OPTIMISATION OF CONDITIONS FOR MUFULIRA RECLAIMED ORE

BY

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OPTIMISATION OF CONDITIONS FOR MUFULIRA RECLAIMED ORE

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PROJECT REPORT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF THE BACHELOR OF MIENRAL SCIENCES (B.Min.Sc) DEGREE OF THE UNIVERSITY OF ZAMBIA

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SUMMARY

The project was conducted at Mufulira Concentrator of Zambia Consolidated Copper Mines Limited (ZCCM).

This concentrator treats sulphide ores whose copper mineralogy is mainly, bornite, chalcocite and chalcopyrite. *Presently this concentrator is treating a mixture of fresh* and reclaimed ores. Approximately about 20 000t per day of ore are currently treated at which about 7% was reclaimed ore as from November 1992. With this practice, it was observed that nuch of copper was lost to the tailings.

Reclaimed ore is the ore that was originally considered to be treated because it was a lowgrade material. This material was therefore, left underground in stopes in preference for high grade material.

The project was, therefore, aimed at optimising the flotation conditions for reclaimed ore in comparison to the existing conditions for gresh ore. It was further aimed at finding the best blending proportions of fresh and reclaimed ores.

A grind of 56% - 75μm, a pH range of 10-11 and a collector dosage rate of 20g/t/10g/t (SIPX/PAX) were found to be optimum.

The blending proportion of 20% reclaimed ore and 80% fresh ore was found to be optimum.

EXAMINERS

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DR. S. SIMUKANGA

INTERNAL EXAMINER: 19-12-94

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EXTERNAL EXAMINER: 19/12/94

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DEDICATION

Dedicated to Mum and Dad, brothers and sisters and friends for their Love inspiration and encouragement during my period of study at University of Zambia.

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ABBREVIATIONS

Conc - Concentrate

Scav - Scavenger

Tails - Tailings

SIPX - Sodium isopropyl Xanthate

PAX - Potassium Amyl Xanthate

%TCu - Percent Total Copper

F:L - Free to Locked

R.A - Relative Abundance

Bn - Bornite

Cc - Chalcocite

Cp - Chalcopyrite

Py - Pyrite

MOG - Mesh - of - grind

CHAPTER 1

INTRODUCTION

This project was conducted from November 1993 to February 1994 at Mufulira Concentrator of ZCCM Ltd. The Mufulira Concentrator treats sulphide ores from two shafts; Mufulira East and Mufulira West. The mineralogy of the ore treated is mainly chalcopyrite, bornite, chalcocite and pyrite, with smaller amounts of covelite, malachite and native copper.

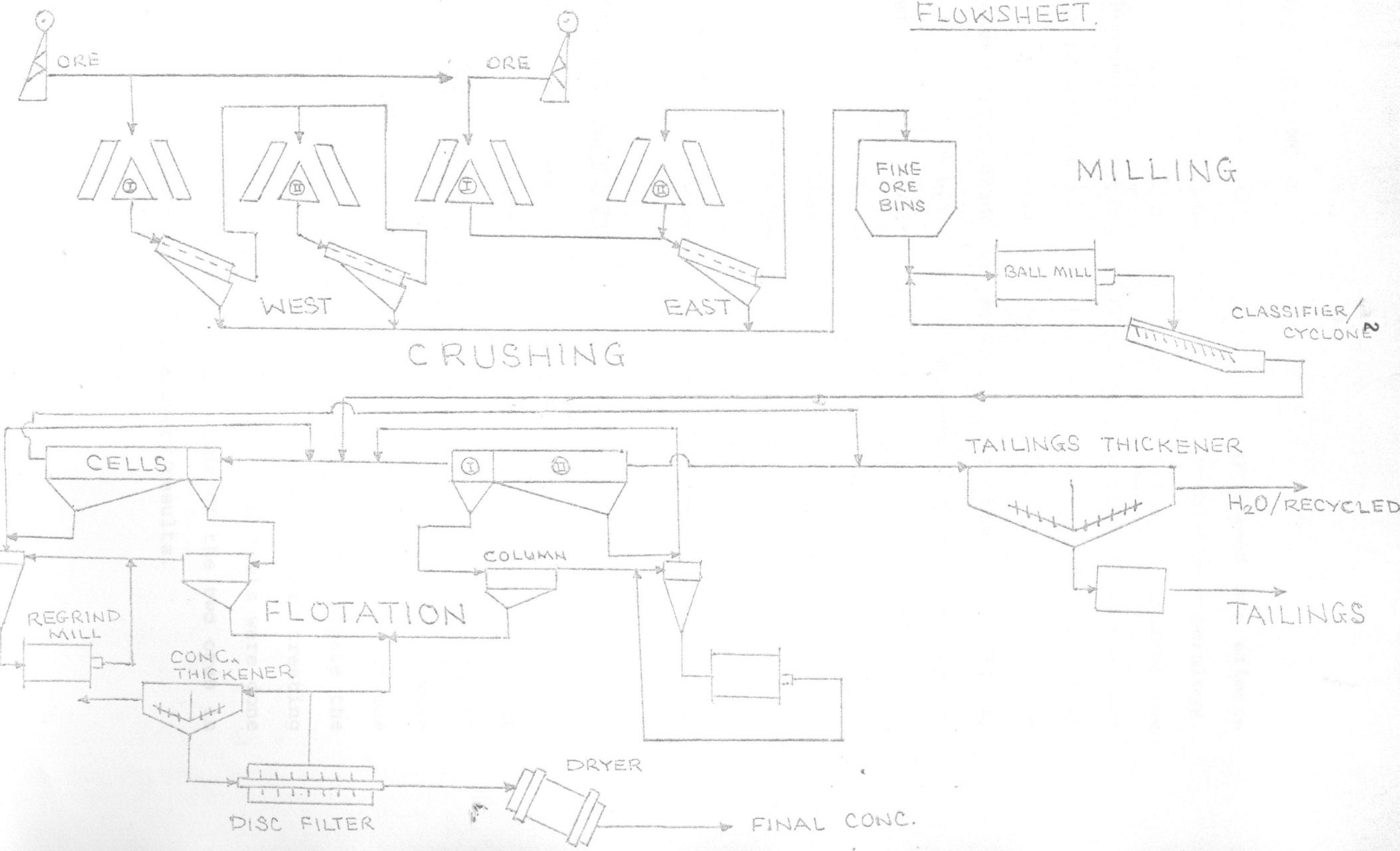
1.1 PROJECT BACKGROUND

In November 1992, Mufulira Concentrator started treating reclaimed ore. This is lowgrade copper ore which was originally considered uneconomical to be treated. Hence it was abandoned and left underground in stopes in preference for high grade material.

Currently Mufulira Concentrator is treating fresh ore along with sufficient fresh ore. The proportions of reclaimed ore treated were 4%, 17%, 25% and 25% for the months of May, June, July and October respectively and the average plant recoveries were 96.0%, 95.8% 95.9% and 95.4%TCu respectively.

Previous work had shown that reclaimed ore affects flotation efficiency. See figure 1 for the Mufulira Concentrator flowsheet.

Figure 1: MUFULIRA CONCENTRATOR FLOWSHEET.



1.2 PREVIOUS WORK

Previous work (1) had shown that reclaimed ore affects flotation efficiency due to its unfavourable mineralogy. For example, in December 1993, flotation performance was adversely affected by high proportions of reclaimed ore and low headgrades in the ore treated resulting in a recovery of 95.21%tCu against the target of 95.8%TCu. The concentrator grade at 46.60%TCu was above the official estimate of 45.50%TCu due to increased bornite/chalcopyrite ratio in the feed. Previous mineralogical investigations (2) have shown that talc levels were higher in the reclaimed ore than normal giving rise to voluminous flows on the rroughers and in column flotation. Tests to depress talc were done in the laboratory and depresants Depolyn C-100 and jaguar were found to be effective.

1.3 PROJECT OBJECTIVE

Due to the undesirable negative effect of reclaimed ore on flotation efficiency when treated alongside fresh ore, it had become imperative to invesigate the mineralogy of reclaimed ore. In addition, the flotation conditions were optimised and compared to the existing optimum conditions for fresh ore. Also tests were done to investigate the possibility of treating reclaimed separately. For treating a mixture of fresh ore and reclaimed ore, tests were done to determine the blending proportions of the two ores in order to get the best grade/recovery results.

CHAPTER 2

TEST WORK

2.1 SAMPLE COLLECTION AND PREPARATION

Samples of reclaimed and fresh ores were received from mining (underground). The samples of reclaimed and fresh ores were collected from different levels and blocks. The samples of reclaimed were then mixed into one composite. The samples of fresh ore were also collected and mixed into one composite for comparative purposes. The samples were all crushed to - 8# (2.4mm) and stored in 2Kg lots.

