

CHAPTER 6. IMPALA 60 litre CONTINUOUS CELL

6.1 Introduction

The challenge in trithiocarbonate collector usage is to get the collector in a phase or form that would make it possible to dose the chemical easily, and the dosing medium should be inert to the flotation system and if not inert, it should improve the chemicals' performance. An emulsion of TTC in SX-12 has been developed (proprietary, Philips Petroleum product). It is stable and unreactive to the salts. The next step was to evaluate this collector suite on a scale that more closely approached plant operational conditions.

6.2 Materials and methods

A continuous 60 litre cell with Merensky ore feed from a cyclone overflow was used. From previous batch floats it was decided to test selected collector suites on the continuous cell.

The following five collectors were tested on the cell. All were the respective sodium salts:

- SIBX/DTP mixture (STD currently used)
- iC_3 -TTC (10% active in water)
- iC_3 -TTC (35% active in solvent)
- iC_3 -TTC/Standard(1:1 on molar basis)
- iC_3 -TTC/DTP(3:1 on molar basis)

The standard activator, frother and depressant were used for the tests and are reported in Table 6.1.

Table 6.1. Chemical dosage levels with 60 litre cell

Dosing	Quantity
CuSO ₄ (1% solution)	60 g/ton
SIBX/DTP	60g/ton
KU-45 (depressant)	70g/ton
Cresylic acid (frother)	70 ml/min

All the other collectors were dosed to be equimolar to SIBX/DTP.

6.3 Experimental

A split stream from the cyclone overflow (Figure 6.1) was pumped via a splitter to the first conditioning tank of the 60 litre cell (Figure 6.2), to give a constant feed of 10l/min to the flotation system. The SG of the ore was measured and the chemical feed adjusted. The normal SG for the pulp is 1.4 and the solids percentage of the feed is 40%.

