Beneficiation of an ilmenite waste stream containing undesirable levels of chromite

by

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Submitted in partial fulfilment of the requirements of the degree Master of Engineering in the Faculty of Engineering, Built Environment and Information Technology, University of Pretoria, Pretoria

April 2003
Role and responsibility of the author

Because this thesis relies on inputs of testwork done by others, the role and responsibilities of the author are discussed in detail below.

This work started when one of the managers from IHM Heavy Minerals asked me to compare the roasting behaviour of LSR with that of crude ilmenite (which was the material which IHM were familiar with). I conducted a brief literature survey and designed the test programme based on work conducted by Nell and Den Hoed on behalf of IHM Heavy Minerals in 1996 (as presented at the 1997 Heavy Minerals Conference). As the IHM Heavy Minerals plant was in the detail design phase and the industry was extremely secretive sourcing of material for test work was difficult. I had to share the small amount of material that was available with other projects that utilised the material for detail plant design test work.

Since I worked for IHM Heavy Minerals and was based in Pretoria the equipment available to me at Kumba R&D included the fluidised bed roaster (that could roast ilmenite samples of 40g or less); the Linn-type furnace that could roast larger samples; the Frantz barrier magnetic separator; a Readings laboratory scale magnetic separator and a Carpcro laboratory scale magnetic separator. To familiarise myself with the operation of the fluidised bed reactor and the Frantz separator I conducted tests on crude ilmenite myself (under the conditions reported). I physically preheated the reactor, placed samples in the glass tube, put the glass tube in the reactor, introduced the fluidising gas, observed during roasting, timed the process, removed the reactor from the furnace, cooled the sample, weighed it before and after roasting, logged the data into a log sheet, bagged, labelled and numbered the samples. I did not operate the Linn furnace myself but use of the furnace was demonstrated to me. I used the Frantz separator myself, splitting samples into fractions at different amperages.

Kumba R&D employed a technician (Jonathan Skosana) who was well trained on the operation of the equipment and he conducted the bulk of the remaining test work on the fluidised bed reactor and the Frantz. Although I was working on the Heavy Minerals Project at that stage (working on the detail design and pre-commissioning activities) I also had an office at the pilot plant where I spent several days a week whilst Jonathan did the test work. Jonathan borrowed the magnetic susceptibility meter from Geotron for the LSR test work. I did not use this specific meter myself but used the meter that was purchased by Kumba R&D at a later stage whilst conducting shift work (engineer on shift) during a roasting pilot plant campaign at Mintek at a later stage (not part of this thesis).

To conduct XRF, XRD and QEMSEM analyses specialised equipment were utilised and although I am familiar with XRF machines (as utilised by laboratories providing a service to steel and heavy minerals plants) I only interpreted the results from the datasets received from the various laboratories.

I wrote the paper and presented the results of this study at the Heavy Minerals Conference in 2001 (Gouws and Van Dyk 2001). At that stage I still assumed that nothing happened to the chromite during roasting. One of the conference attendees commented on the graph for roasted LSR and challenged that assumption. That was the origin of the second hypothesis. I contacted the University of Pretoria and discussed the matter with Prof Pistorius who was quite keen to investigate the matter with me. Both the professor and I investigated possible sources for clean chromite. The best option would have been to separate the chromite in the LSR from the ilmenite. Due to the low chromite concentrations in the LSR this option was impractical. I discussed the matter with the refractory supplier as well as the geologist on site. Prof Pistorius discussed the matter with the Geology Department at the University and they sourced the chromite rock from the UG1 deposit.

The roasting and magnetic separation test work was once again conducted by Jonathan Skosana. By this time it was easy to manage the execution of the test work even from a distance as I had established a relationship with the personnel at Kumba R&D. I updated the literature review over the whole period with an extensive survey in the last 12 months of the project while I was writing the thesis and trying to make sense of the test results. I performed all of the data analysis and interpretation. The conclusions and recommendations were my own.

From the above statements it is clear that I not only contributed to the work but was fully responsible for the research idea, development and execution of the experimental plan, data analysis and interpretation and recommendations made for application of the results and further studies.
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Table of contents

SUMMARY

ACKNOWLEDGEMENTS

ROLE AND RESPONSIBILITY OF THE AUTHOR

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

CHAPTER 1: INTRODUCTION

1.1 Idea of the thesis and motivation for the study

1.2 The research topic & hypothesis

1.3 Research design and methodology in general

1.4 Outline of chapters two to five of thesis

CHAPTER 2: LITERATURE REVIEW

2.1 Discussion of the TiO₂ pigment and titanium containing feed material industries

2.2 Exploitation of heavy minerals resources

2.3 Definition of crude ilmenite and its constituents

2.4 Beneficiation of crude ilmenite from Southern African East Coast deposits

2.5 Description of alternative flow sheets to beneficiate crude ilmenite from Southern African East Coast deposits

2.6 Description of the principles of magnetic beneficiation

2.7 Description of the principles in magnetization

2.8 Magnetic susceptibility of chromite

2.9 Mechanism of magnetic susceptibility changes in ilmenite

2.10 Definition of roasting

2.11 Phase chemical changes during oxidative roasting

3
The effect of \( pO_2 \) and temperature ...................................................................................... 32

