Powder property influence on the local force profile in a granular column
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To cite this version:
Agnès Duri-Bechemilh, Sandra Mandato, Bernard Cuq, Thierry Ruiz. Powder property influence on the local force profile in a granular column. Colloque STPMF - Science et Technologie des Poudres et Matériaux Frittés, Apr 2015, Nancy, France. 2015. hal-01606453
Powder property influence on the local force force in a granular column

Agnès DURI, Sandra MANDATO, Bernard CUQ, Thierry RUIZ

ISSUES
In a mixer equipment, the external mechanical stress induces the mobility of the particles that allows their mixing, segregation or association.
The mobility of the particles are greatly affected by the initial mechanical state of the powder bed.

• How to evaluate the mechanical state of the powder bed before mixing?
• How the physical properties of the particles influence this mechanical state?

OBJECTIVES

Short-term: characterization of the mechanical static state in ensiled granular media of different physical properties (particle size, restitution coefficient, coefficient of friction, cohesion, angle of repose, compactness, history of the bed formation...).

Long-term: better understanding the contribution of the initial mechanical static state of the powder bed on the mobility of the particles.

MATERIALS

Powders - 5 wheat-based powders of identical origin but with a different structure.

<table>
<thead>
<tr>
<th>Sample Name</th>
<th>SEM Image</th>
<th>d90 [mm]</th>
<th>d32 [mm]</th>
<th>Bed compactness</th>
<th>Angle of repose [°]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine semolina</td>
<td></td>
<td>0.210</td>
<td>0.321</td>
<td>0.416</td>
<td>32.2</td>
</tr>
<tr>
<td>Semolina</td>
<td></td>
<td>0.298</td>
<td>0.434</td>
<td>0.446</td>
<td>31.4</td>
</tr>
<tr>
<td>Fine couscous</td>
<td></td>
<td>0.676</td>
<td>0.645</td>
<td>0.578</td>
<td>12.1</td>
</tr>
<tr>
<td>Medium couscous</td>
<td></td>
<td>0.953</td>
<td>0.517</td>
<td>0.573</td>
<td>9.8</td>
</tr>
<tr>
<td>Large couscous</td>
<td></td>
<td>1.095</td>
<td>0.406</td>
<td>0.578</td>
<td>7.6</td>
</tr>
</tbody>
</table>

METHOD

Approach - Transposition from an industrial mixing device (with a 3D blade motion) to an unidirectional mixing device.

The mechanical static state is achieved by measuring the local vertical force (in triplicate) perceived by the blade (immobile) in different z positions in the powder bed.

RESULTS

Local – Global profiles

Local profiles – Physical properties of the particles

Vertical force normalised by the slope of the pseudo-hydrostatic profile (mm)

3 different layers in the bed

PSEUDO-HYDROSTATIC behaviour

Isotropic contact network

DEVIATION from the PSEUDO-HYDROSTATIC behaviour

Pseudo-hydro > couscous
Pseudo-hydro < semolinas

BOTTOM effect

Redirection of the force to the wall

CONCLUSIONS

The study of the mechanical static state indicates:

Å An inhomogeneous lateral repartition of the mechanical static state of the powder bed.
Å A superficial layer of about 50 mm with low shear level and independent from the physical properties of the particles.
Å A median layer of about 70 mm with higher friction level for semolina than for couscous.
Å A bottom layer of about 20 mm for which the bottom wall effect is independent from the physical properties of the particles.

PERSPECTIVES

Å PIV analysis will be performed to characterize the particle motion under the action of the blade motion in the three zones of the bed.
Å Define sizing criteria of powder mixers from the characteristic lengths.