Characterizing Ceramic Powder Blends with Powder Rheology to Optimize Dry Powder Pressing

Tecniche Analitiche innovative in ceramica 2

Sassuolo / 16 novembre 2023

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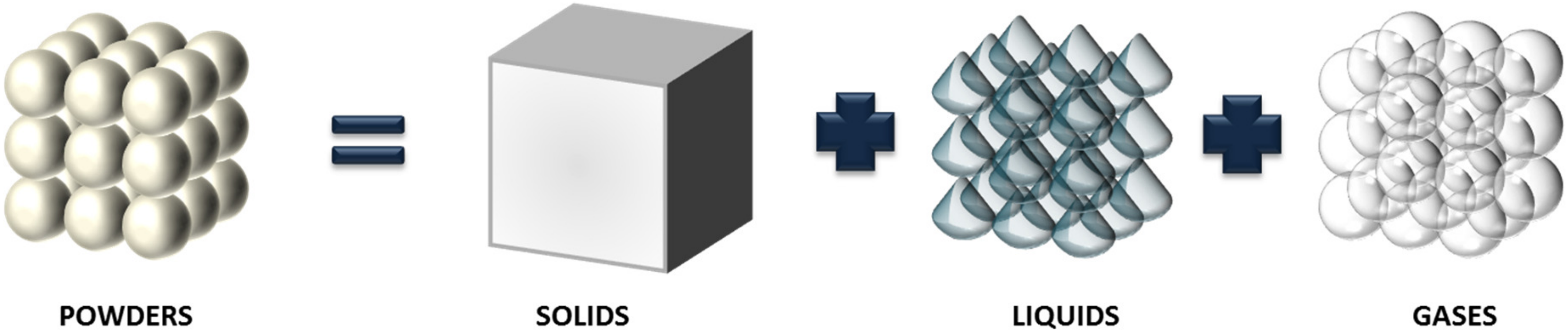
ALFATEST
STRUMENTAZIONE SCIENTIFICA

Powders are bulk materials, made from: -

Solids (the particles)

Liquid (water on the surface of the particle, in the particle or in the air between particles)

Gas (normally air, between particles)



Bulk powder "behaviour" is complex and will depend on how these three phases interact

Particles are complex, and variable

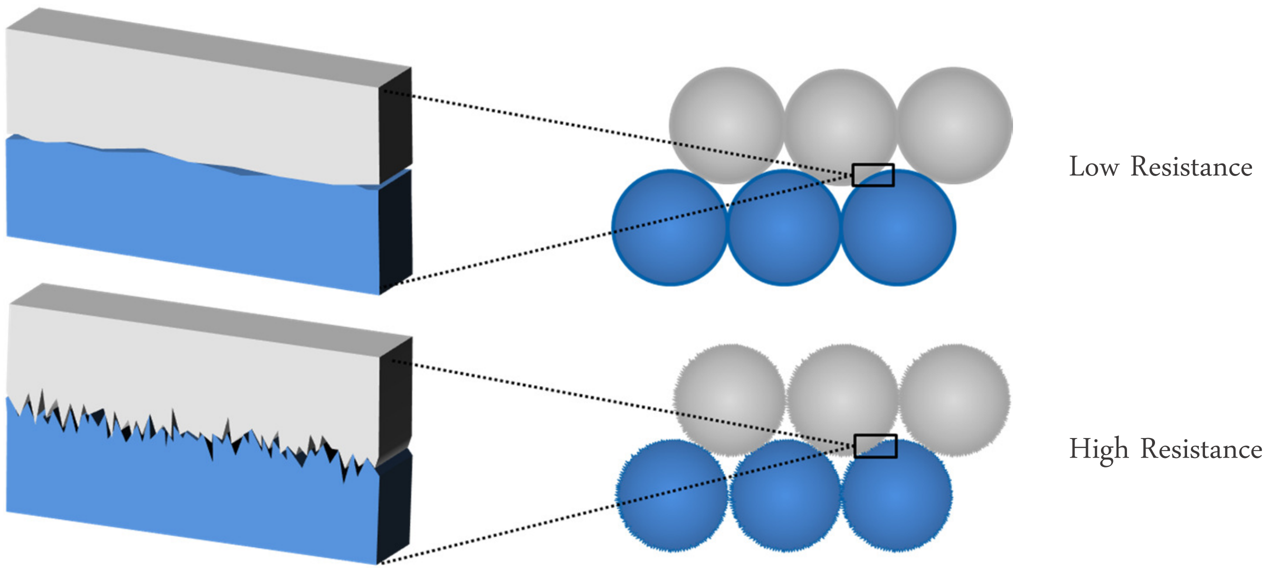
Each particle defined by a set of physical and chemical properties

- Particle Size & Distribution
- Shape
- *Surface Texture*
- Surface Area
- Density
- Cohesion
- Adhesion
- Elasticity
- Plasticity
- Porosity
- Potential for electrostatic charge
- Hygroscopicity
- Hardness / Friability
- Amorphous content

Each will contribute to how the powder behaves!


