Technical and Industrial Developments in Ferro-alloys in Southern Africa

Nic Barcza and Rodney Jones

INFACON XIV

KYIV, UKRAINE

1 June 2015
CONTENTS

• **FeCr** trends over past 40 years
  ➢ Technologies that impacted the FeCr industry in the past 40 years

• **FeMn** trends over the past 40 years
  ➢ Technologies that impacted the FeMn industry in the past 40 years

• **FeNi** trends over the past 40 years
  ➢ South Africa’s role in technology demand and supply internationally
  ➢ Conclusions: developments, challenges, sustainability and what lessons have been learnt?
South Africa’s Minerals sales (2013)

Total sales $30 billion

Source: Department of Mineral Resources, Directorate Mineral Economics
South Africa’s Ferrous ore sales (2013)

<table>
<thead>
<tr>
<th>COMMODITY</th>
<th>YEAR</th>
<th>PRODUCTION</th>
<th>LOCAL SALES</th>
<th>EXPORT SALES</th>
<th>TOTAL SALES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>kt</td>
<td>kt</td>
<td>R million</td>
<td>kt</td>
</tr>
<tr>
<td>CHROME ORE</td>
<td>2013</td>
<td>13 653</td>
<td>8 473</td>
<td>5 866</td>
<td>4 168</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>11 310</td>
<td>6 685</td>
<td>4 683</td>
<td>2 470</td>
</tr>
<tr>
<td>IRON ORE</td>
<td>2013</td>
<td>71 534</td>
<td>9 259</td>
<td>5 746</td>
<td>58 202</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>67 100</td>
<td>8 393</td>
<td>4 448</td>
<td>57 110</td>
</tr>
<tr>
<td>MANGANESE ORE</td>
<td>2013</td>
<td>11 056</td>
<td>3 425</td>
<td>1 569</td>
<td>7 631</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>8 943</td>
<td>1 445</td>
<td>1 135</td>
<td>7 498</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2013</td>
<td>96 243</td>
<td>21 157</td>
<td>13 181</td>
<td>70 001</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>87 373</td>
<td>16 524</td>
<td>9 133</td>
<td>67 094</td>
</tr>
</tbody>
</table>

Source: DMR, Directorate Mineral Economics

Total $9 Billion sales

(*Rand 10 = 1 US $)
South Africa’s FeCr and FeMn Ferro-alloy sales (2013)

<table>
<thead>
<tr>
<th>COMMODITY</th>
<th>YEAR</th>
<th>PRODUCTION</th>
<th>LOCAL SALES</th>
<th>EXPORT SALES</th>
<th>TOTAL SALES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>kt</td>
<td>kt</td>
<td>R million</td>
<td>kt</td>
</tr>
<tr>
<td>CHROMIUM ALLOYS</td>
<td>2013</td>
<td>3 219</td>
<td>360</td>
<td>2 983</td>
<td>3 162</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>3 063</td>
<td>443</td>
<td>3 402</td>
<td>3 188</td>
</tr>
<tr>
<td>MANGANESE ALLOYS</td>
<td>2013</td>
<td>681</td>
<td>58</td>
<td>496</td>
<td>551</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>706</td>
<td>33</td>
<td>263</td>
<td>556</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2013</td>
<td>3 900</td>
<td>418</td>
<td>3 479</td>
<td>3 713</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>3 852</td>
<td>533</td>
<td>4 104</td>
<td>3 834</td>
</tr>
</tbody>
</table>

*Source: DMR, Directorate Mineral Economics*

Total $3 Billion sales

(*Rand 10 = 1 US $)*
Chromite and FeCr growth trends over past 40 years

- Growth of RSA chromite FeCr production from 1970s to 2015 including growth in China, India and Kazakhstan.

- Historical and future trends in chrome ore supply from RSA (UG2 contribution) and demand

- Decline in FeCr production in Europe, Japan and North America

- Forecast of FeCr trends in next five to ten years
Global chromite resources

Source: United States Geological Survey (USGS), Bundesanstalt für Geowissenschaften (BGR), Heinz H. Pariser
Growth of chromite supply from 1950s
Diversity of chromite supply from 2005

Growth Rate 2005 - 2015: 4.8%
FeCr demand > 15% by China 2005 (6.1 Mt)

Average Growth Rate: 5.2% p.a.
FeCr demand > 55% by China 2014 (11.3 Mt)

Average Growth Rate: 6.7% p.a.
The growth in the FeCr industry since INFACON 1, 1974

South African FeCr growth

Chinese FeCr growth

South Africa’s Production Share

Large SAF

AOD

Furnstar

Sintered pellet

Furnstar

Conductive linings

DC Arc furnace

AC Brush arc

Output, in Mill t

Production Share South Africa, in %

Source: USGS; Heinz H. Pariser

South Africa G.R.: 6.5%

Total G.R.: 4.1%

31.5

Technologies that impacted the FeCr Industry in the past 40 years

- AOD in 1970s on charge chrome production from RSA in 1970s

- Development of large SAF furnaces for FeCr over 30MW in 1975

- Improvements in furnace control (Mintek Furnstar) increasing MW to over 40 MW 1980

- Sintered chrome ore pellet process (Outotec) increasing MW to over 50 MW 1990s

- Conductive SAF lining (carbon and graphite) allowing freeze line control with lower basicity ratio slags
Technologies that impacted the FeCr industry in the past 40 years