2.2 MINERALOGICAL EXAMINATION

Mineralogical analysis of reclaimed ore was carried out in order to identify the minerals present and compare with the mineralogy for fresh ore. This helps to determine their abundances, kind, degree of locking of various minerals in granular materials.(4) This in turn makes it possible to determine whether poor recoveries, lowgrade concentrates and other problems are caused by mineralogical factors or by processing factors.

A bulk sample of reclaimed ore with fresh ore was sent to ZCCM Technical services in Kalulushi for mineralogical analysis. A bulk sample of fresh ore was sent for comparative purposes.

Mineralogical data for reclaimed ore and fresh ore at their respective standard grinds were also obtained. Detailed mineralogical results are shown in tables 1, 2, 3 and 4.

2.3 TEST PARAMETERS

In this testwork, the parameter under consideration were; mesh-of-grind, pH, collector dosage rate and also the effect of Natts on the flotation of the sulphide minerals in reclaimed ore and its dosage optimisation. In addition, the effect of reclaimed ore on flotation of fresh ore, when the two ores are blended in different proportions, was investigated.

2.4 OPTIMISATION OF GRIND

The optimum mesh-of-grind is the particle size at which the most economic recovery can be obtained. During this testwork, the samples were ground at different times i.e 5, 10, 15 and 20 minutes. The ground samples were then dried in an oven and screened thereafter. The percent passing 75mm was obtained and plotted against grinding time. This gave a grind-time graph (see figure 2).

Other samples were then ground at different times to give different grinds and floated by a release analysis procedure (see figure 3 for the flowsheet). The flotated concentrates were then sent to Analytical services for %TCu analysis. It was from these data that the cumulative recovery against Wt% floated graph was obtained (see figure 4(a) and (b)).

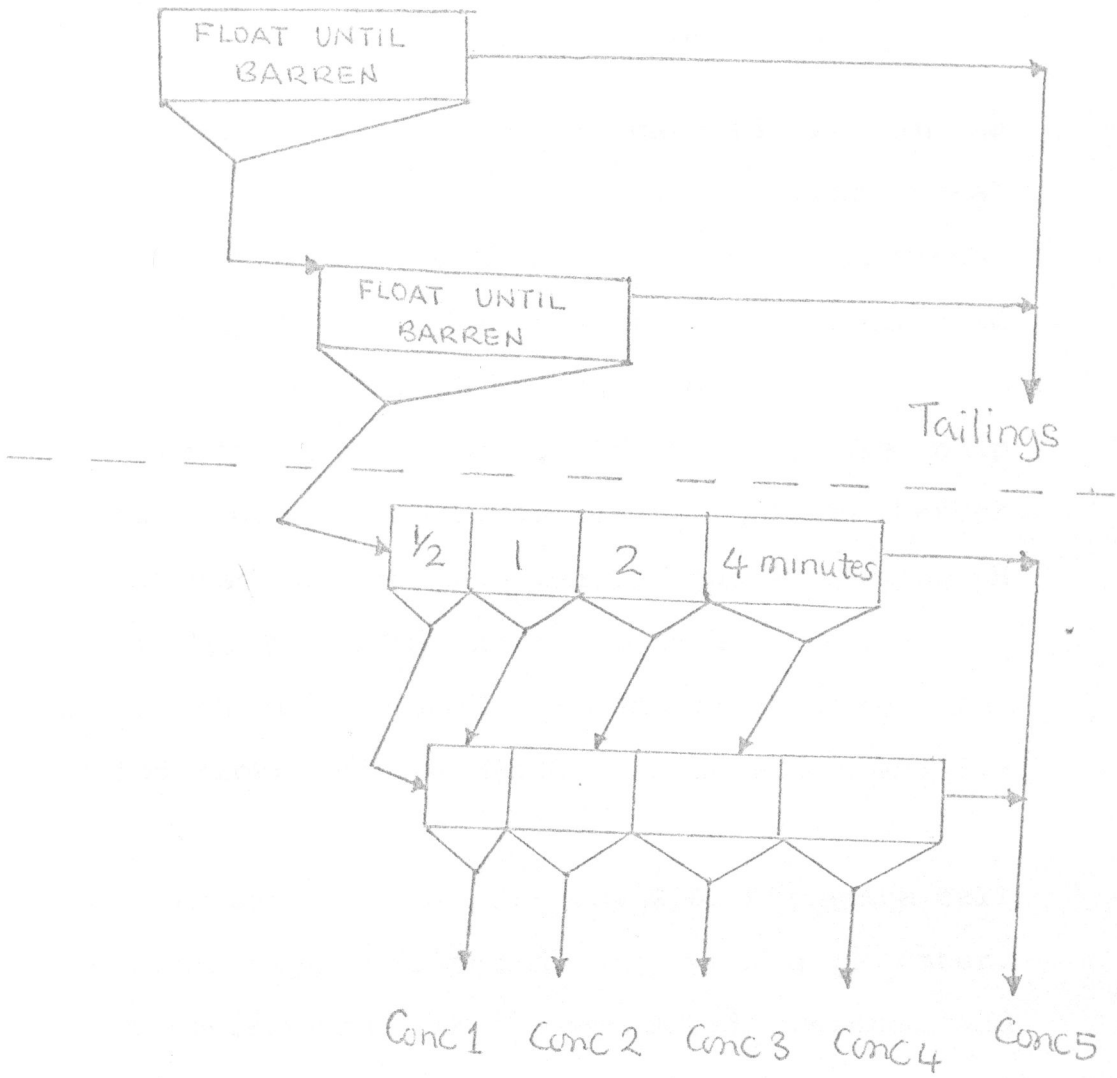


Figure 3 : Release Analysis Flowsheet

2.5 P^H OPTIMISATION

Flotation of sulphides is usually carried out in an alkaline medium as Xanthates, which are the usual collectors, are stable only under alkaline conditions. Alkalinity is cintrolled by lime additions. Sulphuric acid is used where a decrease in pH is required(5).

During this testwork lime was used to regulate pulp alkalinity in a bid to find the optimum pH for better recoveries. Flotation tests were carried out at various pH conditions namely, 8, 9, 10, 11, 12, 13 and
at the natural pH of both reclaimed and fresh ores. The natural pH for fresh and reclaimed ores were 8.1 and 7.9 respectively.

Milk-of-lime was added to the pulp in a 2.0l flotation cell and the pH level regulated accordingly with a pH meter. The flotated concentrates were then dried, weighed and taken for copper analysis at the Analytical serivices (see figure 6 for the results and figure 5 for the flowsheet). Table 5(a) and 5(b) show the pH optimisation results in detail.