freemantechnology
C2031
50mm x 160ml No. 2336
FT Powder Rheometer

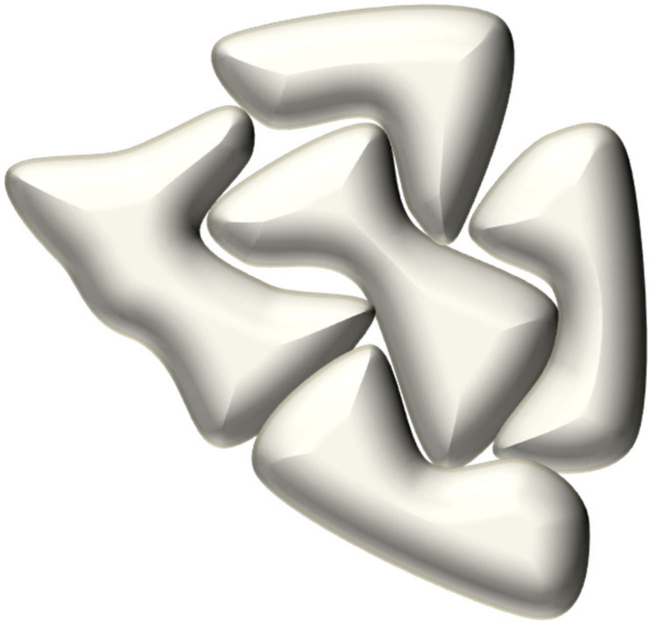
Friction between particles



Mechanical Interlocking of Particles

Related to particle shape

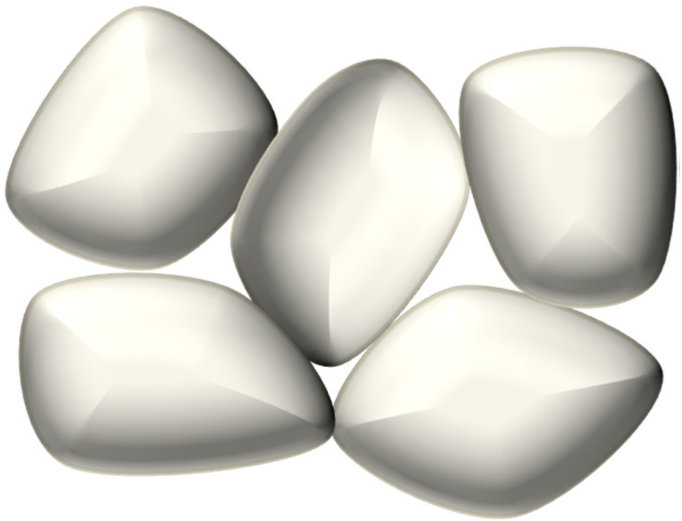
and stiffness



Strong interlocking

High force required for separation (and often breakage) of particles

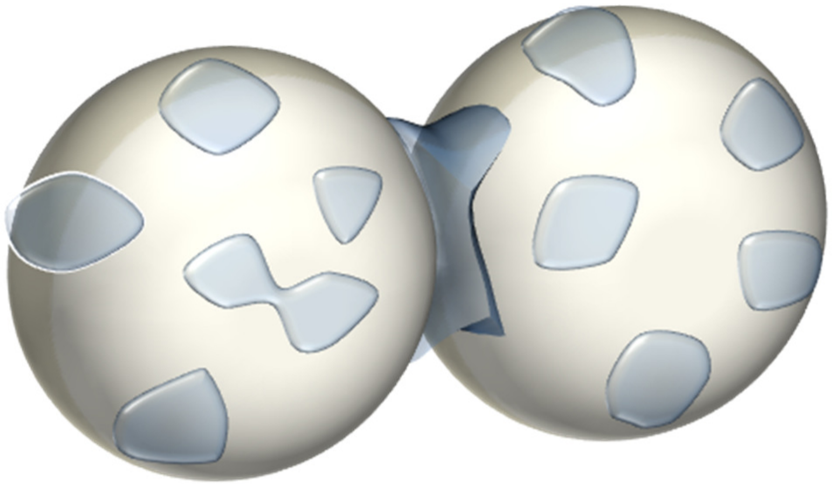
Mechanical Interlocking of particles



Weaker interlocking

Lower force required for separation of particles

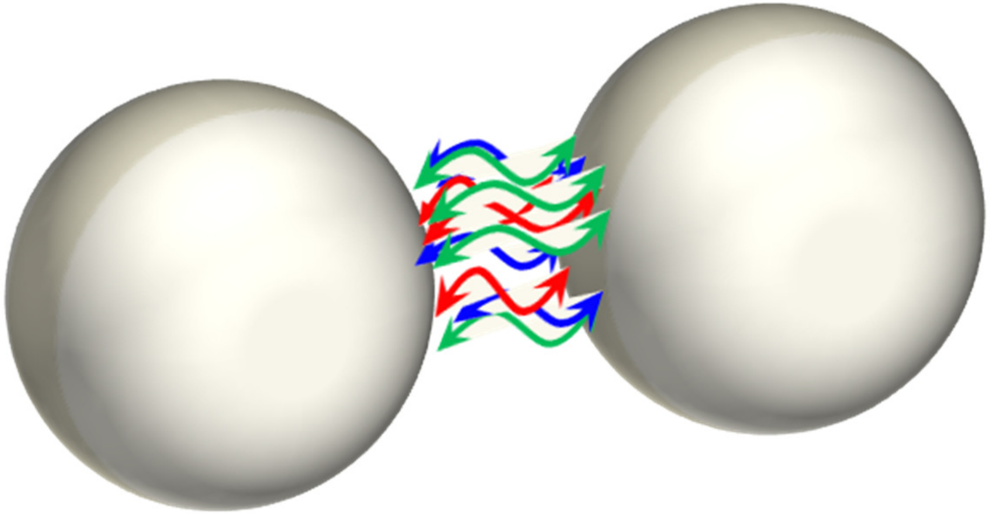
Liquid bridges between particles



Increased particle – particle adhesion

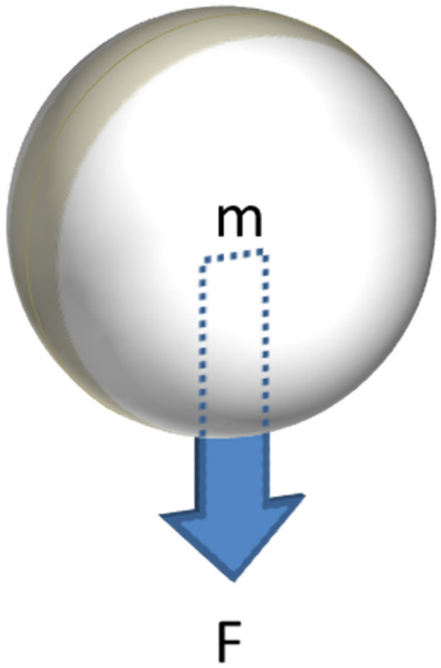
