Key concepts to understand grinding operation

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Comminution and classification of particles belong to the oldest cultural techniques of mankind. Over centuries, empirical approaches lead to the development of many different types of mills. With the advent of systematic research in particle technology from the end of the fifties of the last century, the basic understanding of the underlying mechanisms largely improved and led to the development of first relatively simple and now highly sophisticated numerical models to describe fracture of particles and the operation of mills.

In a first general overview, any grinding operation as part of a larger process (described by a process function) can be understood in terms in terms of a mill and a material function. The mill function depends on operational parameters, which leads to transport of particles in the mill, and describes the applied stress energy distribution to particles through the prevailing stressing mechanisms and the stress number distribution, i.e. how often the particles are stressed in the mill per unit time. The reaction of the particles to the applied stress is condensed in the material function, which includes elastic and inelastic (viscous and/or plastic) deformation. The energy transferred to the particles is either elastically stored or inelastically dissipated. If the elastically stored energy is sufficient for crack opening and crack movement, fracture occurs. Fracture events are described by fracture probability and breakage function, i.e. the size distribution of the fragments. Both are directly linked to size-dependent particle properties.

Based on these underlying principles, the talk will discuss options for (well defined) stressing of single particles by impaction and compression, the role of defects in particles and their relation to the grinding limit and mechanochemical effects.

Specific examples for mill operation will be given for air classifier and jet mills in the gas phase as well as stirred media mills in the liquid phase. Selected applications are related to brittle inorganic materials, polymer and pharmaceutical particles. Finally, possibilities to produce 2D materials by delamination such as graphene will be briefly discussed.