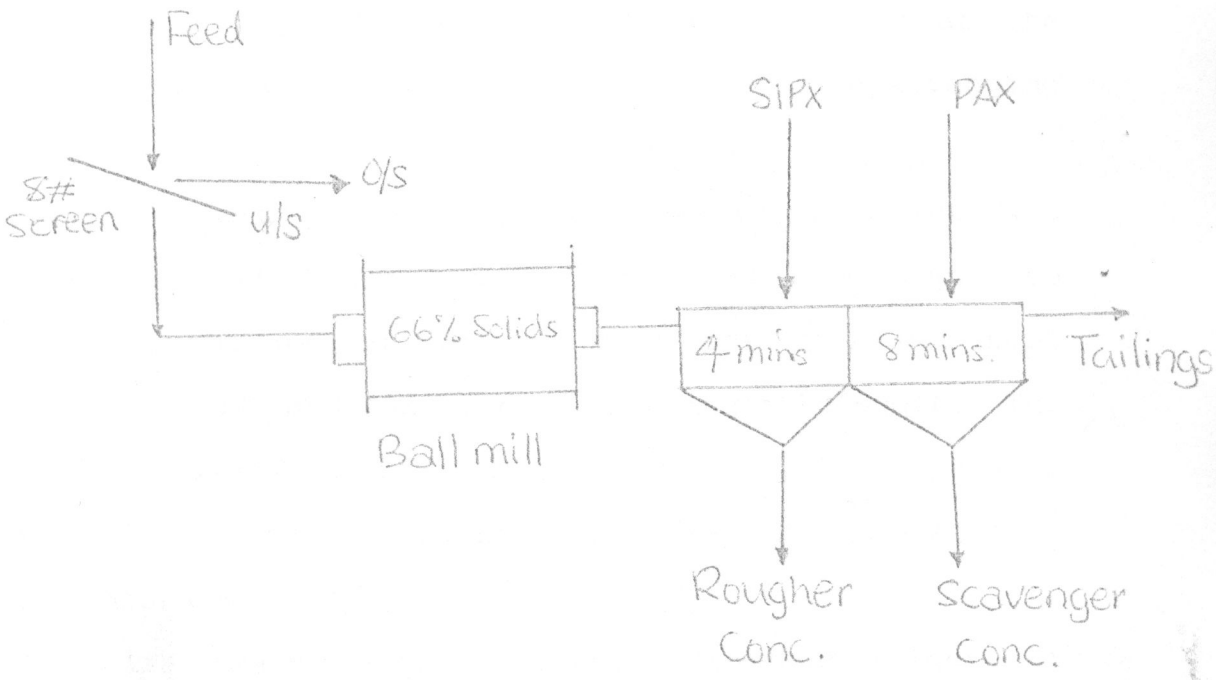


Figure 5: MUFULIRA CONCENTRATOR LABORATORY FLOWSHEET

2.6 OPTIMISATION OF COLLECTOR DOSAGE

Mufulira concentrator is using sodium isopropyl xanthate (SIPX) and potassium amyl xanthate (PAX) on its roughing and scarvenging stages respectively. In this testwork the same collector were used to optimise their dosage rate in the flotation of reclaimed ore. SIPX was added at the roughing stage while PAX was added at the scarvenging stage.

In the first part of the test, the dosage rate of PAX was kept constant at 30g/t and SIPX varried from 10g/t to 60g/t. In the second part of the test SIPX was kept constant at 20g/t and PAX varried from 10g/t to 60g/t. The frother used was Festanol D14. At each stage 2-3 drops of D14 was added. The conditioning time was 2 minutes at each flotation stage.

The Mufulira concentrator Laboratory flowsheet (figure 5) was used. The results are given in table 6 and are shown graphically in figure 7.

2.7 EFFECT OF NaHS

Due to the flotation process problems from the treatment of mainly reclaimed ore it was essential to evaluate the effect of NaHS and optimise its dosage rate. Therefore, Laboratory flotation tests were carried out to the flotability of the sulphide minerals contained in the reclaimed ore and to optimise its dosage rate. The results are as tabulated in table 7 under results

2.8 EFFECT OF BLENDING FRESH AND RECLAIMED ORE IN VARIOUS PROPORTIONS

Currently Mufulira Concentrator treats fresh ore along with reclaimed ore. Laboratory testwork was conducted on fresh and reclaimed ores mixed in various proportions. The quantities of reclaimed ore investigated varried from 0 to 100% reclaimed ore at increments of 20%. However, the proportions of reclaimed ore treated at Mufulira Concentrator were 4%, 17%, 25% and 25% for the months of May, June, July and October 1993 respectively and the average plant recoveries were 96.0%, 95.8%, 95.9% and 95.4%TCu respectively.

The objective of this investigative testwork was to evaluate the effect of the reclaimed ore on both recovery and concentrated grade and also to determine the blending ratio that gives the best copper recovery.

The Mufulira Laboratory ball mill handles 2Kg of ore at a time. Hence a percentage of this was taken as reclaimed ore and the other as fresh ore starting at 20% reclaimed ore at the increment of 20%. The mixture was then ground at the intermediate grind time. The grind time was increased towards the standard grind of reclaimed ore with the increase in the percentage of reclaimed ore treated. For example, at 100% fresh ore the grinding time was taken as 16 minutes (52%-75mm) while at 60% reclaimed ore, the grinding time was taken as 17 minutes (56%-75mm) which is the standard grind for reclaimed ore. The other flotation conditions were as the optimum flotation conditions for

reclaimed ore except for the 100% fresh ore.

To allow for the study of the flotation efficiency of both fresh and reclaimed ore and that of the blended ores, the Mufulira Concentrator Laboratory flowsheet was modified. A cleaning stage was included after the roughing stage. In this stage, the rougher concentrate was cleaned to collect three cleaner concentrates at 0.5, 1.0 and 1.5 minutes of cleaning. The modified flowsheet is as shown in figure 8 below.

The detailed laboratory flotation are presented in table 8 and depicted graphically in figures 9. 10. 11.

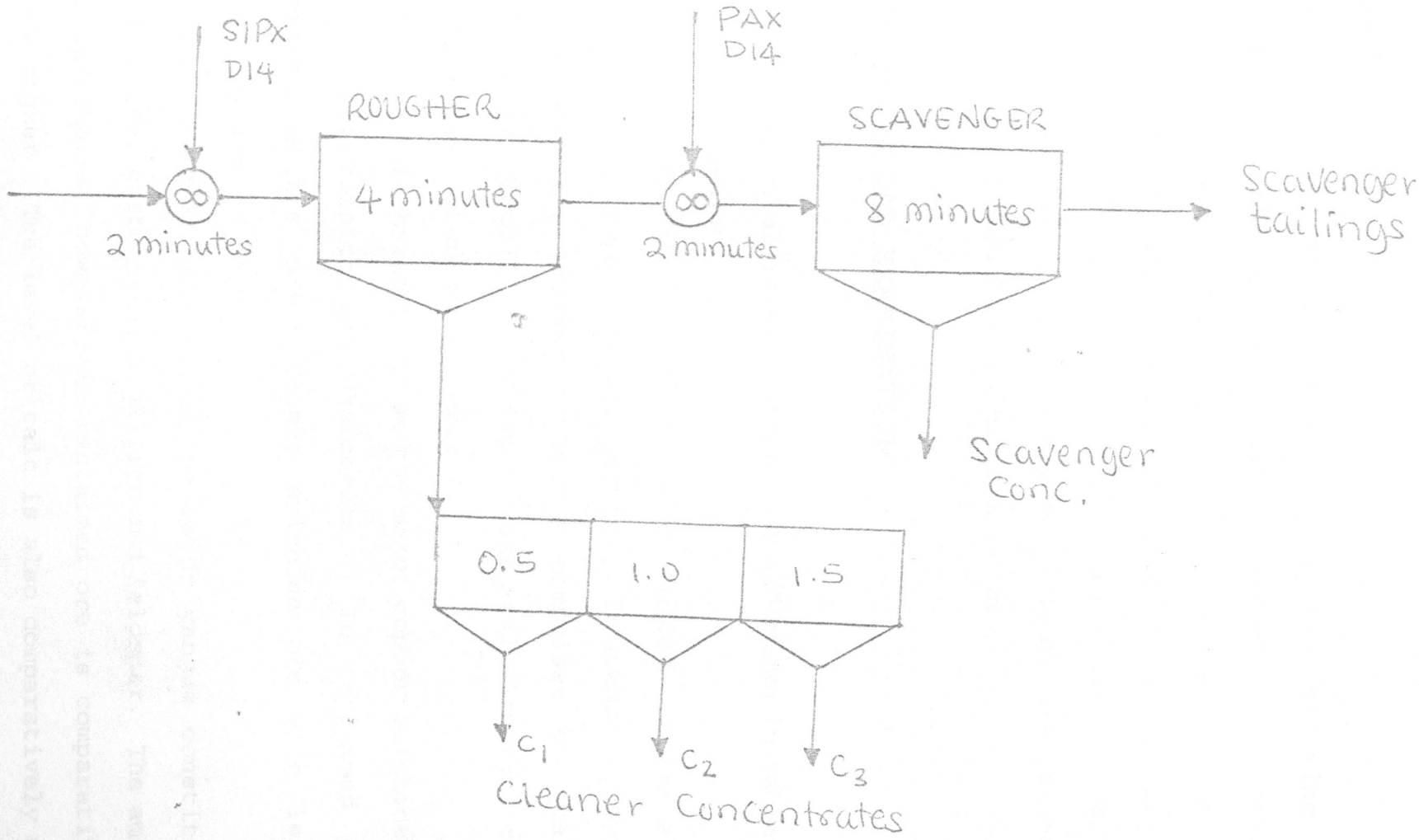


Figure 8: Laboratory Flowsheet used to investigate the effect of reclaimed ore on Mufulira fresh ore.

CHAPTER 3

RESULTS

The objective of the project was to determine the mineralogy, the optimum grind, optimum pH, optimum collector dosage rate, the effect of Natts on the flotability of sulphide minerals in reclaimed ore and the effect of the blending fresh and reclaimed ores in various proportions. The results of the above tests are presented in tables and depicted graphically below.

3.1 MINERALOGICAL EXAMINATION

The mineralogical investigation data are shown in tables 1, 2, 3 and 4 below.

