermore, the breakage criterion can be adjusted on the fly to account for changes of particle properties due to, for example, chemical reactions.

The number and size of fragments replacing the original particle are derived at the moment of breakage. The random packaging of the fragments into the volume of the original particle leads to a compression of the child particles and in further consequence to an unphysical repulsive normal force between them. Our model resolves this problem by limiting these forces by the actually available elastic energy of the particles. Thus, mass, momentum and energy are conserved.

To counter the vast number of particles created by consecutive breakage events, the breakability of particles can be limited by a minimum size, below which no further fragmentation will occur. When coupled to Computational Fluid Dynamics (CFD) simulations, fragments below a predefined size can be dropped from the DEM calculations and may instead be considered as a continuous dust phase.

Coupled CFD-DEM simulations using the CFDEMcoupling software package were conducted to investigate the influence of particle fragmentation on dust generation in and the pressure drop across packed beds.

Embedded into the open-source software framework of LIGGGHTS and CFDEMcoupling, our particle fragmentation model has been fully parallelized and runs numerically stable. Furthermore, first numerical results agree well with experimental observations, proving that this sub-model could represent a versatile simulation basis for particle processes involving particle fragmentation.

REFERENCES

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