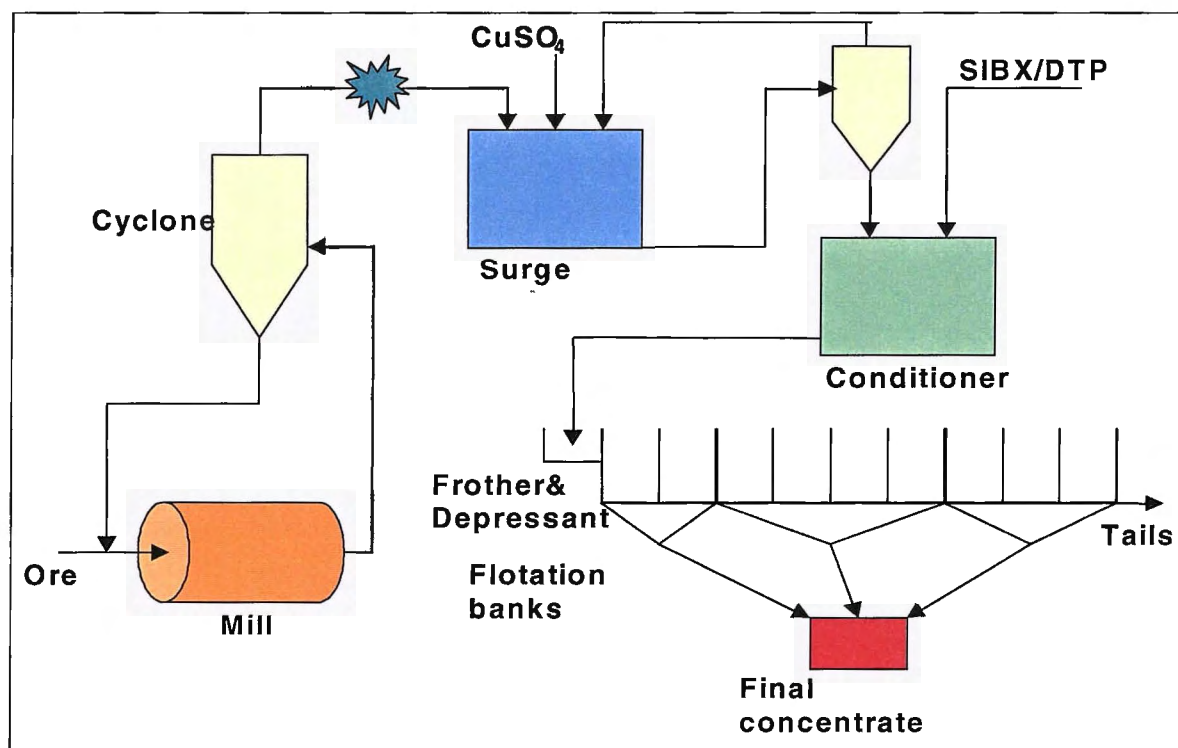


Figure 6.1. Flotation section at Impala Platinum

The CuSO_4 pump was started when the feed was pumped into the first conditioning tank (Figure 6.2). In the second tank, collectors were added and the frother and depressant dosed in the last conditioning tank. The latter tank was the feed for the flotation cell and feed was pumped at a constant rate of 10l/min. The system was allowed to run for at least an hour, until a steady state was reached. The flow to the cell was continuously measured. The air flow of the cell was then opened and samples of the concentrates were taken. These samples along with the feed and tails were then analysed for PGM, Cu, Ni and Cr_2O_3 . Three samples of each test were analysed and the standard deviation of the analyses was calculated.

The detailed operating procedure can be found in Appendix D.