Table 1 shows that the major copper sulphide minerals are chalcopyrite, chalcocite and bornite. In addition, pyrite and gangue are present. Gangue comprises of quartz, carbonates, argillite, feldspar, mica, talc, anhydrite and iron oxides, as shown in table 2.

Fresh ore has chalcopyrite as the major copper sulphide ore with less bornite and chalcocite. In reclaimed ore, bornite is the major copper sulphide ore with lesser chalcopyrite.

In both samples, quartz is the major gangue constituent with lesser carbonates, argillite and feldspar. The amount of carbonates, however, in reclaimed ore is comparatively much higher. The level of talc is also comparatively much higher in reclaimed ore. Table 2 shows that the liberation

of the copper sulphides is high in both samples. In fresh ore the sulphides are 89% to 95% free while in the reclaimed ore the liberation is between 89 and 93% free grains.

However, at the standard grinds the liberation of copper sulphides is 100% free all the sulphides were completely liberated in the 90mm fraction. For reclaimed ore the talc level also increases in the - 90mm fraction. The relative abundances (RA%) of talc in the -45um fraction is negligible. See tables 3 and 4 for the ore mineral data for reclaimed ore and fresh ore at their respective standard grinds.

Table 1: Mineralogical Data for fresh and reclaimed ores

Mineral	Fresh Ore			Reclaimed Ore		
	Wt%	%TCu	F;L	Wt%	%TCu	F;L
chalcopyrite	2.2	0.73	95:5	1.3	0.41	89:11
Bornite	1.6	1.01	89:11	1.4	0.95	92.8
Chalcocite	0.1	0.08	94:6	0.6	0.48	91:9
Pyrite	0.6	-	93:7	0.2	-	92:8
Gangue	95.5	-	-	96.5	-	-
Total	100.0	1.95		100.0	1.65	-

Table 2: Approximate Relative Abundance (RA) of gangue in fresh and reclaimed ores.

Gangue	% R A	
	Fresh Ore	Reclaimed Ore
Quartz	47 - 51	44 - 48
Carbonates	15 - 19	26 - 30
Argillite	14 - 18	16 - 20
Feldspar	12 - 16	5 - 9
Mica	< 1	<< 1
Talc	<< 1	~ 1
Anhydrite	2 - 4	<< 1
Iron		<< 1
oxides/Accessories	<< 1	<< 1
Total	100.00	100.0

N.B: The above results were based on the bulk samples of fresh and reclaimed ores ground at 15 minutes. (50%-75mm)

Table 3: Ore mineral Data for Reclaimed Ore at standard grind (56%-75mm)

Fraction (mm)	Wt %	%TCu	Cu Distrib %	Mineral Distribution				F:L				Talc
				Bn	Cp	Cc	Py	Bn	Cp	Cc	Py	R.A%
250	0.56	1.01	0.74	0.22	0.54	0.33	5.86	49:51	54:46	72:28	20:80	<1
150	7.58	0.87	5.88	4.09	5.52	6.64	11.79	86:14	82:18	93:7	89:11	<<1
125	8.23	0.95	5.87	5.49	7.38	6.65	11.79	92:8	95:5	93:7	91:9	<<1
106	7.20	1.14	5.87	6.15	7.38	3.33	<<0.01	99:1	96:4	97:3	100:0	<<1
90	9.63	1.31	6.63	8.18	7.32	9.47	11.77	99:1	99:1	99:1	100:0	<<1
75	9.37	1.36	9.57	10.24	11.03	6.63	11.77	100:0	100:0	100:0	100:0	<<1
45	15.43	1.69	20.59	22.55	22.12	9.97	23.52	100:0	100:0	100:0	100:0	1
-45	42.00	1.46	44.85	43.08	38.67	56.48	23.52	100:0	100:0	100:0	100:0	-
Total	100.00	1.36	100.0	100.0	100.0	100.0	100.0	-	-	-	-	-

Table 4: Ore mineral Data for fresh ore at standard grind (52%-75mm)

Fraction (mm)	Wt %	%TCu	Cu Distrb %	Mineral Distribution					F:L			Talc
				Bn	Cp	Cc	Py	Bn	Cp	Cc	Py	R.A %
250	0.88	1.11	0.40	0.37	0.50	<<0.01	6.25	34.66	68:32	0:100	58:42	<<1
150	10.45	1.12	4.76	4.85	5.03	-	25.00	80.20	94:6	-	98:2	<<1
125	8.85	1.48	5.16	4.85	6.53	<<0.01	12.50	96.4	98:2	100:0	98:2	<<1
106	7.35	1.94	5.55	5.22	7.54	<<0.01	6.25	97.3	99:1	100:0	100:0	<<1
90	8.06	2.35	7.54	8.21	7.54	<<0.01	12.50	99.1	99:1	100:0	100:0	<<1
75	9.22	2.48	9.13	10.08	9.04	-	6.25	100.0	100:0	-	100:0	1
45	14.37	3.44	20.24	13.81	21.11	<<0.01	6.25	100.0	100:0	100:0	100:0	1
-45	40.32	2.96	47.22	52.61	42.71	100.0	25.00	100.0	100:0	-	-	-
Total	100.0	2.52	100.00	100.0	100.0	100.0	100.0	-	-			-

3.2 OPTIMISATION OF GRIND

The optimum mesh-of-grind is the particle size at which the most economic recovery can be obtained. Figure 2 and 4 shows the results obtained during this test.

The graphs in figure 4 shows that the grinding times that gives 52%-75mm and 56%-75mm give the highest copper recoveries for fresh and reclaimed ore respectively.

This suggests that sulphide minerals in fresh ore are liberated at a coarser grind than in reclaimed ore.

Figure 4(a) Release Curves for mesh-of-grind determination for Reclaimed ore.