Cohesive, inter-particulate forces

- Van der Waals
- Electrostatics



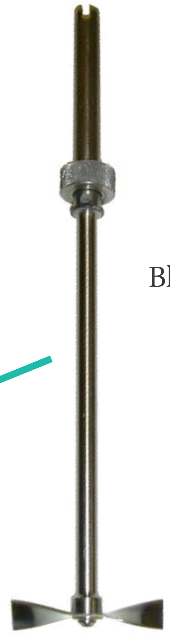
Increased particle – particle attraction

Gravitational forces



$F = mg$

Gravity is often the only motivating force



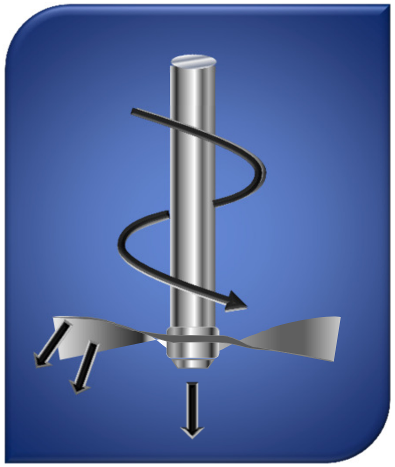
Blade

Powder sample in glass Vessel

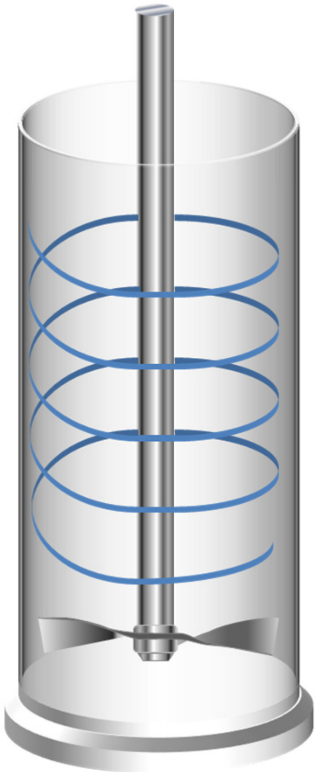
(typ. 10ml to 160ml)

The Powder Rheometer measures the resistance that the powder *exerts on the blade, as the* blade forces its way through the sample.

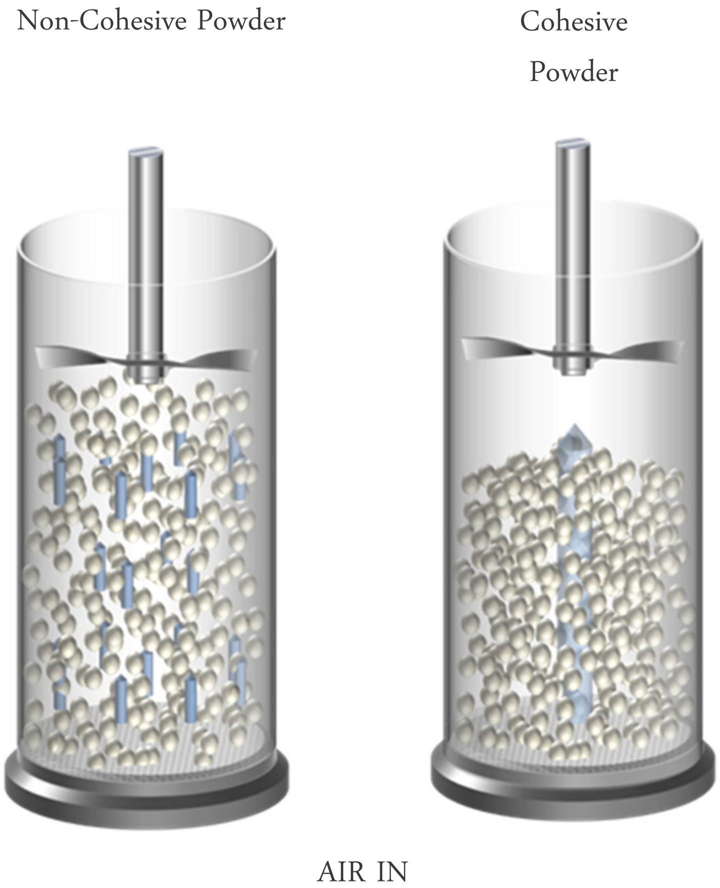
This resistance is expressed as “Flow Energy”, which is calculated from the direct measurements of Torque and Force

