Troubleshooting and process improvements at Zincor

Jacolien Wyethe

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Contents

• Zincor’s position in the zinc industry
• Zincor’s history and its process
• Improvement projects/studies
  • TSL fuming
  • Recovery improvement with zinc oxide fume
  • Recovery from purification residues
• Troubleshooting at the roasters and acid plant
  • Breakthrough study
• Conclusion
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Global Smelter Slab Production (kt/a)

Source: Data from Brook Hunt
73% of Zn is produced at recoveries above 95%
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Zincor History

• 1965: GFSA closes Vogelstruisbult Gold Mine in Springs. Facility is temporarily converted to process uranium

• 1967: Zincor is established (65% GFSA; 35% Iscor)

• 1969, Apr: First ingot cast

• 1999, Feb: GFSA unbundles; Iscor acquires Zincor

• 2001, Nov: Iscor unbundles; mining division of Iscor, including Zincor, is consolidated into a new entity – Kumba Resources

• 2002-2006: Anglo American acquires controlling stake in Kumba Resources

• 2006, Nov: Kumba Resources is unbundled; iron ore business is separated to form Kumba Iron Ore Company; remaining assets and Eyesizwe Coal are consolidated into a new entity - Exxaro Resources. Zincor is now a division of Exxaro Base Metals

Exxaro Base Metals: 100% Zincor, 26% Black Mt and Gamsberg; 50.1% of Rosh Pinah; minor shareholding in Chifeng Smelter in China

GFSA: Gold Fields of South Africa; Iscor: now ArcelorMittal South Africa
Zincor’s role in South Africa

• Zincor is the only primary zinc producer in South Africa

• Slab zinc production of approximately 100 kt/a with inherent capacity up to 115 kt/a
  • Galvanising, alloy production, batteries and chemicals
  • Focus on customer requirement i.t.o. alloys and size

• Sulphuric acid production of approximately 170 kt/a.
  • Fertilizers, chemical processes
Revenue = f((Recovery – 85%); Production cost; TC; Premiums)
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TSL fuming technology

KPI focus

- Zinc sales
  - Zn tonnes
  - * Zn price
- Acid sales
- By-product sales
- Production cost
- Raw materials
- Stock movement
- Other
- Fixed & variable costs
  - - Free Zn
  - - Treatment charge (TC)
- Recovery
  - - 85% of LME

- Zn fed into Zincor
  - * Recovery

- Concentrate
  - * Roaster uptime
  - + ZnO (bypass roaster)

Consolidate back-end of operation
Reduce current environmental liability over time
Zero solid residue operation
TSL fuming technology
Integration in the Zincor circuit

ZnS

Acid Plant

WAB, H₂SO₄

NL

TSL FUMER

Scrubbing & decomposition circuit

Pb/Ag Sulphates

Slag / Cu Speiss

Purification

Eiectrowinning

Mg bleed

Other soln effluents

ETP

ETP residue

Residue dams

Capex ~R1.9B
Neg. business case
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Zinc recovery

Average Zn recovery ~ 90.4%, i.e. Zn loss ~106 kg/tonne Zn produced

- **Fe (insol)** 33%
- **Fe (sol)** 15%
- **Pb/Ag (sol)** 12%
- **Pb/Ag (insol)** 9%
- **Other** 30%

Handling, Cu- Co- Cd-cakes, WAB, Mg bleed, Spillages

Jan-06 to May-07
Zinc recovery
Fe removal circuit

- Residue - jarosite, schwertmannite & ferrihydrite
- Residue typically contains around 35% Fe and 10 - 11% Zn
Zinc oxide

KPI focus

Operating income

Turnover

Zinc sales

Acid sales

By-product sales

Production cost

Raw materials

Stock movement

Other

Zn tonnes

* Zn price

Zn production

- Zn stock movement

Zn fed into Zincor

* Recovery

Concentrate

* Roaster uptime

+ ZnO (bypass roaster)

Fixed & variable costs

- Free Zn

- Treatment charge (TC)

Recovery

- 85% of LME

Cost of sales

Raw materials

Stock movement

Other
**Zinc oxide**

Fumed ZnO for Fe removal

Fumed zinc oxide for iron removal stage.

<table>
<thead>
<tr>
<th>Element</th>
<th>Unit</th>
<th>Calcine</th>
<th>DRC ZnO*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zn</td>
<td>% (w/w)</td>
<td>57</td>
<td>69</td>
</tr>
<tr>
<td>Pb</td>
<td>% (w/w)</td>
<td>2.8</td>
<td>9.3</td>
</tr>
<tr>
<td>Fe</td>
<td>% (w/w)</td>
<td>6.2</td>
<td>0.4</td>
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<tr>
<td>Cl</td>
<td>g/t</td>
<td>&lt;10</td>
<td>280</td>
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<tr>
<td>F</td>
<td>g/t</td>
<td>&lt;100</td>
<td>370</td>
</tr>
</tbody>
</table>

