

# PARTICLE SUSPENSION AND PROCESSING (PSP)

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## FLUIDIZED BED PROCESSING

The research under the theme PSP covers three main areas:

- 1) fluidized bed physical, chemical and thermal processing
- 2) Particle-particle interactions during suspension
- 3) Heat storage, transfer and recovery using PCM.

### ► Physical processing

Granulation, Drying<sup>1</sup>, Coating, PCM micro-encapsulation

### ► Thermal/Chemical Processing

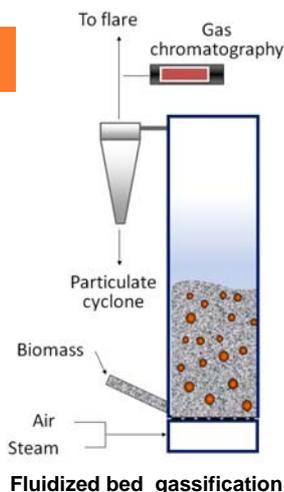
Biomass Gasification and Byrolysis

### ► Particle-Particle Interaction at the micro-scale level

Dense wet/dry suspension

## BIOMASS GASIFICATION

Biomass gasification produces fuel gas or synthesis gas through thermal-chemical conversion of biomass. Air/steam blown fluidized bed is an ideal option for gasification. However, the complex hydrodynamics of the multiphase flow component and the effect of the biomass physical properties on the product gas are poorly understood. CFD and experimental modelling are used for better understanding of the process.

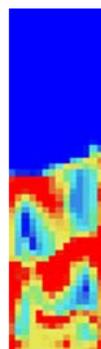


## MATHEMATICAL MODELLING and SIMULATION<sup>2,3</sup>

In-house developed mathematical models are used for the simulation of solid-fluid flow, particularly for fluidized bed applications. In addition, a number of CFD simulation codes are utilized for this purpose, namely:

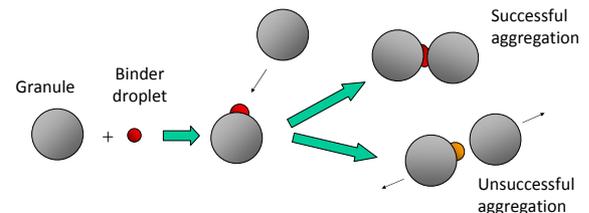
- Fluent (commercially available)
- MFIx (by permission from the US DOE)

All models are based on the two-fluid modelling approach and the Kinetic Theory of Granular Flow (KTGF).



Simulation of fluidized bed

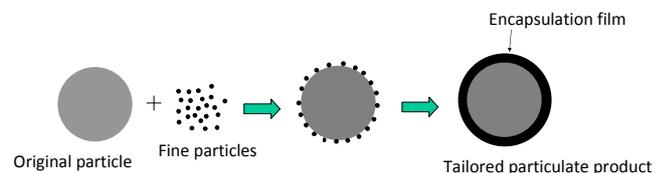
## GRANULATION<sup>4</sup>



Schematic of aggregation process

Granulation process is particularly important for particle size growth; a desirable feature in many industrial product, such as granulated food product and medical tablets. Studies related to Particle-droplet and particle-particle interactions at the micro scale can lead to improved granulation process

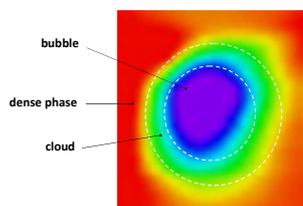
## MICRO-ENCAPSULATION of PCM



Schematic of encapsulation process

Micro-encapsulation is a new emerging technology for the production of particulate product of tailored physical, chemical and thermal properties. Encapsulated Phase Change Material (PCM) has great potentials in heat storage, recovery & transfer.

## TOMOGRAPHIC ANALYSIS OF SOLID-FLUID FLOW<sup>5</sup>



Tomographic image of a bubble in a fluidized bed

Tomographic imaging, namely, the Electrical Capacitance Tomography (ECT) provides fast images of the cross-sectional concentration of a two phase flow mixture ((e.g. solid-gas flow). This is useful for non-intrusive analysis of multiphase flow, particularly for fluidized bed reactors

### REFERENCES

1. Makkawi and Ocone (2009). Mass transfer coefficient for drying of moist particulate in a bubbling fluidized bed. *Chemical Engineering Technology*, 1-10.
2. Makkawi and Ocone (2005). Modelling of particle stress at the dilute-intermediate-dense flow regimes: A review. *KONA - Powder Science and Technology No.23*. 49-63
3. Makkawi and Ocone (2007). Integration of ECT measurements with hydrodynamic modelling of conventional gas-solid bubbling bed. *Chemical Engineering Science*. 4304-4315
4. Kelwin, Makkawi, Hounslow (2009). Time scale analysis for fluidized bed melt granulation I, II, III, submitted. *Chemical Engineering Science*, 2009
5. Makkawi and Wright (2004). Tomographic analysis of dry/semi-wet bed fluidization: the effect of small liquid loading and particle size on the bubbling behaviour. *Chemical Engineering Science* 59 (1), 201-213.

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