- DC arc furnace technology to smelt fines directly (Mintek/Samancor Cr) to over 60 MW 2000s and Kazchrome 4 x 72 MW furnace installation

- Sintered pellet furnace technology (Outotec/Outokumpu) to over 100MW 2012

- Refined Low to Medium Carbon FeCr alloys
60 MW DC arc FeCr smelting furnace
Middelburg Ferrochrome South Africa
4 x 72 MW DC arc FeCr smelting furnaces
Kazchrome, Kazakhstan
Preheated sintered chrome pellet FeCr smelting furnace technology up to 100 MW
GLPS AC Brush arc FeCr smelting technology
Arc flare from DC and AC electrodes
GLPS AC Brush arc FeCr smelting technology
FeCr technology transfer from Europe, Scandinavia, and the USA.
FeCr technology transfer from Europe, Scandinavia and from South Africa
FeMn Trends over the past 40 years

- Growth in RSA FeMn alloy production from 1970 to 2015 including other major producers

- Historical and future trends in manganese ore supply from RSA vs other regions and demand

- Forecast of FeMn production trends (recent developments (eg FeMn alloy project in Malaysia))
Mn ore reserves (570 Mt Mn contained)
Mn ore exports (26 Mt 2013)
FeMn alloy production (18 Mt)
Global Mn Ore & Mn Alloys Production

2001 - 2014

- Total Mn Alloys Production (HC FeMn + Ref FeMn + SiMn)
- Total Mn Ore Production (wet mt)

Source: IMnI

INTERNATIONAL MANGANESE INSTITUTE
Manganese ore and all alloy sales
(South Africa 630 kt 2004 to 2013)

Department of Mineral Resources
Technologies that impacted the FeMn Industry over 40 years

- Development of large SAF furnaces for FeMn over 30MW in 1970s
- Improvements in furnace control (Mintek Furnstar) increasing MW to over 40MW 1980
- Sintered manganese ore technology to improve furnace operation 1980/1990s
Technologies that impacted the FeMn Industry over 40 years

- Challenging developments in DC arc furnace technology to smelt FeMn (Samancor Manganese) 1980s

- Further improvements in furnace control increasing power up to 50 MW 1990s

- DC SAF Concept to increase SAF power to 75MW

- Challenging development to date on combustion induction furnace technology for FeMn alloys 2010s
Manganese ore and all alloy sales from RSA (New technologies)

- Fossil fuel induction furnace based smelting (e.g. AlloyStream, ESS)
- DC SAF Concept 75 MW
- Six electrode 63 MVA SAF
- 1970s & 80s Large SAF

Graph showing sales data from 2004 to 2013.
Manganese technologies to South Africa

Conductive linings

MCFeMn

SAF

SAF
Manganese technologies from South Africa
Manganese ore (and FeNi) smelting technologies for the future

(ESS Process)

“Energy saving Smelting”
Technologies that impacted the FeNi industry in the past 40 years

- Development of large EF furnaces for FeNi over 50 MW in 1990
- Improvements in furnace control (Hatch, SMS Siemag) increasing MW to over 90 MW 2010
- DC arc furnace technology to smelt fines directly (Mintek) to potentially > 80 MW 2000’s
- Hydro-pyro integration using MHP/NHP as feed to RKEF and DC AF processes
FeNi production (excluding NPI) 1970 - 2015

- RKEF FeNi Process
- Large FeNi EF’s 50 to 90 MW
- Hydro-pyro integration
  - MHP & NHP
  - FB DC AF 80 MW
- FeNi Production

© Heinz H. Panzer
FeNi alloy production (400 kt)
(NPI ~100 kt/a)
DC FeNi technologies from South Africa

Technology transfer
Pilot plant testwork
Ferronickel technology
(Mintek twin electrode DC arc furnace)

Copper-coolers
12 MW FeNi DC arc furnace (SUNP)
Copper-coolers for 12 MW DC arc FeNi furnace (SUNP)
Koniambo 2 x 80 MW DC FeNi furnaces
New Caledonia
South Africa's role in technology demand and supply internationally

- Furnace control for most ferro-alloy smelting processes
- Applications of advanced furnace technology in particular DC arc furnaces for FeCr and FeNi
- Applications to special ferro-alloys LCFeCr, Mn slag from dry cell batteries, FeNb, FeV others
- Extensive metallurgical testwork on smelting chromite and nickel laterite ores in support of feasibility studies and the implementation of FeCr up to 70 MW and FeNi up to 80 MW scales.
Relative operating resistances for FeMn, FeCr and FeNi furnaces for SAF and DC AF configurations
Conclusions:
Developments, challenges, sustainability and what lessons have been learnt?

- Driven by regional and market forces.
- Sustainability depends on longer term competitiveness.
- Raw material and energy availability and supply costs are critical factors.
- The global pattern is driven by regional developments and security of supply considerations but not necessarily by competitiveness.
Conclusions:
Developments, challenges, sustainability and what lessons have been learnt?

- Longer term sustainability shifts the balance to regional supply with sustainable competitive cost structure
- South Africa needs to recognise this and position itself accordingly
- Lessons learnt – INFACON XV
Thank you

Acknowledgements:- Heinz H. Pariser-
chrome and nickel data

1. Johannesburg
2. Lausanne
3. Tokyo
4. Rio de Janeiro
5. New Orleans
6. Cape Town
7. Trondheim
8. Beijing
9. Quebec City
10. Cape Town
11. New Delhi
12. Helsinki
13. Almaty
14. Kyiv
15. South Africa
16. ?