* Fumed oxides from Democratic Republic of Congo
Zinc recovery
Fumed ZnO for Fe removal

Zn losses, kg/t slab

Zn from ZnO for neutralisation

Jan-06 Mar-06 May-06 Jul-06 Sep-06 Nov-06 Jan-07 Mar-07 May-07 Jul-07 Sep-07 Nov-07 Jan-08 Mar-08 May-08 Jul-08 Sep-08 Nov-08 Jan-09 Mar-09

Zn losses
Zn from ZnO for neutralisation

35 kg/t
18 kg/t
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Recovery from Purification residues

KPI focus

Turnover
- Zinc sales
  - Zn tonnes
    - * Zn price
  - Zn production
    - - Zn stock movement
- Zn fed into Zincor
  - * Recovery

Turnover
- Acid sales
- By-product sales
- Production cost
- Raw materials
- Stock movement
- Other
- Fixed & variable costs
  - - Free Zn
  - - Treatment charge (TC)
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  - - 85% of LME

Operating income
- Cost of sales
- Recovery from Purification residues
- Concentrate
  - * Roaster uptime
  - + ZnO (bypass roaster)
Recovery from Purification residues

Purification and byproduct circuits

Impure ZnSO₄ → Cu cementation

Zn dust → Cu/Co removal

As₂O₃ → Cu/Co removal

CuSO₄ → Cd removal

Purified soln to cell-house → Cu cement → Cu-Co-As

SALES
Recovery from Purification residues

Purification and byproduct circuits

Impure ZnSO₄

Cu cementation → CuSO₄ production

Cu/Co removal

Zn dust, As₂O₃

Cu-Co-As re-leach → Recycle Zn & Cd

Cd removal → Cd upgrading

Purified soln to cell-house, Upgraded Cd to storage

SALES

Cu cement, Upgraded Cu-Co-As

Recycle Zn & Cd
Recovery from Purification residues

Purification and byproduct circuits

Impure ZnSO$_4$ → Cu cementation → CuSO$_4$ production

Zn dust → Cu/Co removal → Cu-Co-As re-leach

As$_2$O$_3$ → Cd removal → Cd upgrading

Purified soln to cell-house → Upgraded Cd to storage

Recycle Zn & Cd

SALES

Cu cement

Upgraded Cu-Co-As
Recovery Improvement Projects - Summary

- **Zn Oxides (Phase I)** (0.95%)
- **By-products (Phase I)** (0.54%)
- **Mg Bleed to RTP** (0.74%)
- **BZS in Fe removal** (0.45%)
- **Penstock return water** (0.64%)
- **RIP** (1.51%)

Yearly recovery improvements:
- 2007: 90.4%
- 2008: 91.4%
- 2009: 92%
- 2009: 92.7%
- 2009: 93.3%
- 2009: 93.8%
- 2010: 95.3%

**Insoluble losses**
Recovery Improvement Projects - Summary

- **Zn Oxides (0.95%)**
  - 2007: 90.4%
  - 2009: 92%
  - 2010: 93.2%
  - 2012: 93.8%

- **By-products (Phase I) (0.54%)**
  - 2007: 91.4%
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  - 2010: 93.8%

- **Mg Bleed to RTP (0.74%)**
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- **Penstock return water (0.64%)**
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- **BZS in Fe removal (0.45%)**
  - 2007: 91.4%
  - 2009: 92%
  - 2010: 93.3%

- **RIP (1.51%)**
  - 2007: 90.4%
  - 2009: 92%

**Soluble losses & recovery from penstock**

- **95.3%**
  - 2009: 95.3%
Recovery Improvement Projects - Summary

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Recovery (%)

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Soluble losses
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Acid Plant Breakthrough

KPI focus

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Operating income

Turnover

Cost of sales
Roaster throughput below the required target.

Issues:
Equipment availability
Frozen beds

Roaster Uptime (%) - 2008

<table>
<thead>
<tr>
<th>Month</th>
<th>Actual</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan-08</td>
<td>83.9%</td>
<td>92.0%</td>
</tr>
<tr>
<td>Feb-08</td>
<td>65.2%</td>
<td>81.9%</td>
</tr>
<tr>
<td>Mar-08</td>
<td>77.7%</td>
<td>89.8%</td>
</tr>
<tr>
<td>Apr-08</td>
<td>73.9%</td>
<td>91.0%</td>
</tr>
<tr>
<td>May-08</td>
<td>58.7%</td>
<td>91.0%</td>
</tr>
<tr>
<td>Jun-08</td>
<td>80.8%</td>
<td>87.0%</td>
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<tr>
<td>Jul-08</td>
<td>57.4%</td>
<td>68.0%</td>
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<tr>
<td>Aug-08</td>
<td>45.9%</td>
<td>60.0%</td>
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<td>Sep-08</td>
<td>27.8%</td>
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<td>Oct-08</td>
<td>51.1%</td>
<td>73.0%</td>
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<td>Nov-08</td>
<td>61.9%</td>
<td>86.0%</td>
</tr>
<tr>
<td>Dec-08</td>
<td>72.1%</td>
<td>83.0%</td>
</tr>
</tbody>
</table>
Acid Plant Breakthrough