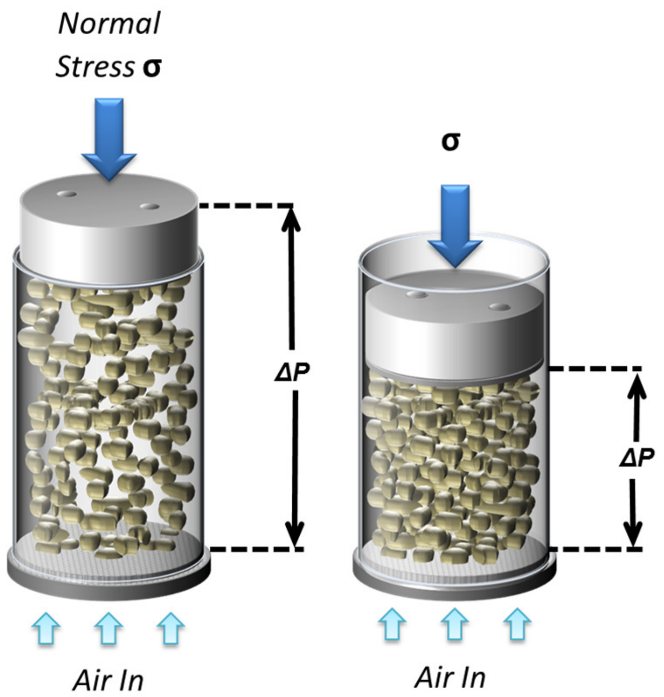


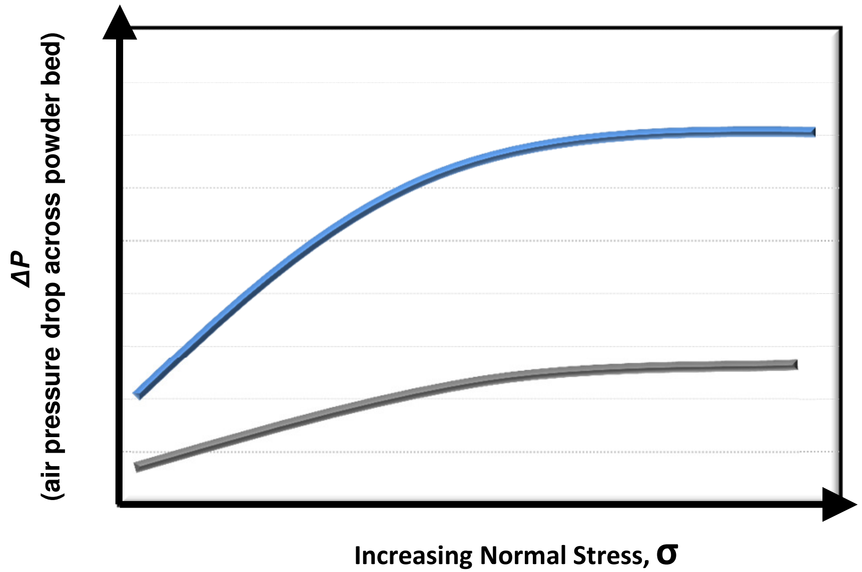
Specific Energy



- Measure of mechanical interlocking & particle – particle friction
- Not dependant on compressibility (like BFE)
- Specific Energy – low value equals low interlocking and friction


