The application of flotation test work to plant design and operation

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Mintek Test Work 1987-1994

- Laboratory Test Work
- Pilot Plant Test Work
- Full scale plant operation
- Development of a scale-up procedure
- Introduction of Unit Cells on Mill discharge
- Modelling of the Flotation Process
- Development of a flotation simulator
- Development of the “Mintek 2-concentrate process”
Optimisation Methodology

- Establish a relationship with operations team
- Have monthly FIXCO meetings
- Conduct sampling campaigns
- Mineralogical analyses
- Fractional analysis
- Hot floats of pertinent streams
- Implementation and monitoring of agreed strategies
- Data analysis and feedback
Case Study 1

Effect of Pulp Rheology
Project Description

• Marula Platinum initiated project in conjunction with Metallicon Process Consulting to determine process bottlenecks and characterise plant performance

• Surveys identified rougher concentrate thickeners as operational bottlenecks

• Surveys also pointed to low cleaner efficiencies

• Second survey initiated to determine potential cause of low cleaner efficiencies

• Results from both reported here.
Process Description

- Nameplate capacity of 165 ktpm treating UG2 ore on Eastern Limb of Bushveld Complex

- MF2 type circuit (mill-float-mill-float) with two stage upfront crushing and SAG ball mills.

- Rougher concentrate thickened and attritioned (at SG >1.6) before density reduced (SG = 1.35 – 1.45) and fed to cleaner circuit.

- Cleaner circuit flexible to operate as 2/3/4 stage cleaners.
Process Flow Diagram

- Milling
- Rougher float
  - Thickener
  - Attritioners
  - Cleaner float
  - Re-cleaners (2/3 stage)
  - Final concentrate

- Tailings
- Dilution water
Preliminary Test Work

- Initial campaign very generalised and included hot batch floats in lab cell on major streams

- Initial campaign included mass balance sample campaigns, screening analyses and down the bank samples.

- Results from mass balance survey and routine plant data indicated high rougher efficiencies but poor cleaner efficiencies

- Data was confirmed by hot batch floats results.
Grade Recovery Curves
Rougher Conc

Rougher conc - grade recovery curve

Grade [g/t]

Recovery

[Graph showing grade recovery curves for rougher concentration]
Grade Recovery Curves

Attritioner Discharge

Attritioner discharge - grade recovery curve

After dilution - ie cleaner feed

Grade [g/t]  Recovery

0%  10%  20%  30%  40%  50%  60%

0  40  80  120  160  200
Discussion

• Three potential causes identified
  – Lack of reagents (specifically collectors) due to thickening and attritioning
  – Effect of “ageing” (or oxidisation) in thickeners (not confirmed)
  – Effect of increased density in cleaner feed compared to rougher concentrate.

• Reagent addition to cleaners increased significantly with no improvement noticed.

• Test work through hot floats and plant trials were initiated to evaluate density effect.
Effect of changing density

Primary thickener underflow - time recovery curve

Recovery

Time (min)

0 5 10 15 20 25

- 1.45 SG
- 1.36 SG
- 1.30 SG
- 1.20 SG
- 1.20 SG
- 1.10 SG

metanza

Metallicon

MINERAL PROCESSORS (PTY) LTD

PROCESS CONSULTING (PTY) LTD
Recovery Density relationship

Recovery after 7min vs solids concentration

% Recovery

Solids concentration

R² = 0.972
Case Study 2

Tackling the chromite problem in UG2 flotation
Characteristics of UG-2 Ore

• Major Source of PGM’s
• Two major gangue phases
  – Chromite (25% to 40%)
  – Siliceous gangue phase
• Specific gravity circa 3.8
• PGM’s occur in a variety of minerals
• Mode of occurrence of PGM’s varies
• Low base metal sulphide content
Challenges in Processing UG-2

• Mode of occurrence of PGM’s
• Two predominant gangue phases
  – Different physical properties
  – Different chemical properties
• Concentrate mass pull limitation
• Stringent chromite specification in concentrate grade to smelter
Typical Results on UG-2 ore

- Concentrate PGM+Au Grades
  - Range from 80 g/t to 350 g/t
- Concentrate Chromite Grades
  - Range from 2.5% to +6%
- Recoveries
  - Range from 75% to +90%
The grades in the industry

