



## Wolfson Department of Chemical Engineering Seminar

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# Development, validation and application of SuperDEM-CFD model for non-spherical particles binary fluidization and biomass pyrolysis

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PhD Final-Seminar

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**Abstract:** Solid fuels (biomass, plastic, etc) pyrolysis reactors are extremely complex multiphase systems involving gas phases, non-spherical solid particles, and phase transitions due to chemical reactions, varying multi-scales in time and space. A comprehensive understanding of the chemical and physical phenomena in biomass/plastic pyrolysis across multiple scales is essential for promoting the efficient transformation of biomass thermochemistry. This research developed various models integrated into the SuperDEM-CFD (Superquadric Discrete Element Method-Computational Fluid Dynamics) framework to understand the transport phenomena of non-spherical particles in gas-solid systems.

In the first work, the fluidization behavior of spherical and cylindrical plastic particles, as well as their binary mixtures, was experimentally investigated. A machine learning-aided image processing method was developed to segment particles from the background for particle dynamics analysis. The SuperDEM-CFD method was extended to adequately simulate the fluidization behavior of binary mixtures of spherical and cylindrical particles and was validated against experimental results.

The second work developed a coarse-grained SuperDEM-CFD method that lumps spherical or nonspherical particles into parcels to reduce computational cost. For validation, sand-plastic binary fluidization experiments with varying cylinder mass fractions were carried out. The machine-learning-aided image-processing method was employed to analyze bubble properties. Compared with experiments, the coarse-grained model can successfully predict pressure drops, fluidization behavior, expanded bed height, particle height, orientation distributions, and bubble properties.

In the last work, new heat-conductive models based on the SuperDEM (Superquadric Discrete Element Method) were developed for non-spherical particles, and particle-particle contact and particle-fluid-particle conduction were considered. Compared with analytical and PR-DNS (Particle Resolved-Direct Numerical Simulation) results, the developed models can successfully simulate different heat conduction of non-spherical particles. The effects of particle shape, orientation, and temperature difference were comprehensively investigated. Additionally, heat conduction in packed beds of non-spherical particles was investigated and compared with the PR-DNS results.