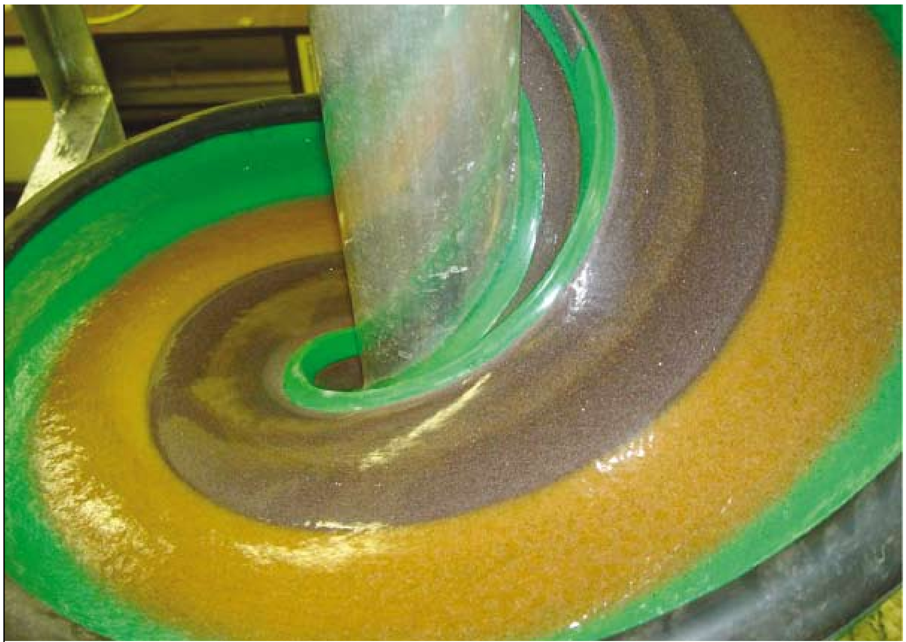
UNDERSTANDING METAL ACROSS THE SPECTRUM

Final-year undergraduate students in the Department of Materials Science and Metallurgical Engineering at the University of Pretoria complete a substantial research project as part of their degree programme. All projects are linked to specific local industries and require significant experimentation. Students complete these projects under the supervision of academic staff members. The projects span the spectrum of metallurgy, including minerals processing, hydrometallurgy, pyrometallurgy, and the processing and use of metals. Some of the projects delivered in 2005 provided some interesting research examples.

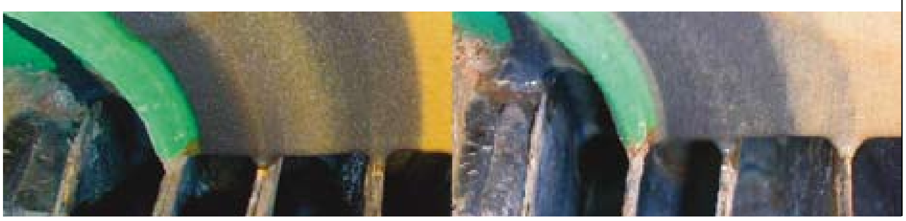


→ *1 A spiral concentrator in operation. The dark band is ilmenite – the valuable (denser) mineral that collects close to the axis of the helix as the material washes down its surface.*

Spiral concentrators separate mineral particles based on density differences. Each concentrator is a static, helically twisted trough of a metre or more in height. The feed material is transported in water and the minerals separate as the material flows down the helix. A single plant typically contains hundreds of helices, so it is impossible to adjust each individually. Separation is sensitive to the solid-to-liquid ratio in the feed, the proportion of dense minerals in the feed and the flow rate. If the feed grade changes (as it inevitably does), the same separation can be achieved by adjusting the feed to the spiral: hanging solid-to-liquid ratio, or flow rate, or both.

Geraldine Krebs (with lecturer Thys Vermaak and sponsor Kumba Resources) tested the effect of increased viscosity that can arise when the feed material contains fine, clay-like material. Geraldine found that separation is sensitive to increased viscosity, but remains sensitive to the solid-to-liquid ratio of the feed. Correcting for feed changes is feasible.

→ *2 The view from above: with a higher viscosity (right) the dark ilmenite band shifts much closer to the axis of the helix.*



Manganese efficiency

Manganese metal – an additive in various alloys – is produced through electrolysis. Existing processes use a sulphate-based electrolyte as the plating solution. Pieter Scholtz (with lecturer Dr Dick Groot, and input from MMC) studied possible advantages of using chloride-based solutions instead. Scholtz performed electrowinning of manganese from chloride solutions, varying the solution composition (manganese and ammonium chloride levels) and current density.

Electrowinning at high-current densities is possible. Values of three times more than those for the existing sulphate process were used successfully. The existing process has a current efficiency of some 65%. Combining high manganese and high ammonium chloride concentrations yielded current efficiencies of 80%, which have a substantial energy saving.

