International Fine Particle Research Institute

Project Brief

Mill Selection and Optimization for Size Reduction of Soft Materials

IFPRI recently held a milling workshop (June 2025, Carry-le-Rouet, France) at which we surveyed the current state of understanding of milling processes and breakage behavior of materials and identified opportunities for future research. One of the topics that emerged from this discussion was milling of soft (ductile materials), which is broadly used in a wide range of industries, particularly food, pharmaceuticals, personal products, and recycling. The consensus at the workshop was that we need to improve our understanding of how soft materials deform and break and how this influences mill selection and operation.

The framework of the discussion of the workshop – and for this project – is the "deconvolution" of a milling process into a "mill function" and a "material function." The mill function describes how particles are stressed in a particular mill type and geometry. The material function describes how a particle of a give material deforms and breaks under stress and strain.

This project focuses on both aspects of milling soft materials:

Comprehensive Physical Characterization of Soft Materials: Conduct thorough physical characterization of soft materials, focusing on key properties that control deformation and fracture such as glass transition temperature, yield stress, Young's modulus, Poisson's ratio, and initial flaw size. These parameters will be augmented with breakage response determined through experimental approaches such as (single) particle impact experiments under controlled conditions to develop the material function.

Optimal Machine Function for Process (Mill) Selection: Utilize the developed material function framework to identify the optimal machine function and select the most suitable milling equipment for a given material.

Process Optimization and Validation: Leverage the material function framework to optimize process set points for a given mill. This includes determining the optimal energy input and size reduction efficiency. The proposed process parameters can be used to validated against empirical data obtained from lab-scale milling or controlled breakage tests, ensuring alignment with theoretical predictions.

Materials to be considered include food powders, biopolymers, polymers, organic composites and multi-component granules such as inorganic loaded agglomerates.

Well defined model ductile particles could form the basis of the methodology development however industrial relevant samples must be included in the study.

Out of scope: The resulting milled particle size distribution should not be less than 20 microns with the feed material not to exceed 4mm.