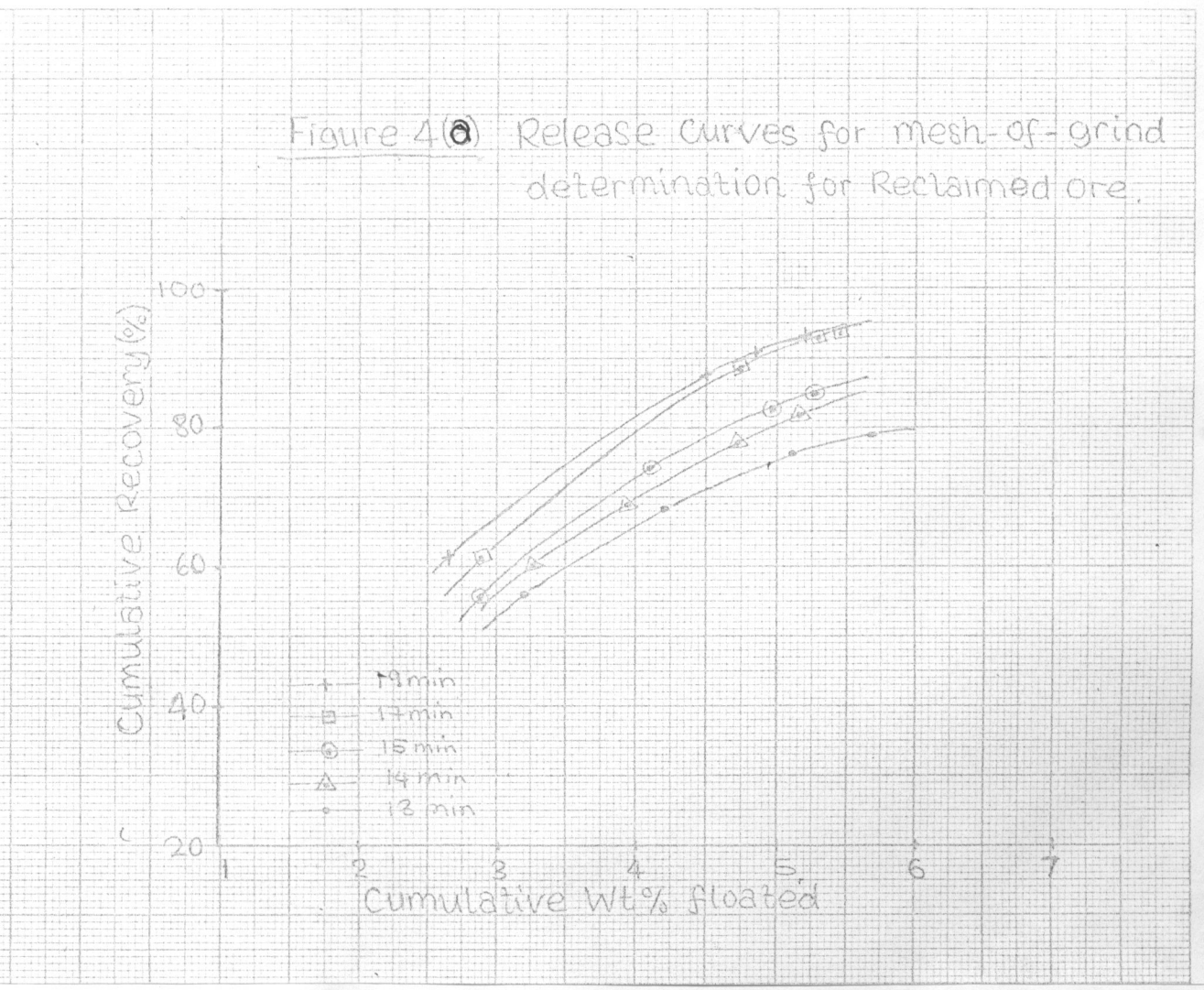


Figure 2: Grind - Time graph

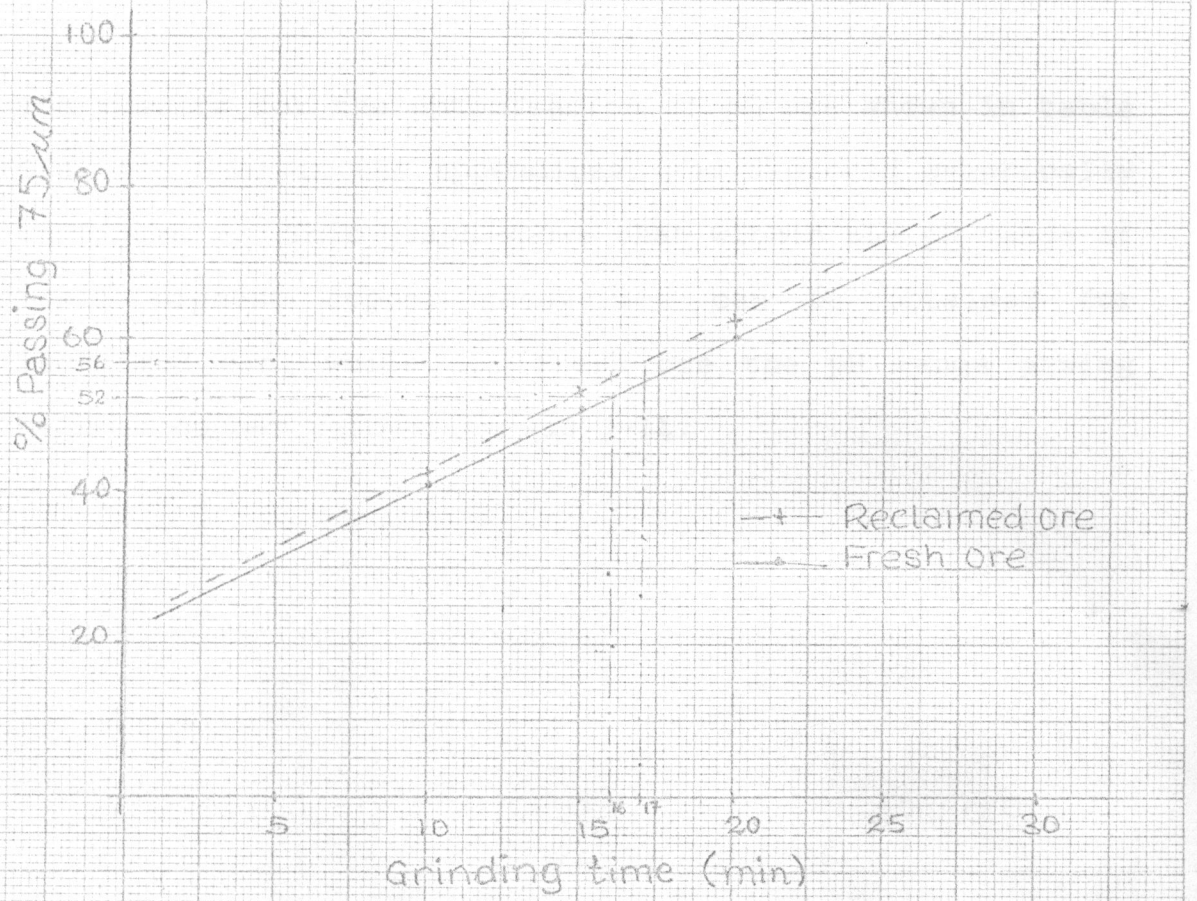
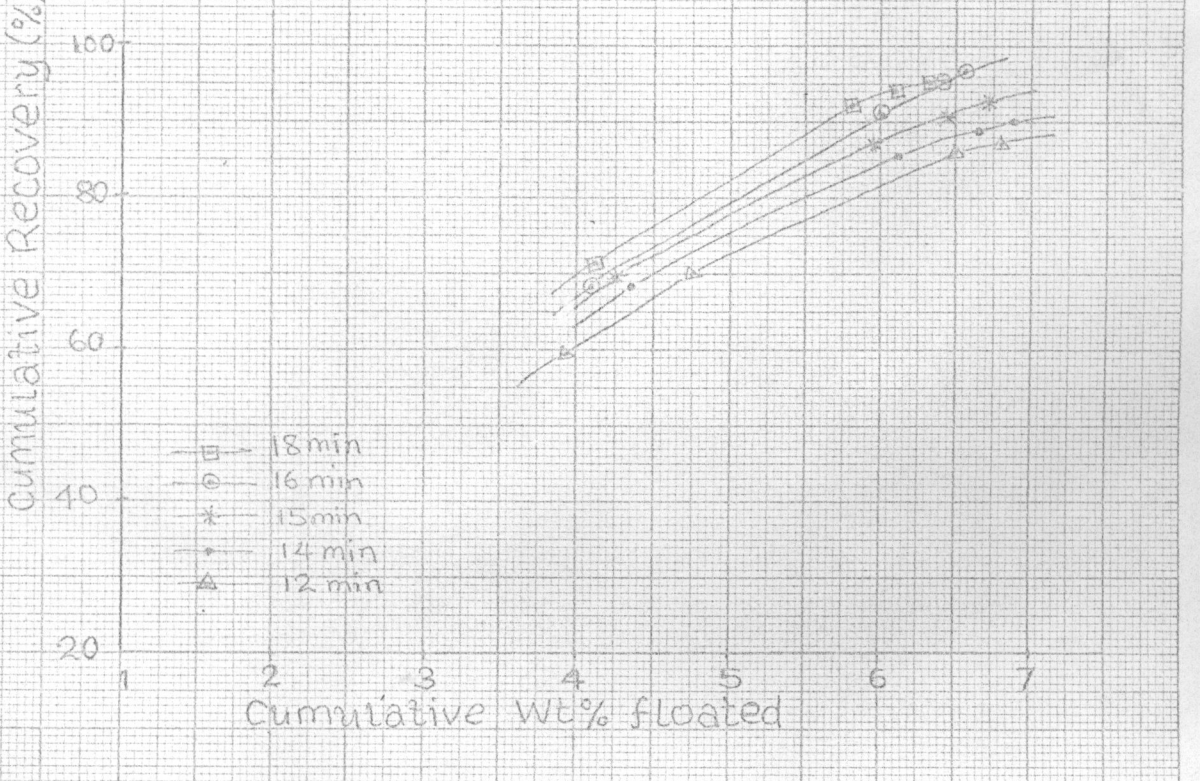


