The Latest Developments in Iron Ore Processing

5 June

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Iron ore Processing
Introduction: Iron Ore Processing

- **Overview**
  - Suppliers, sources early days

- **Crushing Techniques**

- **Processing Options**
  - Coarse processing
  - Fines processing

- **Conclusions**
Overview

Largest Iron Suppliers

- Vale
- BHP
- Rio Tinto
- Kumba Iron ore
Iron Ore Sources

- Hematite \((\text{Fe}_2\text{O}_3)\)

- Magnetite \((\text{Fe}_3\text{O}_4)\)

- Titaniferous Magnetite \((\text{Fe}^{2+} (\text{Fe}^{3+}, \text{Ti})_2\text{O}_4)\)
Overview

Occurrence

- Massive
- Banded Iron Formation (BIF)
- Limonite
- Taconite
• **Main Use of Iron Ore**
  – Steel Industry

• **Iron Ore Processing in the Early Days**
  – Mine
  – Crush
  – Screen
  – Sell

• **Present**
  – Need Upgrading
Objective of Processing

• Preparation for smelting
  – SiO$_2$ <3%
  – Fe>63%
  – Al$_2$O$_3$ <3.5%
  – S and P content minimise

• Maximise recovery and yield
Iron Ore Crushing
Crushing Techniques

• Primary/Secondary Crushing
  – Jaw
  – Gyratory
  – Kawasaki

• Tertiary Crushing
  – Cone
  – High Pressure Grinding Roll (HPGR)
Cone Crushing vs. HPGR

- **Cone Crushing**
  - Minimise flakiness
  - Shape factor influences Jig/DMS performance

- **HPGR**
  - Better liberation in tertiary capacity
## Processing Options

<table>
<thead>
<tr>
<th>Hematite</th>
<th>Magnetite</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coarse (-32+8mm)</strong></td>
<td>DMS/Jigging</td>
</tr>
<tr>
<td><strong>Medium (-8+1mm)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Fine (-1mm+212 / 75(\mu)m)</strong></td>
<td>Spirals/TBS/WHIMS/Flotation</td>
</tr>
<tr>
<td><strong>Slimes (-212(\mu)m)</strong></td>
<td></td>
</tr>
</tbody>
</table>

- LIMS/Flotation
Jigging on Iron Ore
Jigging on Iron Ore

• Narrow size classes
  – -32+8mm
  – -8+3mm
  – -3+1mm

• Size and Density Separator

• Fines Jigs hard to control

• ‘Over the bed’ Jigs

• ‘Through the bed’ Jigs
  – Ragging

• Capacity
  – 85t/h per meter width of jig to max of 4m wide jig
Dense Media Separation on Iron Ore

DMS Drum

DMS Cyclone
Dense Media Separation on Iron Ore

Feed

Sinks

Overflow

Floats sieve bend
Dense Media Separation on Iron Ore

DMS Drum Sinks

DMS Drum Floats
Dense Media Separation on Iron Ore

• **DMS Drum**
  – Up to 4.6m diameter
  – Process 600t/h lumpy iron ore

• **DMS Cyclone**
  – Only -6mm material for iron ore
  – 360mm diameter cyclone
  – Process 40t/h per cyclone

• **Larcodems**
  – -90+6mm stones
  – 1.2m diameter
  – Operating capacity of 600-800t/h
  – Efficient separation at SG’s as high as 4.1g/cm³
• Cut SG of 3.6-3.8 g/cm$^3$
• Not considered at 4g/cm$^3$
  – Viscosity of FeSi
• Ferrosilicon
  – Water atomised
  – Gas atomised
• Maximise recovery and yield
Dense Media Separation on Iron Ore
DMS vs. Jigging

**DMS**
- High operating cost
- Efficient separation
  - Depends on bottom size
  - Near density material
  - Optimise yield and recovery
  - Lower tailings grades

**Jigging**
- Low operating cost
- Less efficient separation
  - Narrow size classes
  - Recovery losses
  - Higher tailings grades

**Density Separation**
- Small effect on size

**Size and density separation**
Results for the same product grade

<table>
<thead>
<tr>
<th></th>
<th>DMS</th>
<th>Jig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ep</td>
<td>0.07</td>
<td>0.144</td>
</tr>
<tr>
<td>D50</td>
<td>3.16</td>
<td>3.19</td>
</tr>
<tr>
<td>Yield</td>
<td>77%</td>
<td>70%</td>
</tr>
</tbody>
</table>

NB: Very dependent on feed size distribution
Fines Processing

Hematite
- -1mm + 212 / 75μm
  - Spirals and Teeter Bed Separator (TBS)
  - Wet High Intensity Magnetic Separation (WHIMS)
  - SLon Magnetic Separation
- -212 / 75μm
  - WHIMS
  - SLon
  - Flotation

Magnetite
- -1mm + 212 / 75μm
  - Wet Low Intensity Magnetic Separation (LIMS)
  - TBS
- -212 / 75μm
  - LIMS
  - TBS
  - Flotation
• **Mostly water flushed spirals**
  – SC20FE
  – 1.5t/h

• **High capacity spirals**
  – Reduce footprint of plant
  – Deeper troughs
  – Wider
  – 4-7t/h
Teeter Bed Separation (TBS)
Teeter Bed Separation (TBS)

- Fluidised bed

- Part of spiral circuit
  - Final cleaning of concentrates

- Feed preparation for spiral circuit on coarse material
  - -3mm particles are too coarse for spirals

- BIF as a two pass system
Wet High Intensity Magnetic Separation (WHIMS)
• **Magnetic susceptibility**  
  – Difference has to be large

• **Not recommended**  
  – Paramagnetic gangue minerals are present

• **Effective on slimes**  
  – Much finer sizes than 212μm

• **Capacity of 120t/h**
SLon

- High gradient magnetic separator (HGMS)

- **Combined force field**
  - Magnetism
  - Pulsating fluid
  - Gravity

- **China and Peru**

- **Separating fine hematite and magnetite**

- **Capacity of 120t/h**
Flotation

• Main purpose to add additional recovery

• Reverse/Direct flotation

• Taconite
  – Part of magnetic separation circuit
  – Selective flocculation
  – Fine grinding, pellitisation
Typical Magnetite Processing Circuit

Crushing

HPGR

"212" micron

Coarse LIMS max 5 passes

"75" micron

Fine LIMS max 5 passes

Fine TBS

MINTEK
Wet Low Intensity Magnetic Separator (LIMS)
Processing of Titaniferous Magnetite

• Mostly magnetic separation

• Performance of gravity separation affected by grind

• Possibility of producing a secondary ilmenite product???
Conclusions
Acknowledgements

Jeremy Bosman – University of Pretoria/ Pesco
Carl Bergmann - Mintek
Thank you

www.mintek.co.za