International Fine Particle Research Institute

Project Brief

Artificial Intelligence Assisted Characterization of Bulk Powder Flow

This project aims to develop an AI-assisted computer vision characterization method for assessing bulk powder flow characteristics from small samples of powder. The intent of this method is to facilitate prediction of bulk powder properties early in development of particulate products when quantities of some raw materials (e.g. active ingredients) are limited.

The objective of the project is to predict bulk powder flow (ideally quantitatively) by capturing images of small quantities (1 g for destructive measurements; 2 g for non-destructive measurements) of non-static powders (e.g. during agitation, dispersion, flow down an incline, etc.) and using AI algorithms to link these images to powder flow characteristics, both quasi-static and dynamic. Additionally, easily measurable data at the particle level, such as primary size and shape distribution and density, can be incorporated as input to enhance the model's robustness. The underlying premise of the project is that bulk powder properties are a function of particle morphology and particle contact mechanics, and the images of dynamic powders contain information about the interparticle interactions that are absent in purely morphological measurements.

Furthermore, the small quantity of material makes this approach suitable for calibrating Discrete Element Method (DEM) and Computational Fluid Dynamics (CFD) simulations, advancing the field towards more robust digital twin simulations.

To enhance analytical capabilities, the principal investigator should consider utilizing cutting-edge computer vision algorithms, such as auto-encoders or vision transformers. Once trained, these models can analyze the dynamic structure of powders and link that structure to the intrinsic bulk and particle properties of the powder.

For improved success, the PI is encouraged to select small-scale systems that capture inter-particle forces such as friction, cohesion, and electrostatics, as these factors influence imaging results. By addressing these multifactorial aspects, the model aims to deepen the understanding of bulk powder behavior, leading to enhanced material processing strategies across diverse industries.

There is no restriction on the materials that are studied except that they should span a wide range of flowability (e.g. flow-functions that span free-flowing to poorly flowing). Model systems are in-scope as are industrial materials that may be recommended by IFPRI members. The project is restricted to dry powders (i.e. does not include slurries or liquid dispersions).