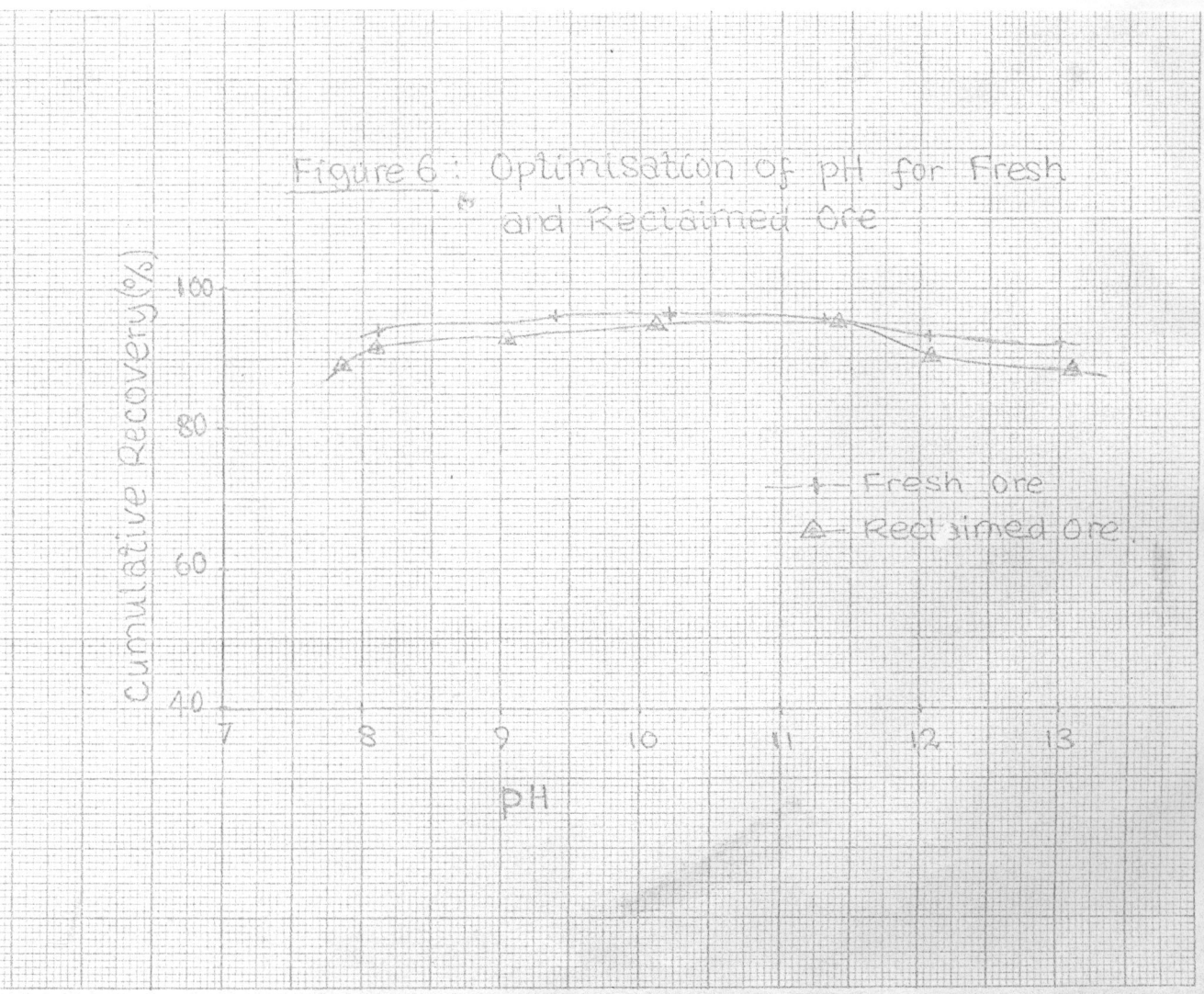
Figure 4(b) Release Curves for mesh-of-grind determination for Fresh ore.



3.3 OPTIMISATION OF pH

The results for the optimisation of pH are shown in table 5(a) and 5(b) in the appendices, and depicted graphically in figure 6. This graph shows that within the pH range of 10-11 highest copper recoveries can be obtained for reclaimed ore, while for fresh ore the pH range giving highest copper recoveries was 9-11.

Figure 6 : Optimisation of pH for Fresh and Reclaimed Ore

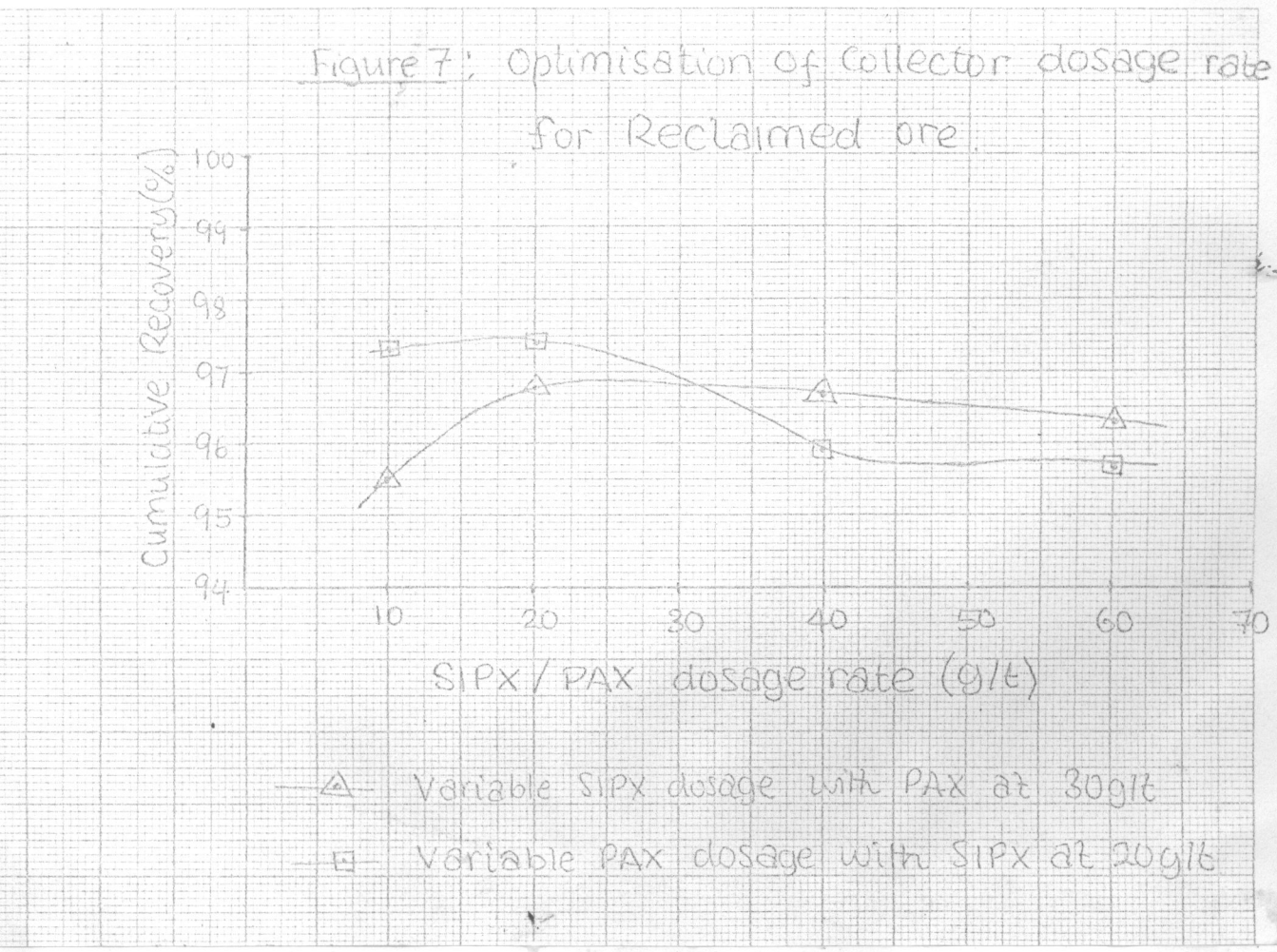


3.4 OPTIMISATION OF COLLECTOR DOSAGE

From the graph in figure 7 it can be seen that 20g/t of SIPX and PAX on both the roughing and scavenging stages gives a higher copper recovery of 97.34%TCu. This was obtained in the second part of the test. The first part of the test gives 96.8%TCu at a dosage rate of 20g/t/30g/t. However, the dosage rate of 20/t/10g/t gives a better grade- recovery relationship. Hence the optimum dosage rate for SIPX and PAX was taken as 20g/t and 10g/t respectively. See table 6 in the appendices for tabulated results.

The existing dosage rates for fresh ore are 20g/t and 30g/t respectively.

Figure 7: Optimisation of Collector dosage rate for Reclaimed ore



3.5 EFFECT OF NaHS

Table 7 below shows the summary of results of this test. From the table it can be seen that the effect of NaHS on the flotability of sulphide minerals is not so significant upto the dosage rate of 10g/t, above which the flotability was adversely affected. At 10g/t the percent weight and grade of the scavenger concentrate
are higher than the scavenger concentrate for the control. Further, the recovery on the scavenging stage at 10g/t is higher than the recovery of the scavenging stage for the control test. Hence the average recovery at 96.34%TCu at the dosage rate of 10g/t is higher than the average recovery for the control which gave an average recovery of 95.74%TCu.

