Particle Shape - Cubicity
Magnus Evertsson
Design of a Plant circuit

How do we get a cubical product from a Hydrocone crusher or a Merlin VSI?
Good shape fractions

- Rail-way Ballast 32-56(63) mm from secondary crusher
- Concrete fractions 8-16, 16-32 mm and sand
- Asphalt fractions 4(5)-8, 8-11, 11-16 and 16-22 mm.
- Most critical fraction to get cubical are the 4-8 or 5-8 mm and crushed concrete sand (machine sand)
Test norms

Test methods for determining cubical shape

- Europe
  - Shape index (SI) where $L/T > 3$
  - Flakiness Index (FI) $W/T$ where $W/T > 0.6$
- British Standard BS 812, Flake Index, the slot hole width is $3/5$ of the median dimension of the fraction.
- ASTM – Superpave $L/T > 5$
- Others, Russia, China, India etc
Feed materials

Rule of thumbs

- Higher Impact Work Index (WI) gives in H/C larger CSS
- Materials with coarse crystalline structure usually give better shape than fine crystalline material.
  - Coarse crystalline is for example Granite, Gneiss.
  - Fine crystalline is for example Basalt, Diabase
- Sedimentary rocks can be difficult to shape up due to the laminar structure in the material
  - Laminar structure in for example Slate, Sandstone
- Long feed fractions normally gives better shape
  - Top feed size $< 3/4$ of intake opening
  - In Merlin VSI 0-fraction increase the cubicity
- Contaminations reduce the possibility of produce good shape
Important guidelines H/C

To get cubical products from the Hydrocone
- The crusher should always be choke fed
- Surge Bin with feeder and the Surge Bin equipped with max/min level indicators. (min level indicator interlocked with the feeder).
- Max level indicator in the feed Hopper of the Hydrocone to be interlocked with the feeder.
- Long fraction (4-32 mm) gives high pressure in the crushing chamber and more interparticle crushing
- Max feed size \( \frac{3}{4} \) of intake
- Preferable reduction ratio 3.
- Smaller crushers give better shape in fine fractions

ASR
Important guidelines VSI

To get cubical products from the Merlin

- The crusher should always be even fed
  - Capacity, watch up for under feeding
  - Particle size distribution, well mixed
- 0 – fraction reduce impact crushing and increase abrasion breakage which increase cubicity
- Max feed size $\frac{3}{4}$ of intake
- Preferable By-Flow™ process.
- Can be used as fraction(s) upgrader
Particle Shape

Flakiness Index Fl [%]

Flakighetssindex Fl [%]

Particle Size [mm]
Cone Crushers
Effect of CSS and average feed size

Increased CSS

Increased Feed Size

Flakiness Index [%]

Fraction [mm]

Flakiness Index [%]

Fraction [mm]
Particle shape in fine aggregates

- Natural Gravel
- Cone Crusher
- VSI (High rotor speed)
- VSI (Low rotor speed)

Fraction [mm]:
- 0.063/0.125
- 0.125/0.25
- 0.25/0.5
- 0.5/1
- 2/4
F-Shape
Optical Microscope

+250-500 microns

Cone crusher  Natural gravel  VSI
F-Shape
Optical Microscope

+250-500 microns

Cone crusher  Natural gravel  VSI
No cubicity Plant

Production 0 – 16 mm

Deck 2
Sep 16 mm

Why?
Upgraded cubicity Plant

Production 0 – 16 mm

Deck 1
Sep 16 mm

Deck 2
Sep 25 mm

Why?
Cubicity Plant

Production 0 – 16 mm

Why? Alternative?
One example

<table>
<thead>
<tr>
<th>Feed (mm)</th>
<th>4 – 8 mm</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 – 32</td>
<td>15 %</td>
<td>MF, ecc 29 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ASR</td>
</tr>
<tr>
<td>32 – 63</td>
<td>31 %</td>
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<td></td>
<td></td>
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</tr>
</tbody>
</table>
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DYNO
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SANDVIK
Kornform i fin ballast
Reologitest

- Ursprung: New Zeeland standard 3111:1986
- Mätar massflöde
- Ett antal smala fraktioner är provade
\[ \dot{m} = C \cdot \rho_b \cdot \sqrt{g} \cdot (D - k \cdot d)^{5/2} \]
Jämförelse mellan reologitest och F-Shape


y = 3.2679x + 0.5151
R² = 0.9854

y = 5.8374x - 1.9421
R² = 0.9868