Working towards an increase in manganese ferroalloy production in South Africa - a research agenda

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Introduction
Background
Methodology
Results
Conclusion

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MINTEK (Established 1934)

Government-owned research council
Employs ~750 people (250 professionals)
Annual budget of ~R450m (£23.7m)
State : Corporate funding (50 : 50)

www.mintek.co.za/Pyromet/
Reijnders (2016) defined manganese as one of relatively rare metals (associated with steel-making):

‘geochemically relatively scarce (having an upper crustal abundance < ~0.025 (mass)%’

OR

‘subject to national stockpiling to prevent shortages in alloy’

12th most abundant element in Earth’s crust average concentration of 0.1 per cent

Concentrations in ore of commercial use geographically limited
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- geochemically relatively scarce (having an upper crustal abundance < ~0.025 (mass)%) OR
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12th most abundant element in Earth’s crust

average concentration of 0.1 per cent

Ores in ore of commercial use geographically limited
MANGANESE ORES IN SOUTH AFRICA

>75% of land-based Mn-deposit commercial use

Ore-body
Hotazel, Northern Cape Province

Harbour
Port Elizabeth, Eastern Cape Province
MANGANESE ALLOYS IN SOUTH AFRICA

1937 HCFeMn in blast furnace

1942 HCFeMn in electric submerged-arc furnace

SiMn:
Transalloys, Mogale Alloys

HCFeMn, refined FeMn:
Metalloys, Assmang
Ore production quadrupled

Alloy production stagnant
Market for both ore and alloys lies outside of the country.
We have the ore

We have the technology, knowledge and skills to produce the alloys

Why are we not upgrading the ore?
Identifying barriers faced by key role players in the SA manganese industry.

M.Eng. (in progress)

We have the ore

We have the technology, knowledge and skills to produce the alloys

Why are we not upgrading the ore?

Herman van Zyl
Rising cost of electricity 7x

Average SA price [cent / kWh]

760MVA
Installed capacity
3600 GWh/annum
High cost of transportation

Low productivity of labour

Weak market conditions
RESEARCH QUESTION

What should the research agenda be, from a multi-organisation perspective – South Africa Incorporated (SA Inc) – to best support the development of the manganese ferroalloy industry in South Africa in the medium- to long-term.

The intention was to identify research opportunities that will:
1) Support existing operations,
2) Work towards step-change technologies.
MANGANESE VALUE CHAIN

A1: Ore

A: Geology, mining, and beneficiation

Market A

B1: Primary alloy

B: Reduction

Market B

C1: Refined alloy

C: Refining

Market C

<table>
<thead>
<tr>
<th></th>
<th>%Mn</th>
<th>%Si</th>
<th>%C</th>
<th>%P</th>
<th>%S</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCFeMn</td>
<td>74 - 82</td>
<td>&lt; 1.2</td>
<td>7.5</td>
<td>&lt; 0.35</td>
<td>&lt; 0.05</td>
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<tr>
<td>SiMn</td>
<td>65 - 68</td>
<td>12.5 - 21</td>
<td>1.5 - 3</td>
<td>&lt; 0.2</td>
<td>&lt; 0.04</td>
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<tr>
<td>MCFeMn</td>
<td>80 - 85</td>
<td>0.35 - 1.5</td>
<td>1.5</td>
<td>&lt; 0.3</td>
<td>&lt; 0.02</td>
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</tbody>
</table>
## RESEARCH PHASES

### PHASE 1: Initial Identification

<table>
<thead>
<tr>
<th>Categories of research opportunities identified</th>
<th>Desktop study</th>
<th>Per category, research opportunities identified: (1) Improve existing, (2) Develop step-change technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge leaders identified</td>
<td></td>
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</table>

### PHASE 2: Further development

<table>
<thead>
<tr>
<th>Categories of research opportunities revised</th>
<th>Workshop at 2\textsuperscript{nd} School on Manganese Ferroalloy Production, SAIMM</th>
<th>Research opportunities prioritised</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per category, research opportunities revised: (1) Improve existing, (2) Develop step-change technology</td>
<td></td>
<td></td>
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</tbody>
</table>

### PHASE 3: Finalisation

<table>
<thead>
<tr>
<th>Final list of prioritised research opportunities</th>
<th>Validation</th>
</tr>
</thead>
</table>
WORKSHOP

- Geology
- Mining
- Beneficiation

- Geology
- Mining
- Beneficiation

- Improve EXISTING technologies

- Develop STEP CHANGE technologies

- Reduction

- Refining

- Refining

- Reduction
PRIORITIES

1. Geometallurgy and mineralogy including a database to utilise for ore blending or product design, and data for smelters.

2. Renewable energy for mines including solar photo-voltaic, wind and concentrated solar power.

3. Training and skills development along the value chain.

OTHER (highlights)

1. Pre-treatment at mines (pre-reduction, agglomeration) incl. Solar sinter.

2. Vertical integration of mining and smelting processes close to mine-site.

3. Tax benefit or other incentive for beneficiation or selling to local smelters.
PRIORITIES

1. Closed furnaces with stand-alone pre-heating units.
2. Recycling and reuse of waste products.
3. Use of alternative reductants.

OTHER (highlights)

1. Energy recovery from off-gas, slag and/or metal.
2. Improved refractory design for energy containment.
3. Technology to determine electrode tip position.
4. Alternative reduction technologies (less electricity).
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PRIORITIES

1. Market and technology research for new refined products.
2. Research on the use of slag as a cement extender.
3. Heat recovery from off-gas.

OTHER (highlights)

1. Product diversification (higher value products).
2. Ladle refining of SiMn by adding silicon (Si) and ferrosilicon (FeSi) fines to increase silicon content to approximately 30%.
3. Powdered SiMn to use as feed to electrolytic manganese dioxide (EMD) process.
4. Converter dust as alternative to electrolytic manganese.

Clean Ferroalloys
(Synergy two SAIMM Schools: 2nd Mn-ferroalloy, Clean Steel)
South Africa has a significant manganese resource and the intention to beneficiate it locally.

Challenges to overcome include cost of electricity, market conditions. Research agenda presented here identified potential research areas along the value-chain.

Next steps include:

2. Develop technology roadmap to execute research within MINTEK.
3. Identify research collaborators.
4. Source funding.