2.12 Equipment ..................................................................................................................... 34
   2.12.1 Laboratory scale equipment .................................................................................. 34
   2.12.2 Full scale magnetic separators .......................................................................... 36
   2.12.3 Full scale roasting equipment ........................................................................... 37

2.13 Findings and conclusions ........................................................................................... 37

CHAPTER 3: RESEARCH DESIGN & METHODOLOGY ...................................................... 38

3.1 Formulation of hypotheses and overall experimental plan ........................................ 38
3.2 Sourcing and preparation of crude ilmenite and LSR .............................................. 39
3.3 Characterization of crude ilmenite, LSR and chromite in LSR ................................ 41
3.4 Determination of the optimum roasting conditions for LSR and comparison with crude ilmenite ........................................................................................................... 43
3.5 Preparation of fractionation curves for crude ilmenite and LSR before and after roasting at optimum roasting conditions ................................................................. 45
3.6 Sourcing and preparation of chromite ........................................................................ 47
3.7 Characterization of chromite ....................................................................................... 48
3.8 Determination of the impact of roasting, at conditions used to determine optimum roasting conditions for LSR, on the magnetic susceptibility of chromite ........................................... 48
3.9 Preparation of fractionation curves for chromite before and after roasting at optimum roasting conditions for LSR ................................................................. 49
3.10 Data capturing ............................................................................................................. 49

CHAPTER 4: RESULTS – PRESENTATION AND DISCUSSION ........................................ 50

4.1 Characterize crude ilmenite, LSR, chromite in LSR and UG 1 chromite before roasting. 50
   4.1.1 Presentation and discussion of results ................................................................ 50
   4.1.2 Concluding interpretation .................................................................................. 54

4.2 Characterization of crude ilmenite, LSR, chromite in LSR and UG 1 chromite after roasting ..................................................................................................................... 56
   4.2.1 Presentation and discussion of results ................................................................. 56
   4.2.2 Concluding interpretation ................................................................................... 63

4.3 Fractionation of crude ilmenite, LSR and UG 1 chromite before roasting ............ 65
   4.3.1 Presentation and discussion of results ................................................................. 65
   4.3.2 Concluding interpretation ................................................................................... 70

4.4 Fractionation of crude ilmenite, LSR and UG 1 chromite after roasting ............... 71
   4.4.1 Presentation and discussion of results ................................................................. 71
   4.4.2 Concluding interpretation ................................................................................... 72

4.5 Appendix 1: Method used to calculate the composition of the chromite from elemental EDX or WDS analysis ................................................................. 72
4.5.1 Assumptions ....................................................................................................................... 72
4.5.2 Calculations ........................................................................................................................ 73

CHAPTER 5: CONCLUSIONS & RECOMMENDATIONS .......................................................... 75
5.1 Summary of main findings .................................................................................................... 75
5.2 Results linked to literature and theory ................................................................................ 76
5.3 Gaps, anomalies and deviations in the data ......................................................................... 76
5.4 Recommendations ................................................................................................................ 77

LIST OF REFERENCES/BIBLIOGRAPHY ........................................................................... 79
# List of abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC</td>
<td>Alternating current</td>
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<tr>
<td>CPC</td>
<td>Central processing complex</td>
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<td>CSTR</td>
<td>Continuous stirred tank reactor</td>
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<tr>
<td>DC</td>
<td>Direct current</td>
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<tr>
<td>DIC</td>
<td>Dry ilmenite circuit</td>
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<tr>
<td>DMDS</td>
<td>Dry magnetic drum separation</td>
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<tr>
<td>EDX</td>
<td>Energy-dispersive X-ray analysis</td>
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<tr>
<td>HCP</td>
<td>Hexagonal closed packed</td>
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<tr>
<td>HGMS</td>
<td>High gauss magnetic separators</td>
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<tr>
<td>HIWMS</td>
<td>High intensity wet magnetic separators – also called WHIMS</td>
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<tr>
<td>HMC</td>
<td>Heavy mineral concentrate</td>
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<td>HSR</td>
<td>High susceptibility fraction</td>
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<tr>
<td>IA</td>
<td>Image analyzer</td>
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<tr>
<td>LIMS</td>
<td>Low intensity magnetic separators</td>
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<tr>
<td>LIWMS</td>
<td>Low intensity wet magnetic separators</td>
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<tr>
<td>LSR</td>
<td>Low susceptibility fraction</td>
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<tr>
<td>PFR</td>
<td>Plug flow reactor</td>
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<tr>
<td>PWP</td>
<td>Primary wet plant</td>
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<tr>
<td>QEM*SEM</td>
<td>Quantitative Evaluation of Materials by Scanning Electron Microscopy</td>
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<tr>
<td>URIC</td>
<td>Unroasted ilmenite circuit</td>
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<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
</tr>
<tr>
<td>ROM</td>
<td>Run-of-mine product</td>
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<tr>
<td>SEM</td>
<td>Scanning electron microscope</td>
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<tr>
<td>VHM</td>
<td>Valuable heavy mineral</td>
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<tr>
<td>WDS</td>
<td>Wavelength dispersive spectrometry</td>
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<tr>
<td>WHIMS</td>
<td>Wet high intensity magnetic separators – also called HIWMS</td>
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<tr>
<td>XRD</td>
<td>X-ray diffraction</td>
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<td>XRF</td>
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