Non-Cohesive Powder
Cohesive Powder
AIR IN





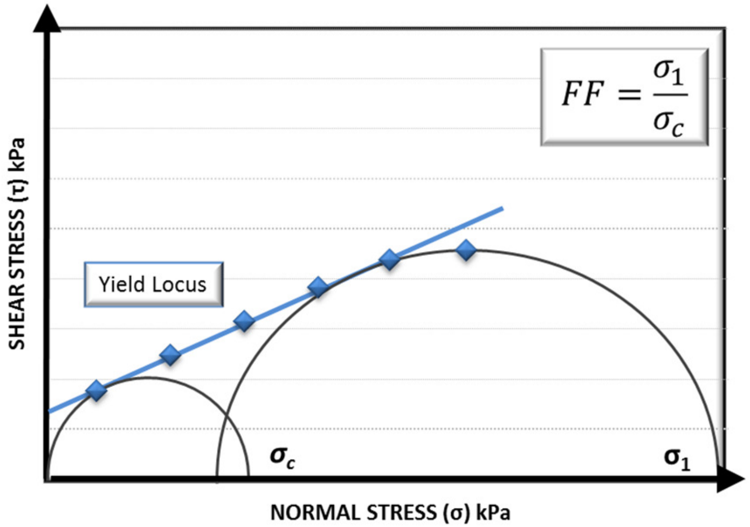
Powder behaviour during: -

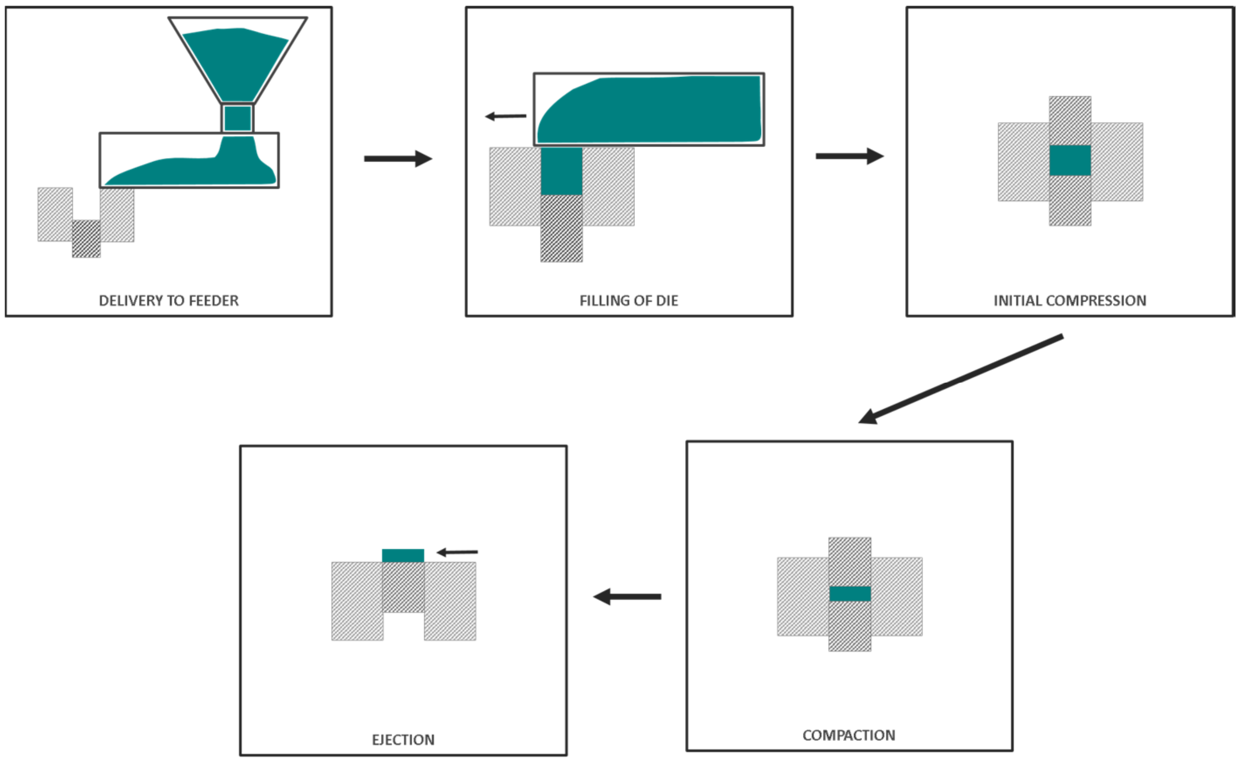
- Aerosolisation / DPI
- Hopper Flow
- Direct compression
- Pneumatic transfer

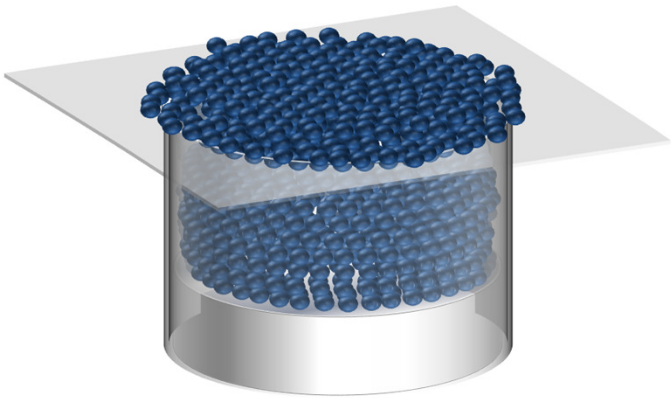
Low Air Pressure Drop means air can escape easily