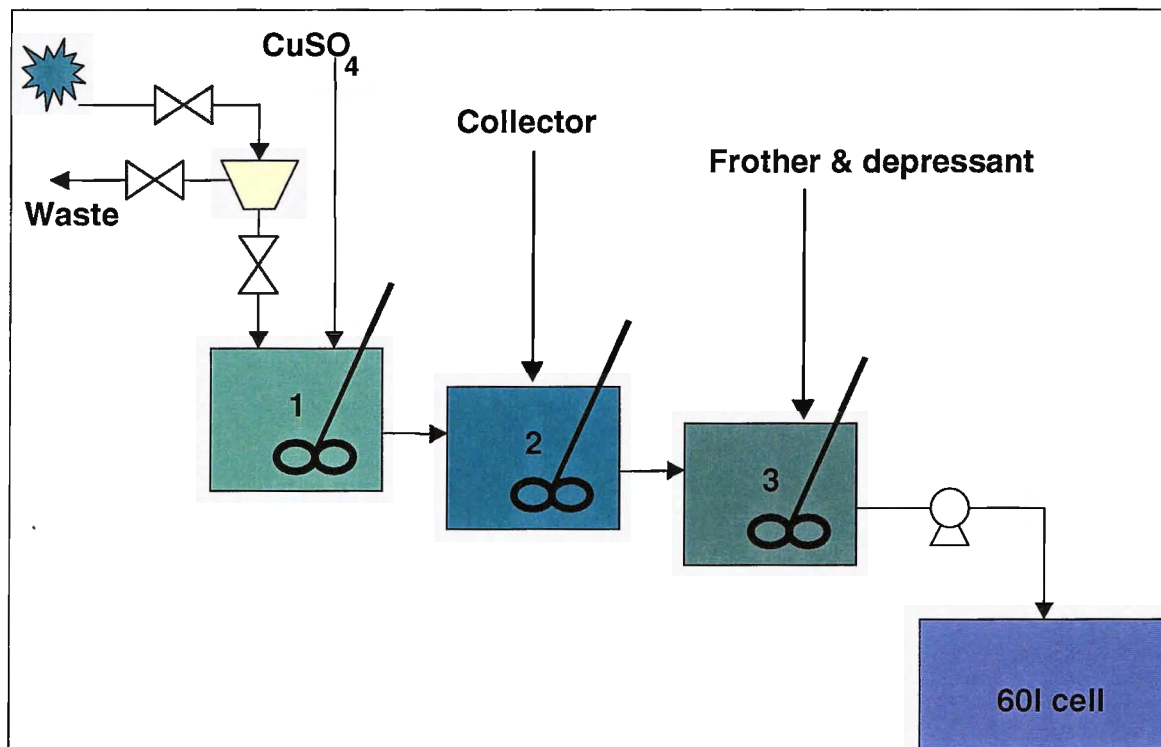


Figure 6.2. 60 litre cell at Impala Platinum

6.4 Results

The 60 litre cell was operated with a froth level of 7cm. Initial tests with the emulsion iC₃-TTC (35%) collectors showed that this froth level was too high for efficient mass pull. By trial and error the froth height was chosen at 6 cm. This resulted in a higher solids recovery but also reduced the grades of the concentrate. Combinations of the iC₃-TTC with SIBX and DTP were tested to verify any synergism between these chemicals.

6.4.1 Water and Solids Recovery

The solids and water recovery of these tests are indications of their frothing properties. Gangue entrainment is usually related to water recovery. Table 6.2 shows the effect of different chemicals on water and solids recovered.

Table 6.2 Water and Solids Recovery on 60 litre cell

Collector	Mass Solids	Water Rec.
	(%)	(%)
STD	7.89	39.7
iC ₃ -TTC (35%)	9.16	38.4
iC ₃ -TTC (H ₂ O)	5.92	27.2
iC ₃ -TTC/STD	0.74	3.37
iC ₃ -TTC/DTP	0.14	4.59

The highest mass recovery of all the collectors was with the iC₃-TTC (35% solvent) followed by the standard and then the iC₃-TTC (H₂O). From previous batch floats (Section 4) it was determined that the iC₃-TTC (H₂O) had the lowest mass pull. The SIBX/DTP mixture usually had the highest mass recovery in the batch floats. It could be that the continuous dosing of frother in the cell improved the frothing properties of iC₃-TTC (solvent).

Large water recovery is expected to result in large amounts of gangue entrainment, which would result in decreased grades. More water was recovered with the standard

collector and this would result in lower grades. There was a good correlation between water and solids recovered for the collectors tested.

Combinations of SIBX, DTP and iC₃-TTC showed low solids and water recoveries. This could be a result of insufficient froth phase. Possible solutions to this problem could be variations in CuSO₄ and frother dosages. DTP usually improves frothing, but in this case it proved the opposite. The low mass pulls resulted in high grades for the latter two tests.

6.4.2 Platinum Group Minerals

The consistent improvement of PGM recovery with iC₃-TTC relative to the standard collector suite was the main reason for further research on these chemicals. Various researchers (Steyn, 1997 and Slabbert, 1985) have observed these improvements.

Table 6.3 shows the results on PGM recoveries and grades.

Table 6.3 PGM recovery and grades on 60 litre cell

Collector	PGM		
	Grade	Rec	Stdev for rec
	(ppm)	(%)	
STD	62.69	77.91	0.51
iC ₃ -TTC (35%)	61.63	80.76	0.87
iC ₃ -TTC (H ₂ O)	78.58	75.34	0.07
iC ₃ -TTC/STD	128.65	24.36	0.11
iC ₃ -TTC/DTP	97.68	6.19	

The best collector was iC_3 -TTC (35%) with an almost 3% improvement over the standard collector suite with good repeatability on the analyses. The grades obtained with the first two collectors tested were almost identical.

Again the iC_3 -TTC, as a powder, produced higher grades than the first two collectors. The low mass pull of this collector (Table 6.2) reduced the overall recovery by this chemical and on recovery performed worse than the standard collector did.

Combinations of the standard collector suite and the iC_3 -TTC gave very high grades of PGM but low recoveries. This is a result of low solids recovery. The DTP mixture should have improved the frothing properties of the collector suite, but again the performance was poor.

6.4.3 Copper

Previous batch floats always indicated that the standard collector suite recovered more copper. Table 6.4 shows the copper recoveries and grades of Merensky ore obtained with the 60 litre continuous cell.

