Simulation of stressing probability and energy distribution within stirred media mills using a coupled CFD-DEM approach

C. Schilde*, S. Beinert*, G. Fragnière*, B. Finke*, A. Kwade*

*Institute of Particle Technology
TU Braunschweig
Volkmaroder Strasse 5, 38104 Braunschweig, Germany
e-mail: c.schilde@tu-bs.de, web page: http://www.ipat.tu-bs.de/

ABSTRACT

Stirred media mills are very common devices in the chemical, pharmaceutical, ore and paint industry for fine wet grinding and dispersing of product particles down to a targeted particle size of few microns or even less. Apart from fragmentation of particles, agglomerates and aggregates followed by a stabilization process, emulsification processes, disruption of single-celled microorganisms, particle synthesis or chemical reactions are potential applications for stirred media mills as well.

Within this framework, the main aim of this study is the development of a simulation method to predict and optimize grinding and dispersing processes in wet operated stirred media mills. Therefore, coupled CFD-DEM simulations were carried out on the meso and macro scale with the focus on the stressing probability, grinding media motion and stressing energy distribution within stirred media mills. On the meso scale, the numerical simulation of the interaction between product particles, the grinding media and the fluid phase was realized via a DEM-CFD coupling using the "immersed boundary method" (LIGGGHTS, Openfoam, CFDEMcoupling). The grinding media was considered as spheres or as fixed boundaries with a defined relative velocity, rotation and total displacement in normal direction. Using this method, the fluid flow in between can be resolved in detail. A coupled non-resolved DEM-CFD simulation method was applied for the determination of the grinding media movement and stressing energy distribution on the macro scale. Hereby, the effect of tip speed and grinding media size on the stressing conditions was investigated.

The simulation results on the meso scale level show decisive influence of the rotational and translational movement of the grinding media on the capture probability. High values of translational or rotational velocity of the beads lead to an increased stressing probability. For this reason, the effect of kinetic energy that induces impact, shearing, torsion and rolling on the capture probability has to be identified and implemented in the macro scale level, at which point the stressing energy distribution of the mill is calculated based on the relative velocity of the grinding media. The main outcome from the macro scale CFD-DEM simulation is the contact frequency of grinding media and the contact energy distribution. The contact frequency gives an indication of the rate at which product particles are stressed. An effective stressing energy distribution can be calculated for various process parameters in combination with results from simulation of the product particle capture between two grinding beads on the meso scale level.