Table 7: Effect of NaHS and its dosage optimisation

Natts Dosage (g/t)	Rouger			Scavenger			Combined Conc.	Calculated Head Grade
	Wt%	Grade %TCu	Recov (%)	Wt%	Grade %TCu	Recov (%)	Cum Recov (%)	%TCu
Control	4.16	28.95	83.44	4.52	3.86	12.30	95.74	1.42
5	4.42	26.93	82.03	4.54	4.27	13.37	95.40	1.45
10	3.98	28.27	70.80	4.56	8.90	25.54	96.34	1.59
15	4.62	27.28	84.08	4.50	3.60	16.79	94.87	1.50
20	4.05	30.07	82.29	4.72	4.01	12.77	95.06	1.48

3.6 EFFECT OF BLENDING FRESH AND RECLAIMED ORES IN VARIOUS PROPORTIONS

The results depicted in figure 9 show that when reclaimed ore is blended with fresh ore the copper recovery drops steadily from 94% down to 89%TCu at 100% reclaimed ore. This shows that reclaimed ore has an adverse effect on the flotation of fresh ore when added in increased proportions of reclaimed ore in the ore treated leads to a drop in copper recoveries. However, at 40% reclaimed ore the highest copper recovery was obtained. At this blending ratio the cumulative recovery was 94.2%TCu at a cumulative grade of 9.46%TCu. comparatively at 20% reclaimed ore a recovery of 94.0%TCu was obtained at a cumulative grade of 10.26%TCu.

Figure 10 shows the grade -recovery relationship of fresh and reclaimed ores mixed in various proportions. From this graph it can be seen that at 20% reclaimed ore there is a better grade - recovery relationship, hence it was taken as the best blending ratio.

From figure 11, it can be seen that fresh ore has better flotation kinetics than reclaimed ore. For example, %TCu recovery from fresh ore was 87% as compared to 79%TCu for reclaimed ore after 1.5 minutes of cleaning.

Tabulated results can be seen from table 8. From the table it can be seen that three cleaner concentrates were collected. The first concentrate was collected after 0.5 minutes of cleaning, the second concentrate was collected after 1.0 minute of cleaning and the third concentrate was collected after 1.5 minutes of cleaning.

Figure 9: Effect of Reclaimed ore on floatation of Fresh Ore.

Figure 10: Grade - Recovery Curves for Fresh and Reclaimed ore blended in Various proportions.

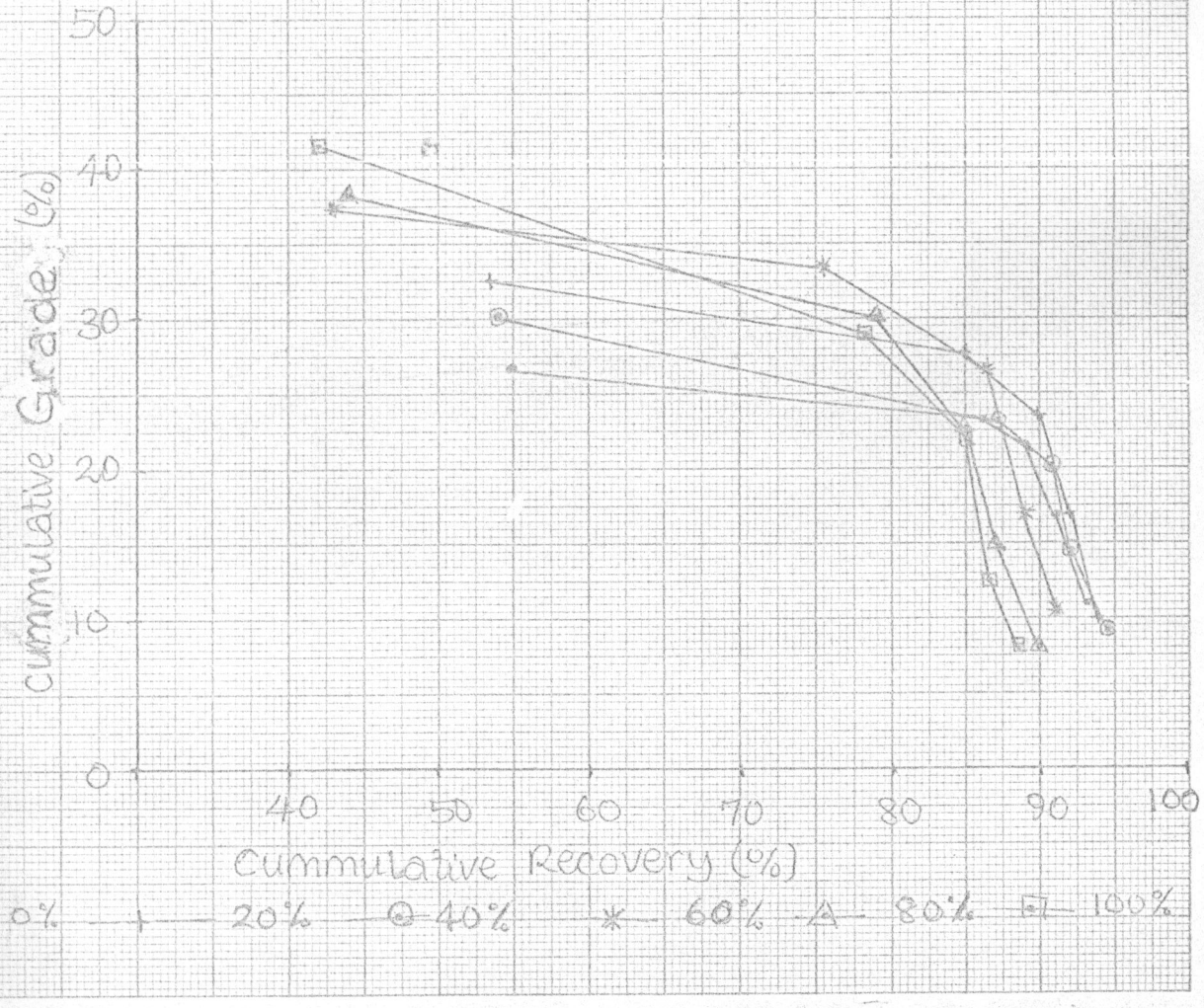


Figure 11: Time-Recovery Curves for Fresh and Reclaimed ore.