Clean steel

Clean steel contains very low levels of impurities. Small, ceramic inclusions (up to a few microns in diameter) can affect steel ductility and fatigue resistance. For steel to be 'clean', the inclusion content must be less than a few tens of parts per million of the steel mass. The inclusions can cause blockages of the ceramic tubes through which liquid steel flows. Treating liquid steel with calcium counteracts blockages. This highly reactive metal is injected into the steel by adding calcium oxide to the composition of the inclusions. This fluxes the inclusions, turning them into microscopic droplets of liquid, rather than small abrasive particles.

Rima Rampersadh (with lecturer Prof. Chris Pistorius and inputs from Japanese steelmaker and academic, Prof. Toshi Emi) studied the effectiveness of calcium treatment, as practised at the Vereeniging plant of Mittal Steel. Rampersadh sampled the steel at different stages of processing, examined the samples by electron microscope and found the compositions of the samples by microanalysis. A phase diagram determined whether the inclusions had been liquid or solid while the steel was being processed. The success of calcium treatment was evident and the inclusions were largely liquid, even after the steel picked up a small amount of oxygen from its surroundings.

Lighter tipper trailers

High-strength aluminium alloys give major mass savings in applications that include high-performance motor cars, aeroplanes and tipper trailers. Francois Vlok (with lecturer Prof. Waldo Stumpf) studied the abrasion resistance of a series of aluminium alloys from Hulett Aluminium (5083, 5182 and 6061 in different heat treatment conditions) used in manufacturing tipper trailers. These trailers require sheet and extruded material to be welded after manufacturing, and the alloys should have acceptable abrasion resistance in a 'load-haul-dump' application. The material hauled varies from soft to very hard. Therefore, the question to be answered is which alloys and tempers are best suited to high abrasion areas in such tipper applications.

A macroscopic groove or deep scratch can be produced in a single contact by the force between the abrading body and the wearing surface. A standard test (ASTM G65) was performed in which an abrasive (silica sand or coal) was fed between a rotating rubber wheel and the test piece. A hardened and tempered reference sample of En24 steel (a low-alloy steel), as prescribed by the ASTM test, was tested under identical conditions. The different aluminium alloys tested all have approximately the same wear resistance, even with a soft abrasive (coal). Consequently, wear resistance will not be the determining factor when choosing a suitable alloy for manufacturing a tipper truck. As the electron micrographs show, the main wear mechanisms were cutting and ploughing. There was no significant difference in the wear mechanisms between the 5XXX and 6XXX alloys. Silica sand caused more cutting wear than coal. It is estimated that an aluminium tipper may generate an extra income of R900 per day with the total cost of the aluminium tipper covered by the extra income in just over seven months.

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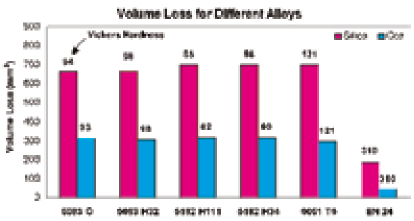
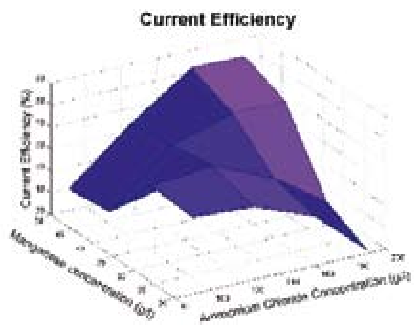
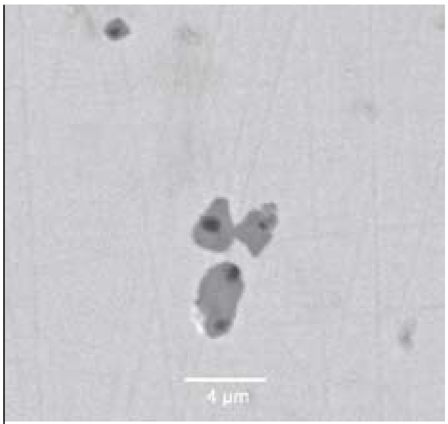
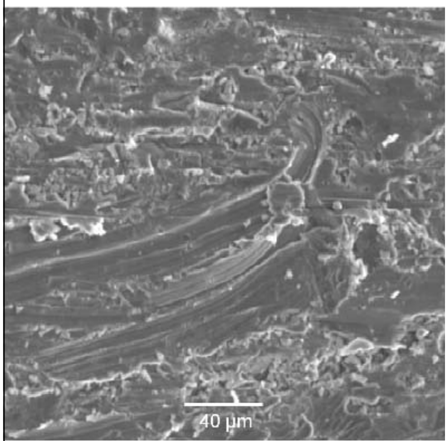




→ 3 High-current efficiencies are possible for electrowinning of manganese from chloride solutions, given the right choice of electrolyte composition (high manganese and high ammonium chloride).



→ 4 Microscopic inclusions (darker grey areas) in steel, found by examining polished cross-sections of steel samples in a scanning electron microscope



→ 5,6 Scanning electron micrographs of the surface of 6061 alloy surface after abrading with silica sand (above) and coal (below)