Challenges and Trends in Particle Size Reduction Technology

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Abstract

Milling is one of the oldest technologies developed by early civilisations. Remnants of roller mills for cereal milling can be seen in the Roman archaeological sites of Pompeii and Herculaneum in southern Italy. In modern times a vast range of mill types have been developed and are now available to suit particular applications ranging from minerals, foods and pharmaceuticals and more recently for producing nano-particles. The old technologies of roller mills and ball mills have found renewed interest arising from improved performance in the former and suitability for nano-particle production for the latter. Developments in the last few decades have led to pin mills and more recently to fluid energy mills. The latter is particularly suited for producing micrometre-size range particles for applications such as xerography and dry powder inhalation. At the University of Leeds the dynamics of these mills is analysed by DEM-CFD approach; http://ghadiri-group.leeds.ac.uk/our-research/milling/.

Related processes such as attrition milling and mechanofusion are also recent developments. The latest developments in metal recovery from minerals use powerful microwaves in short durations to weaken the particles before stressing them to break, thus providing substantial energy savings. The challenges in front of us are great, as milling is not only the most energy intensive and inefficient particulate solids process, but it is also the least understood. The physics of damage and fracture is highly complex and dependent on material structure, properties and interactions with machine dynamics. From a process engineering view point, the interest is in energy utilisation and scale-up of various mill types, issues which are of great interest to industry. The materials-related aspects of interest pose even greater challenges, some of which are summarised below:

(i) The smallest possible particle size, which can be produced.
(ii) The most desirable, yet challenging issue of being able to *predict* the size distribution.
(iii) The most appropriate methods of application of stresses for a given set of materials properties.
(iv) For crystalline solids, the role of crystal habit in affecting milling and the product properties.
(v) For amorphous solids, the chemical and physical stability following size reduction.
(vi) Surface modification in a liquid environment and effect of humidity and gas environment

The grand challenge in size reduction is to develop *predictive* tools for product attributes of new materials. In this presentation current work on analysis of various types of mills will be presented and the methodology for relating grindability to breakability will be explored.

Speaker:

Professor of Chemical Engineering at the University of Leeds, UK, with research activities on Particle Technology, and focussing on the link between bulk particulate solids behaviour and single particle properties with the aid of simulations by combined DEM and CFD. Application areas of interest are cohesive powder flow and fluidisation, size reduction and enlargement, environmental effects and electrical phenomena in particulate systems. For details of the current projects, collaborators and publications please see the following web pages: Group's web page: http://ghadiri-group.leeds.ac.uk/.