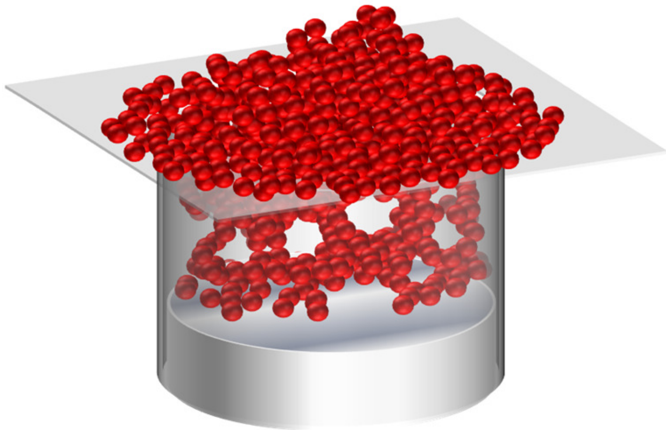
Shear in consolidated powder occurs during flow in a hopper or IBC, or during force feeding through augers or transfer chutes

- Shear Cells measure the onset of flow, the transition from static to dynamic
- Good for understanding behaviour in hoppers
- Flow largely dependant on mechanical properties like size, distribution, morphology, surface texture, adhesion due to binders




DELIVERY TO FEEDER
FILLING OF DIE
INITIAL COMPRESSION
COMPACTION
EJECTION





GOOD

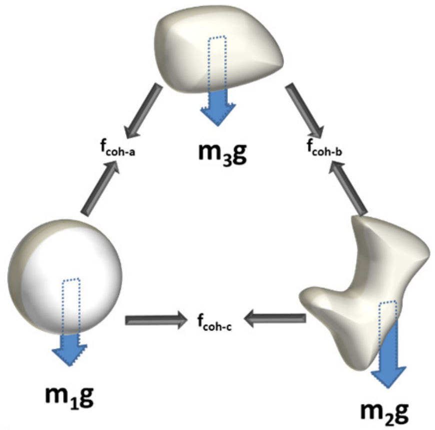
Uniform Filling, Low Porosity

POOR

Non-Uniform Filling, High Porosity

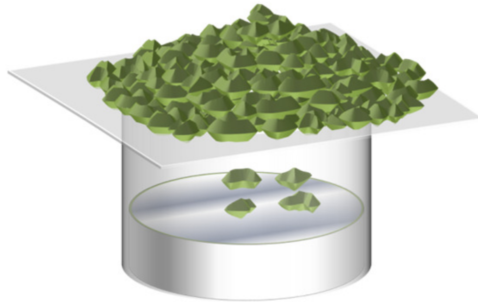
...leading to weight variation and capping and lamination