Roaster bed failure
Acid Plant Breakthrough
Harvest and generate ideas

120+ ideas captured during various brainstorming sessions

- First line operational management
- Shift bosses and section leaders (x3)
- Shift workers (x4)
- Specialist team
- Senior maintenance team
- Maintenance team (x2)
- Middle management maintenance team (x2)

Fundamentals of operation
- Plant uptime
  - Maintenance
  - Capital projects
  - Critical spares

People related matters
### QEMSCAN of concentrate

<table>
<thead>
<tr>
<th>Mineral Name</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Background</td>
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<tr>
<td>Sphalerite</td>
<td>87.60</td>
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<tr>
<td>Zincite</td>
<td>0.08</td>
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<tr>
<td>Galena</td>
<td>0.29</td>
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<tr>
<td>Alabandite(MnS+MnS2))</td>
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</tr>
<tr>
<td>Pyrite</td>
<td>2.87</td>
</tr>
<tr>
<td>Pyrrhotite</td>
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<tr>
<td>Chalcopyrite</td>
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</tr>
<tr>
<td>Rutile/Leucox</td>
<td>0.01</td>
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<tr>
<td>Arsenopyrite</td>
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<tr>
<td>Alunite</td>
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<td>'Sulphosalts'</td>
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<tr>
<td>Other sulphides</td>
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<tr>
<td>Barite</td>
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<tr>
<td>Quartz</td>
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<tr>
<td>Celsian(Ba-feldspar)</td>
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<td>K-feldspar</td>
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<td>Ba-K-feldspar</td>
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<td>Muscovite</td>
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<tr>
<td>Ba-Mica (Phlogopite)</td>
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<td>Chlorite</td>
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<tr>
<td>Mica</td>
<td>0.10</td>
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<tr>
<td>Dolomite</td>
<td>4.66</td>
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<tr>
<td>Calcite</td>
<td>0.55</td>
</tr>
<tr>
<td>Apatite</td>
<td>0.08</td>
</tr>
<tr>
<td>Ba-Ca-carbonate</td>
<td>0.02</td>
</tr>
<tr>
<td>Ba-carbonate(Witherite_Norsethite)</td>
<td>0.06</td>
</tr>
<tr>
<td>Anhydrite/Gypsum</td>
<td>0.00</td>
</tr>
<tr>
<td>Other carbonates</td>
<td>0.10</td>
</tr>
<tr>
<td>Fe-oxides/hydroxides</td>
<td>0.04</td>
</tr>
<tr>
<td>Others</td>
<td>0.08</td>
</tr>
<tr>
<td>Amphibole-2-Rim</td>
<td>0.00</td>
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</tbody>
</table>
Fundamentals of operation

Hypothesis – growth of roaster bed particles

790°C  \( \text{CaMg(CO}_3\text{)}_2 \rightarrow \text{CaCO}_3 + \text{MgO} + \text{CO}_2 \)

\( >940°C \)  \( \text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2 \)

\( \text{CaO} + \text{SO}_3 \rightarrow \text{CaSO}_4 \)

\( \text{ZnO} + \text{CaSO}_4 + \text{SiO}_2 \rightarrow \text{Ca}_2\text{ZnSi}_2\text{O}_7 \)

Hypothesis to prevent formation of \( \text{Ca}_2\text{ZnSi}_2\text{O}_7 \):

• Prevent \( \text{CaSO}_4 \) and \( \text{CaO} \) from forming by maintaining operating temperature below 940°C
Fundamentals of operation

Evaluation of hypothesis

Control operating temperature between 890 and 910°C

Improved bed gradings without affecting roasting efficiency
Acid Plant Breakthrough

The Proof...

Fundamentals
Maintenance
People management

Roaster Uptime (%) - 2008

Roaster Uptime (%) - 2009

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<td></td>
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<thead>
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<td>Avg '08</td>
<td>62.6%</td>
<td>80.2%</td>
</tr>
<tr>
<td>Jan-09</td>
<td>62.5%</td>
<td>74.1%</td>
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<tr>
<td>Feb-09</td>
<td>85.1%</td>
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Acid plant breakthrough

- Breakthrough process focuses attention - improvements are often the result of increased focus.
- Ongoing tracking is critical to ensure implementation of ideas to eliminate risks and ensure sustainable results.

Process Improvements

- Zincor retain focus on customer requirements i.t.o. capacity and product mix
- Increase recovery to >95% at relatively low capital cost:
  - Neutralising agent for Fe removal
  - Zn recovery from purification residues
  - Recovery of soluble Zn from the existing circuit and Zn returned from slimes dams
- Increase revenue from by-product sales by increasing Cu and Co content in purification cementation products
Acknowledgements

• Zincor management and personnel
• Fumer project team
• Exxaro R&D
• Acid Plant breakthrough team

QUESTIONS?