![Graph showing PGM+Au Grade vs Chromite Grade](image)
Various Strategies

• Reagent optimisation
• Circuit configuration
• Application of alternative technology
• Compromising recovery to meet specifications
Sub-Processes in Flotation

Froth Phase

Pulp Phase

Flotation

Drainage

Entrainment
Sub-processes in UG-2

• Flotation
  – PGM+Au (primary)
  – Copper and Nickel Sulphides (primary)
  – Siliceous Gangue (secondary)
  – Chromite (negligible)

• Entrainment
  – PGM+Au (secondary)
  – Copper and Nickel Sulphides (secondary)
  – Siliceous Gangue (primary)
  – Chromite (primary)
Strategy

• Maximise PGM+Au recovery through flotation
• Minimise chromite recovery through entrainment
• Judiciously add depressant to reduce silicates recovered by flotation
• …. without increasing chromite grade
Laboratory study
Laboratory Testwork

• Batch testwork in Denver D12 machine
• Grind : 80% -75 micron
• Reagents
  – Copper Sulphate
  – SIBX
  – Depressant (CMC)
  – Frother (Dow 200)
• Test parameters
  – Solids Concentration
  – Frother Concentration
  – Depressant Concentration
Effect of Solids Concentration on Solids Recovery

![Graph showing the effect of solids concentration on solids recovery for different ores with linear trend lines.

- X: Ore A
- ■: Ore B
- Linear line for Ore A
- Dashed line for Ore B]
Effect of Solids Concentration on PGM+Au Grade

![Graph showing the effect of solids concentration on PGM+Au grade for two different ores, A and B. The graph includes data points and linear lines for both ores.](image-url)
Effect of Frother Concentration on Solids Recovery

- Ore A
- Ore B

NB !!!!
Effect of Frother Concentration on PGM+Au Grade

![Graph showing the effect of frother concentration on PGM+Au grade for two different ores, with linear fits for each.]

- Ore A
- Ore B
- Linear (Ore B)
- Linear (Ore A)
Effect of Depressant Concentration on Solids Recovery

![Graph showing the effect of depressant concentration on solids recovery for two ores, A and B. The graph includes linear regression lines for each ore.]
Effect of Depressant Dosage on PGM+Au Grade

![Graph showing the effect of depressant dosage on PGM+Au grade for ores A and B. The graph illustrates a linear relationship between depressant dosage and PGM+Au grade for each ore type.]
Effect of Depressant on Chromite Grade

![Graph showing the effect of depressant dosage on Cr$_2$O$_3$ grade for Ore A and Ore B.]

**NB !!!!**
Observations on Plants
Plant Observations

- Depressant is successful in improving PGM+Au grade
- Depressant may result in an increase in chromite grade
- Selection of depressant dosage points is important

- Frother and solids concentration have a significant effect on entrained solids to concentrate
Effect of High Depressant Dosage on Fast Floating Fraction

![Graph showing the effect of high depressant dosage on high grade concentrate. The graph plots PGM+Au Grade [g/t] against PGM+Au Recovery [%]. Three lines represent different depressant dosages: 500 g/t, 700 g/t, and 900 g/t. As the PGM+Au Grade increases, the recovery decreases for all dosages.][1]

[1]: https://example.com/graph.png
Application of findings
Successful reduction in final concentrate chromite grade

![Graph showing final Cr$_2$O$_3$ grade versus frother dosage for Western and Eastern Ore, with linear trends for both.]
Conclusions and Recommendations

• Chromite and PGM+Au grade targets can be successfully achieved through reagent optimisation

• Effect of solids and frother concentration on entrained mass is significant

• Increased depressant may result in an increase in chromite grade
  • Selection of depressant dosage points is important

• Optimisation of reagent suite by starting from scratch
  • Greater understanding of entrainment required
PGM+Au Grade

- Been able to increase grades from circa 100g/t to over 200g/t
- No decrease in PGM+Au recovery
- No increase in chromite grade
- Major reduction in tonnage to the smelter
Challenges

- Interrupting the comfort zone
- Lack of buy-in
- Inappropriate flotation cell sizing
- Skills shortage
- Unstable feed characteristics
- Poor plant control