UC SANTA BARBARA
M&M Flow Lab
Multiphase & Multiscale

IFPRI
International Fine Particle
Research Institute

DRYING WET POWDERS WITH SHEAR TO PREVENT AGGLOMERATE FORMATION

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Fluids and Interfaces

Grains, Powders and Suspensions

Heat Transfer and Phase

MOTIV... ...GREGATES SIZE AFTER DRYING

suspensions

$$w = \frac{V_{liq}}{V_{sol}}$$

dry | pendular | funicular | capillary | dense | diluted

10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1}

No agglomeration | Agglomeration

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Drying a mixture of particles and liquid affect the state of agglomeration of the final dried product. What is the influe...

Issues: ...play between ...e particles, the liquid, the humidity, temperature, shear, ...

Ex... ...rizing the drying of wet ...of agglomerates

OSCILLATING BOX

+ liquid binder

High shear granulation

$\vec{g}$

$A \cos \omega t$

A model granulator?

Raux et al., Phys. Rev. Fluids

Granulation

with Pascal Raux and Pierre Jop (SVI - CNRS/Saint-Gobain, 2018)

200-250 µm
63-80 µm

OSCILLATING BOX: FIRST TE...

1 cm

After 1 min of vibrations for glass beads and water

$a = 1\,g,\ d = 65\,\mu m,\ W = 30\,\%$ (volume)

Bi-dimensional system

Some initial issues:

Removable Lid

Locking Mechanism

Quasi 2D Box (Transparent)

Model Powder

g

Vibrating Stage

Adhesion causes coating of a grain layer, making visualization of agglomerates challenging

Trade-off between visualization and functionality

First version: ready to test!

No-moisture exchange

Normalized by the projected area of a single grain
$\Rightarrow$ Estimate of agglomerate size

Smaller grains $\Rightarrow$ more grains per agglomerate

Over time agglomerates become smaller

Agglomerate Size

A_i/A_0

$A_0 = \pi (d/2)^2$

$d = 65\,\mu m$
$d = 300\,\mu m$

t [min]

Agglomerate Concentration

A_{agg}/A_{tot}

$d = 65\,\mu m$

$A_{agg}(t) = \sum_i A_i(t)$

Agglomerates breakup over time, as the system approaches a cohesive layer at the bottom of box

Agglomerate Shape

$\xi = w/l$

ξ

$d = 65\,\mu m$
$d = 300\,\mu m$

t [min]

Agglomerates roughly circular in shape for all times for smaller grains

To be tested with non-spherical grains

Next steps

- Reach higher acceleration of the oscillating box (higher shear)
- Automatization of the processing methods
- Air Exchange: Design updates to allow air without leaking powder
- Humidity and temperature control
- Parameter space sweep and first tests with small glass beads
- Tests with powders

APPROACH

Development of the best proxy for the testing of the drying of wet powders with shear

Tool 1: high-shear drying
Oscillating box

$A \cos(\omega t)$

Typical velocity: m/s
Typical particle energy: μJ

Transversal tasks
- Development of the humidity chamber
- Processing tools to measure the time evolution of the aggregate size during the drying process

Tool 2: low and medium shear drying
Rotating drum

Typical shear rate: $\dot{\gamma} \sim 100\,s^{-1}$

Characterizing the formation of agglomerates during drying with different model powders and shear conditions

Practical results
- Experiments performed with model powders (e.g. calcium carbonite, quartz, cornstarch, etc.)
- Experiments with model material (glass beads) and liquid phase that solidifies upon drying
- Time-resolved regime map varying the temperature, relative humidity and energy input
- Key results: agglomerates size distribution

Input from IFPRI members with powders of interests

R... ...CONSTRUCTION)

Drum: 2 x 5" disk
2 x 4" disk
1 x 4" ID tube

1mm glass beads: dry | 1mm glass beads: 1% wet

Ongoing work:
- Faster motors
- Larger drum
- Measure and vary humidity exchange
- Characterize aggregate size - image processing

"CONCLUSION"

- Ongoing design phase of the oscillating box and the rotating drum
- Design an air exchange mechanism (humidity and temperature control)
- Automize the processing of the experimental pictures
- Start considering real powders

Input from IFPRI members?
- Powders and liquids relevant to applications ?
- Typical range of shear rate interesting ?
- Range of temperature and humidity ?
- Is it interesting to have all the time evolution ?