High cohesion

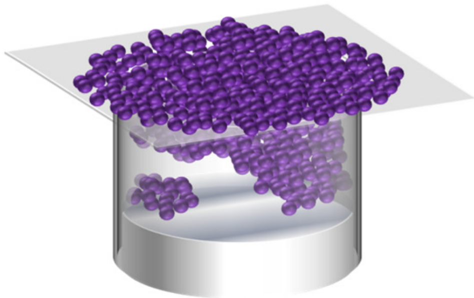


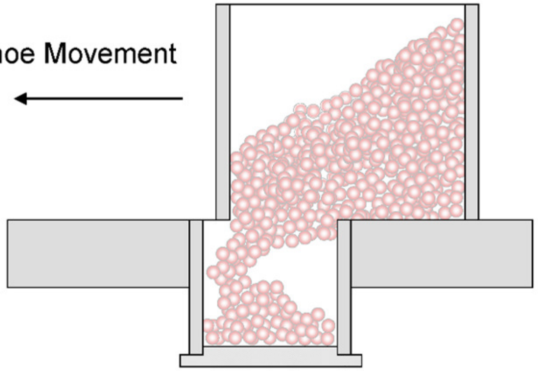
Cohesive forces >> mg

High mechanical friction & Interlocking

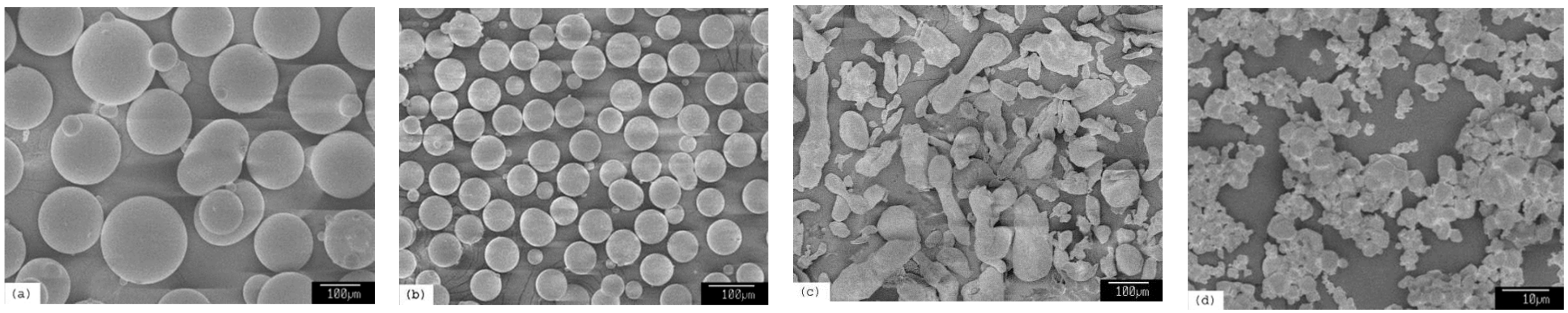


Low permeability

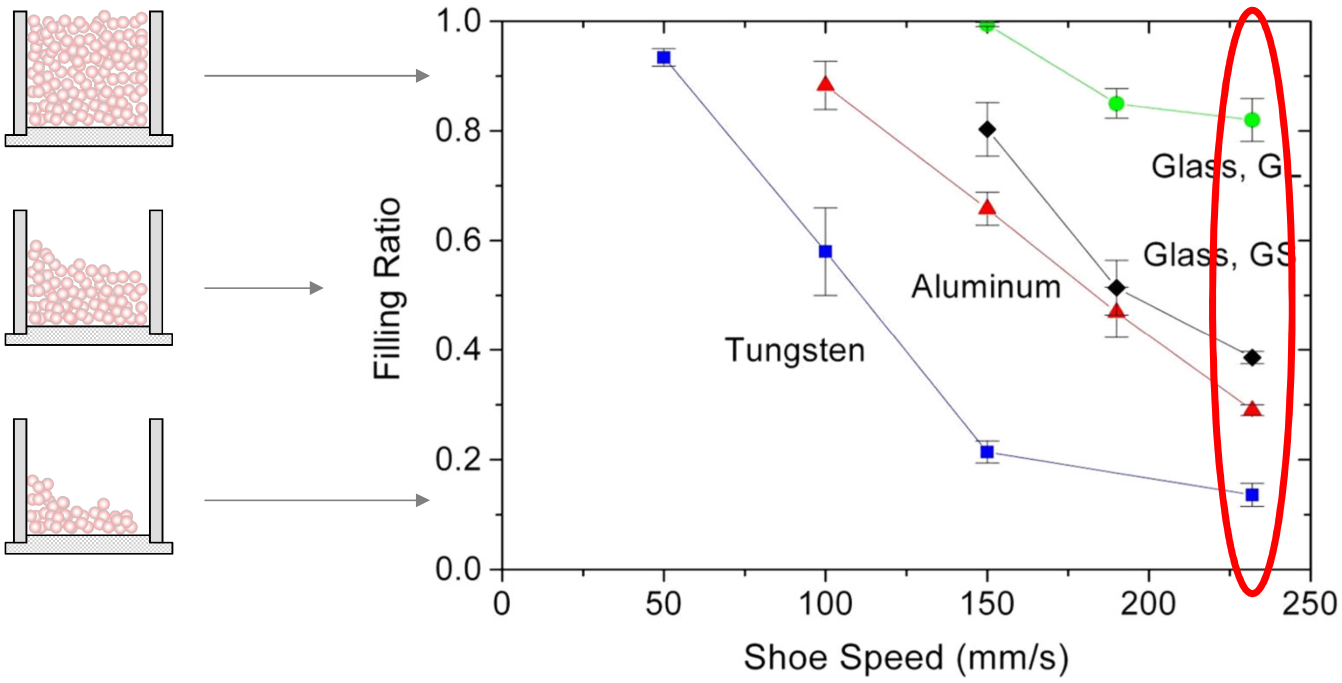




Material	Material/Powder description	D_{50} (μm)	Shape
(a)	GL Glass beads	174	Spherical
(b)	GS Glass beads	68	Spherical
(c)	Granular Aluminium powder	134	Irregular
(d)	Tungsten powder	4	Angular



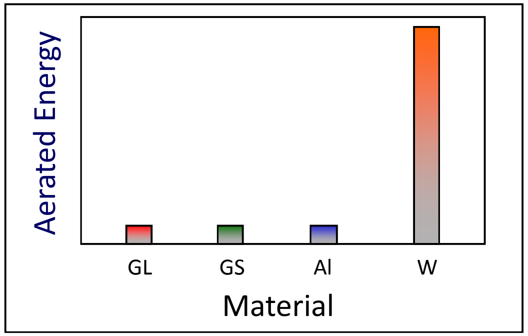
Ratio of actual mass in die compared to mass calculated from bulk density and volume of die



Measurements:	Glass GL	Glass GS	Aluminium	Tungsten
Fill Ratio	0.82	0.40	0.29	0.14
Aeration Energy, AE (mJ)	< 10	< 10	< 10	~300

Low Cohesion

High Cohesion



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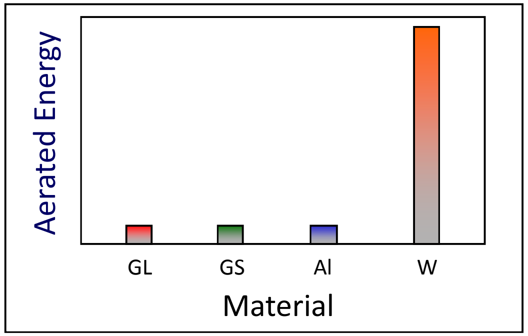
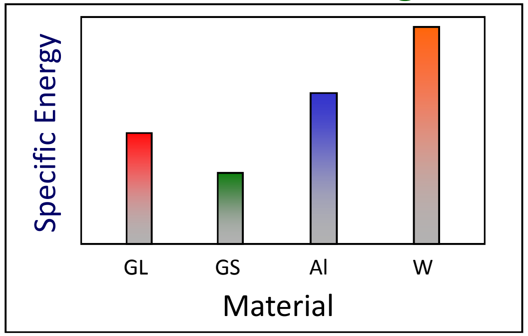
Fill Ratio	0.82	0.40	0.29	0.14
Aeration Energy, AE (mJ)	< 10	< 10	< 10	~300
Specific Energy, SE (mJ/g)	3.4	2.4	4.4	6.7