Table 6.4 Copper recovery and grades

Collector	Cu		
	Grade	Rec	Stdev
	(%)	(%)	
STD	1.69	82.87	0.43
iC ₃ -TTC (35%)	1.74	88.32	2.61
iC ₃ -TTC (H ₂ O)	2.59	86.00	2.77
iC ₃ -TTC/STD	3.50	39.40	0.22
iC ₃ -TTC/DTP	2.58	10.89	

The copper recovery has the same order as the PGM results. Copper and PGM recovery are usually the same on the 60 litre cell (Van Hoogstraten, 1998).

The iC₃-TTC, both in water and emulsion, gave higher total recoveries than the standard. This is contrary to previous batch tests. The larger cell and coarser grind could have improved chalcopyrite recovery. More coarse ore could increase copper recovery (Theron, 1998). The iC₃-TTC in water showed the best grade of the first three collectors. This had been recorded before. Combinations of DTP and iC₃-TTC again had high copper grades but low recovery (Steyn, 1997).

6.4.4 Nickel

Table 6.5 shows the results for nickel obtained on the 60 litre continuous cell.

Table 6.5 Nickel recovery and grades

Collector	Ni		
	Grade	Rec	Stdev
	(%)	(%)	
STD	2.39	70.17	0.76
iC ₃ -TTC (35%)	2.22	69.28	3.58
iC ₃ -TTC (H ₂ O)	3.65	68.98	1.25
iC ₃ -TTC/STD	3.11	12.64	0.19
iC ₃ -TTC/DTP	3.78	3.69	

All the collectors tested showed a similar final recovery for nickel. The iC₃-TTC in water showed better grades than the other collectors tested, but with almost the same final recovery.

When comparing the batch flotation data of the base metals, scaling up shows that there was good consistency between the performance of the Leeds batch and 60 litre cell floats with base metals, but the iC₃-TTC in water in batch cells at Biliton recovered more nickel than the standard collector suite.

6.4.5 Chromite

Chromite recovery needs to be minimised for better smelter performance. Table 6.6 shows the final chromite recoveries and grades.

Table 6.6 Chromite recovery and grades

Collector	Cr ₂ O ₃		
	Grade	Rec	Stdev
	(%)	(%)	
STD	0.58	2.91	0.20
IC ₃ -TTC (35%)	0.63	3.87	0.24
IC ₃ -TTC (H ₂ O)	0.40	2.13	0.05
IC ₃ -TTC/STD	0.53	0.32	0.00
iC ₃ -TTC/DTP	0.42	0.06	

The iC₃-TTC in water caused low chromite recovery, but in suspension the TTC caused high chromite recovery. The hydrophobicity of the suspension and the high water recovery of this collector could also increase chromite recovery.

6.4.6 Size distribution of feed

The 60 litre cell ran continuously on the flotation section of the plant. The inconsistency of ore feed from the plant also affected the feed to the cell which could have influenced the overall recovery of precious minerals and metals.

Various samples of the feed were screened to determine the size distributions of the tests performed. Figure 6.3 shows the ore size distributions for the three collectors tested.

