The FT4 Powder Rheometer
The FT4 Powder Rheometer

FT4 Blade

Powder sample in glass Vessel
(typ. 10ml to 160ml)
**Conditioning**

Variation in the packing state of the powder will significantly change the flow properties.

Powder that is consolidated during filling will flow differently to one that was filled gently, perhaps trapping air.

Essential to prepare the sample before the test by Conditioning.

The Conditioning process involves gentle displacement of the whole powder sample in order to loosen and slightly aerate the powder into an homogenised state.
Dynamic Testing - Standard Flow Pattern
Other FT4 Operating Modes

Axial compression (no rotation) – for consolidating the powder

Vented Compaction Piston
**Other FT4 Operating Modes (cont.)**

Rotation at controlled normal stress – for shearing the powder

- **Glass vessel containing powder**
- **Applied Force**
  - (Normal Stress, $\sigma$)
- **Rotation**
  - (Shear Stress, $\tau$)
- **Shear Cells**
- **Wall Friction**
Other FT4 Operating Modes (cont.)

Aeration – for introducing air into the bottom of the powder

![Diagram showing aeration test and permeability test](image)
FT4

BULK
- Density
- Compressibility
- Permeability

DYNAMIC FLOW
- Basic Flowability
- Aeration
- Consolidation
- Flow Rate
- Specific Energy

SHEAR
- Shear Cell
- Wall Friction

PROCESS
- Segregation
- Attrition
- Caking
- Electrostatics
- Moisture
- Agglomeration
Typical process cycle for tablet compression
GOOD
Uniform Filling, Low Porosity

POOR
Non-Uniform Filling, High Porosity

...leading to weight variation and capping and lamination
What Properties Restrict Filling of the Die?

- **High cohesion**
- **High mechanical friction & Interlocking**
- **Low permeability**

Cohesive forces >> mg
Non – Cohesive Powder

Cohesive Powder

AIR SUPPLY

OR
Non-Cohesive Powder

Air in

Cohesive Powder

Air in
Measuring Cohesion

Aeration Test – low value of Aerated Energy = low cohesion
Mechanical Interlocking & Friction

Specific Energy – low value equals low interlocking and friction
Permeability

Low Pressure Drop = high Permeability (entrained air can easily escape)

Normal Stress $\sigma$

$\Delta P$

$\Delta P$ (air pressure drop across powder bed)

INCREASING NORMAL STRESS, $\sigma$
### Table: Material and Powder Description

<table>
<thead>
<tr>
<th>Material</th>
<th>Material/Powder description</th>
<th>$D_{50}$ (µm)</th>
<th>Shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>GL Glass beads</td>
<td>174</td>
<td>Spherical</td>
</tr>
<tr>
<td>(b)</td>
<td>GS Glass beads</td>
<td>68</td>
<td>Spherical</td>
</tr>
<tr>
<td>(c)</td>
<td>Granular Aluminium powder</td>
<td>134</td>
<td>Irregular</td>
</tr>
<tr>
<td>(d)</td>
<td>Tungsten powder</td>
<td>4</td>
<td>Angular</td>
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</table>
**Filling Ratio**

*Ratio of actual mass in die compared to mass calculated from bulk density and volume of die*
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<td>0.29</td>
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<tr>
<td>Aeration Energy, AE (mJ)</td>
<td>&lt; 10</td>
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**Low Cohesion**

**High Cohesion**
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Lowest mechanical interlocking / friction

Highest mechanical interlocking / friction
➤ For efficient filling, require
  ➤ Low Cohesion (low Aerated Energy)
  ➤ Moderate to low mechanical interlocking (low Specific Energy)
  ➤ High permeability (low Air Pressure Drop)
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<td>Pressure Drop across the powder bed at 2mm/s air velocity, PD_{15} (mbar)</td>
<td>0.8</td>
<td><strong>5.2</strong></td>
<td>1.4</td>
<td>15.3</td>
</tr>
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