Lowest mechanical interlocking / friction

Highest mechanical interlocking / friction





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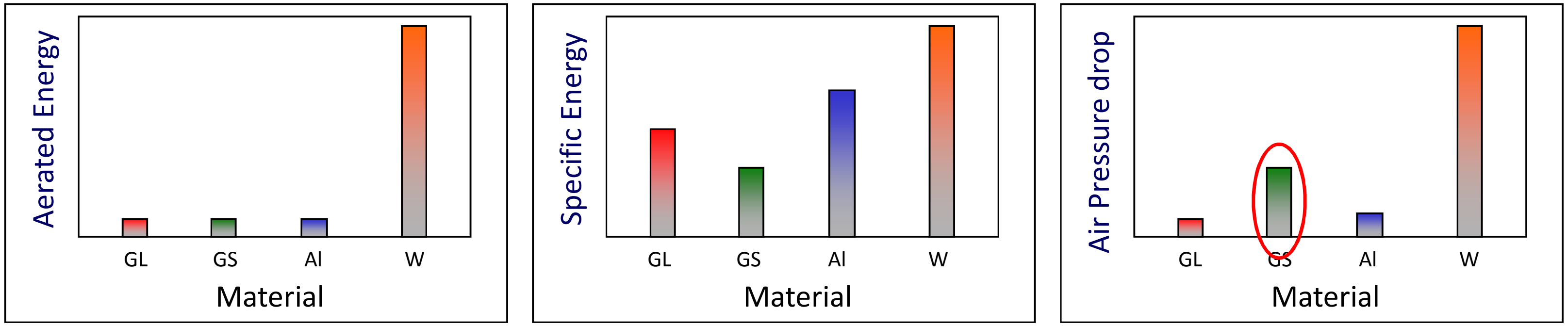
Pressure Drop across the powder bed at 2mm/s air velocity, PD_{15} (mbar)	0.8	5.2	1.4	15.3



- For efficient filling, require
  - Low Cohesion (low Aerated Energy)
  - Moderate to low mechanical interlocking (low Specific Energy)
  - High permeability (low Air Pressure Drop)

Measurements:	Glass GL	Glass GS	Aluminium	Tungsten
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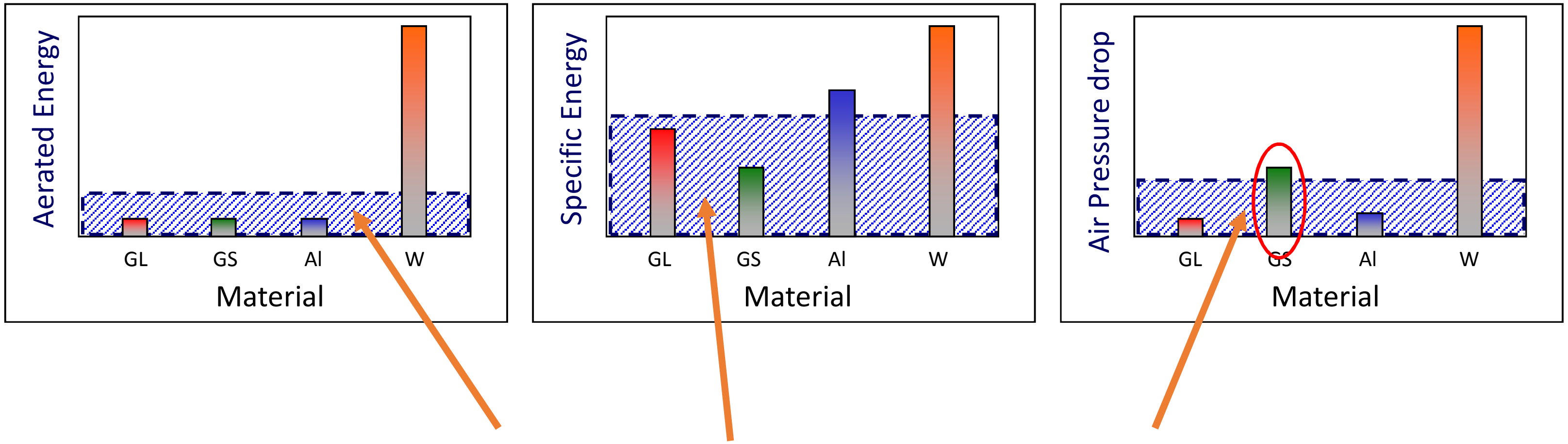

Acceptable process behaviour

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GRAZIE DELL'ATTENZIONE

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