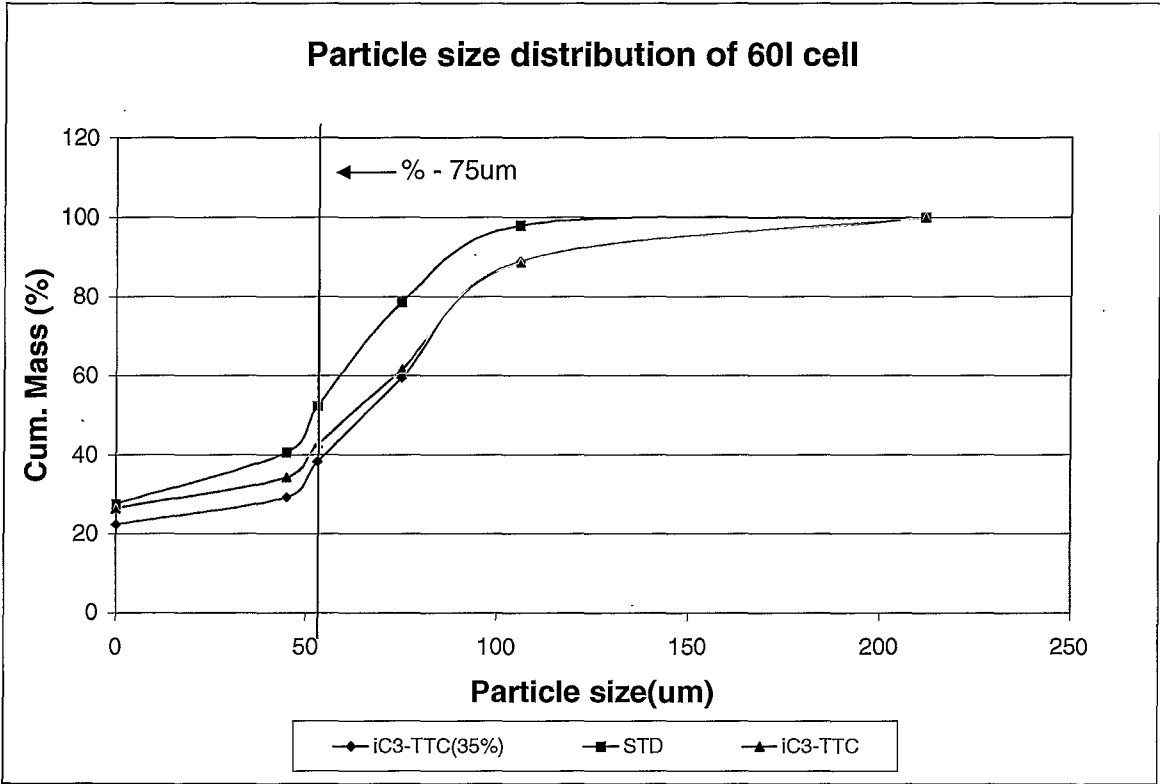


Figure 6.3 Size distribution of feed to the 60 litre cell

The ideal situation would be to do all the tests on the same grind, but since these tests were done online there was no control over the feed. The grinding of the three tests was not consistent and the screening of the feed samples was done in triplicate.

The rule of thumb is that the finer grind has the higher recovery potential if the feed grades are constant. The feed grades (PGM) and the grinding for the three tests are as follows:

Table 6.7 Size range for the 60 litre continuous cell

Collector	Grade	Size range
STD	3.56 ppm	52% -75µm
iC ₃ -TTC(10% in water)	4.40 ppm	43% -75µm
iC ₃ -TTC(35% in SX12)	3.45 ppm	38% -75µm

From this one can see that the that the TTC in the solvent was superior to the standard collector suite as indicated by the increase in PGM recovery even with a more coarse grind. The head grade for the solvent sample was slightly lower than that for the standard collector.

6.5 Conclusions

Batch floats conducted by the author and previous researchers showed that the iC₃-TTC collector was better than the standard collector suite (SIBX/DTP). These results needed confirmation on a larger scale. The tests on the 60 litre cell were performed as a final test for the iC₃-TTC collectors before plant trials. Tables 6.2 – 6.5 show the results from these tests.

The successful collectors tested were the iC₃-TTC in water and a solvent (emulsion). PGM recovery significantly increased with iC₃-TTC in solvent. Higher grades were observed with the iC₃-TTC in water. Low mass pull of the combinations of SIBX/DTP/ iC₃-TTC resulted in high grades and low recoveries. Variations in the CuSO₄ and frother dosages could have been part of this problem.

The iC_3 -TTC in water as well as in solvent showed improvement of final recoveries with copper. Again the iC_3 -TTC in water showed a higher grade, and the high mass pull of the collector in solvent resulted in a better final recovery.

Nickel results were almost the same for all collectors tested. The iC_3 -TTC in the solvent showed a higher recovery of chromite. This could result from heavy froth and entrainment in the froth phase.

The coarser grind for the TTC in the solvent sample would have affected the recovery, but this collector still improved on the standard. The three percent increase in PGM recovery achieved is even more significant in view of the coarser grind.