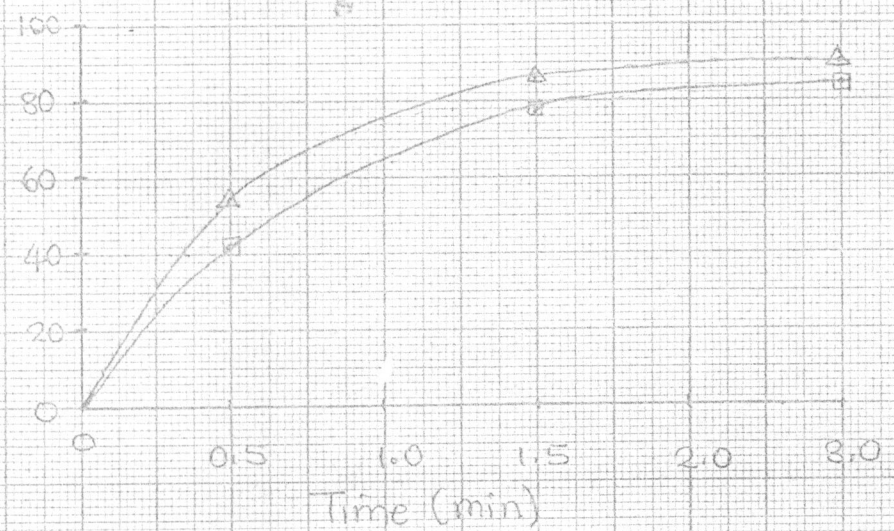


Table : 8 Results of Reclaimed and Fresh Ores mixed in various Proportions

%Reclaimed ore	Fraction	Wt %	Grade %	Recov %	Cum Grade %	Cum Recov %
0	Cleaner Conc 1	3.66	26.93	54.9	26.93	54.9
	2	2.97	18.94	31.3	23.35	86.2
	3	0.78	7.78	3.4	21.71	89.6
	Cleaner Tails	2.00	1.53	1.7	17.42	91.3
	Scav. Conc	5.94	0.64	2.1	10.93	93.4
	Scav Tails	84.65	0.14	6.6	2.49	100.0
	Heads	100.00	2.49	100.00	-	-
20	Cleaner Conc 1	2.99	32.52	53.7	32.52	53.7
	2	2.64	21.43	31.3	27.31	85.0
	3	1.26	7.02	4.9	23.61	89.9
	Cleaner Tails	3.10	1.21	2.1	16.66	91.9
	Scav. Conc	6.60	0.57	2.1	1026	94.0
	Scav. Tails	83.42	0.13	6.0	2.38	100.0
	Heads	100.00	2.38	100.00	-	-
40	Cleaner Conc 1	3.28	29.93	53.7	29.93	53.7
	2	3.56	17.00	33.1	23.20	86.8
	3	1.62	4.58	4.0	19.64	90.8
	Cleaner Tails	3.26	0.78	1.4	14.39	92.2
	Scav. Conc	6.49	0.55	2.0	9.46	94.2
	Scav. Tails	81.79	0.13	5.8	2.06	100.0
	Heads	100.00	2.06	100.00	-	-
60	Cleaner Conc 1	2.12	37.54	37.54	43.3	43.3
	2	2.02	29.23	29.23	32.1	75.4
	3	1.84	10.63	10.63	10.6	86.0
	Cleaner Tails	3.54	1.33	1.33	2.6	88.6
	Scav. Conc.	6.39	0.65	0.65	2.3	90.9
	Scav. Tails	84.09	0.20	0.20	9.1	100.0
	Heads	100.00	2.14	100.00	-	-
80	Cleaner Conc 1	2.07	38.11	44.0	38.11	44.0
	2	2.67	23.57	35.1	29.92	79.0
	3	1.97	5.44	6.0	22.73	85.0
	Cleaner Tails	3.86	0.98	2.1	14.79	87.1
	Scav. Conc.	9.23	0.54	3.0	8.17	90.2
	Scav. Tails	80.20	0.22	9.8	1.79	100.00
	Heads	100.00	1.79	100.00	-	-
100	Cleaner Conc 1	1.83	41.49	42.3	41.49	42.3
	2	2.97	21.84	36.1	29.33	78.4
	3	2.88	4.04	6.5	19.87	84.8
	Cleaner Tails	4.74	0.64	1.7	12.53	86.5
	Scav. Conc.	6.57	0.62	2.3	8.41	88.8
	Scav. Tails	81.00	0.25	11.2	1.61	100.0
	Heads	100.00	1.61	100.00	-	-

CHAPTER 4

DISCUSSION

From the mineralogical investigations data it can be seen that reclaimed ore has a much higher percentage of gangue minerals. In adition, the chalcopyrite/bornite ratio is comparatively lower percentage of gangue minerals an hence the higher heudgrades.

The grind optimisation data show that the optimum mesh-of-grind is 52%-75μm and 56%-75μm for fresh and reclaimed ore respectively. This shows that the sulphide minerals in the fresh ore are liberated at a comapratively coarser grind.

For the pH optimisation test, the limiting factor was the pH meter. It was very unreliable because it was not in perfect working condition. For example, during the duplicate test run, on several occations the pH meter could stop functioning. This could have an effect on the results obtained. The results used in this project are therefore based on the first test run rather than on the duplicate. However, for fresh ore, at the pH level of 10.2 the concentrate grade obtained was much higher even for the duplicate. The duplicate gave 33.24%TCu, but because of the unreliability of the pH meter during the duplicate test, the result of the first float test was prefered.

The 20g/t/20g/t SIPX/PAX dosage rate was considered as the optimum dosage rate for reclaimed ore because it gave a comparatively higher recovery on the rougher flotation and finally a higher cumulative recovery. The concentrate grade however, was lower than that obtained for a

20g/t/10g/t dosage rate. The 20g/t/qog/t dosage rate gave a higher grade, but a lower recovery. The cumulative grade for 20g/t/10g/t dosage rate was 12.50%TCu compared to 11.65%TCu for the 20g/t/20g/t dosage rate, with 97.31%TCu and 97.34%TCu recovery respectively. In view of this, the prefered optimum collector dosage rate was 20g/t/10g/t SIPX/PAX.

For the flotation of fresh and reclaimed ores mixed in various proportions, the effect of reclaimed ore was adverse. The copper recoveries were adversely affected by increased proportions of reclaimed ore in the ore treated. This was attributed the higher level of talc in the reclaimed ore that gave rise to voluminous flows on the rougher flotation leading to low copper recoveries on the roughers and finally low cumulative recoveries were obtained, For example, at 60% and 20% reclaimed ore the recoveries on the rougher flotation were 88.6% and 91.9%TCu respectively. Depressants to depress talc and carbonates could not be obtained in good time to allow a trial to depress talc and carnonates.

From table 8, it can be seen that at 20% reclaimed ore the cumulative grade is higher than that at 40% reclaimed ore. i.e. 10.26%TCu and 9.46%TCu respectively with cumulative copper recoveries of 94.0%TCu and 94.2%TCu respectively. In addition the percent weight flotated was 16.59Wt% at 20% reclaimed ore while at 40% reclaimed ore it was 18.21Wt%. In view of this, 20/80% reclaimed to fresh ore ratio gave the best grade - recovery relationship.

CHAPTER 5

CONCLUSION

From the testwork carried out it can be said that the mineralogy of reclaimed ore is comparatively unfavourable and as such affects flotation efficiency. Because of the unfavourable mineralogy much reagent is washed in an effort to get the best recoveries possible. This contributes to a rise production costs. Nevertheless from the test results, the 20/80% blending ratio of reclaimed ore and fresh ore respectively gives the best grade/recovery relationship.

The pH range of 10-11 for reclaimed ore and 9-11 for fresh ore was found to be optimum. A collector dosage rate of 20:10g/t (SIPX/PAX) was found to be optimum for reclaimed. The existing conditions for fresh ore are 20:30g/t (SIPX/PAX). From this it can be concluded that treating reclaimed separately saves on the amount of collector used per tonne ore treated.

The effect of NaHS on the flotability of sulphide minerals contained in reclaimed ore was not significant and as such NaHS should not be used.

Finally the optimum mesh-of-grind for reclaimed ore was obtained at 17 minutes and for fresh ore at 16 minute corresponding to 56%-75μm and 52%-75μm respectively. It can be concluded from this that the sulphide minerals in fresh ore are liberated at a comparatively coarse grind. Therefore when reclaimed ore is added to fresh ore, the sulphide minerals in reclaimed ore are not completely liberated at that coarse grind. This leads to flotation problems that lead to lower recoveries obtained.

CHAPTER 6

RECOMMENDATIONS

From the conclusions outlined earlier, I therefore recommend that the suggested optimum conditions in this project be applied. I further recommend that higher collector dosages be tried in the laboratory. Further more, a suitable depressant for talc and a depressant for carbonates in reclaimed ore be tried in the laboratory. For the flotation of fresh ore and reclaimed ore mixed in various proportions, I recommend a 80/20% ratio of fresh to reclaimed ore respectively for a better grade-recovery relationship, though a 60/40% ratio will also give a better recovery only that it is at a comparative lower grade.

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December, 1994

APPENDICES

- RELEASE ANALYSIS PROCEDURE
- CALCULATIONS FOR A RELEASE ANALYSIS CURVE.

RELEASE ANALYSIS

The release analysis technique is presented as a basis for the interpretation of separation performance. The release analysis results are used to plot the release curve which is then used as a means of studies liberation and as a yardstick against much to measure the accuracy of an actual separation.

The release analysis technique aims to separate flotables from non-flotable tailings and flotable into fractions by flotation in order to determine the best praticable separation. The fractions produced progress from high grade to low grade.

A number of methods have been used to carry out the release analysis technique. In this testwork the procedure shown diagramatically in figure 3 was employed.

Two cleaning stages were employed to remove most of the gangue. The samples were flotated until bamen and then the concentrate was reflotated in the same way. Separation of the cleaned concentrate into fractions was carried out in two timed stages. Fractions were collected for 1/2, 1, 2 and 4 minutes. Then concentrate 1 was reflotated alone for 1/4 minute and concentrate 2 from first float was added. Flotation was continued for a further 1/4 minutes and basins are changed. Concentrate 2 was collected for 1/2 minute after which concentrate 3 from first float was added. Flotation was continued for a further 1/2 minute after which the basins were changed. Concentrate 3 was collected for 1 minute and concentrate 4 from the first float was added. Flotation was continued for a further 1 minute after which

basins were change. Concentrate 4 was then collected for 4 minutes as before. The final concentrate 5 was combined and assayed.

Excess water from the basins was removed by use of syringe and then used to wash material from the basin into a 2 litre cell.

The Denver flotation machine was used with a constant speed of 1500rpm throughout the testwork.

Figure 12 shows the release curves fro fresh and reclaimed ores at their standard grinds. Table 9. shows detailed results for the calculation of a release curve.

Figure 12. Release Analysis Curves for Fresh and Reclaimed ore at standard grinds.

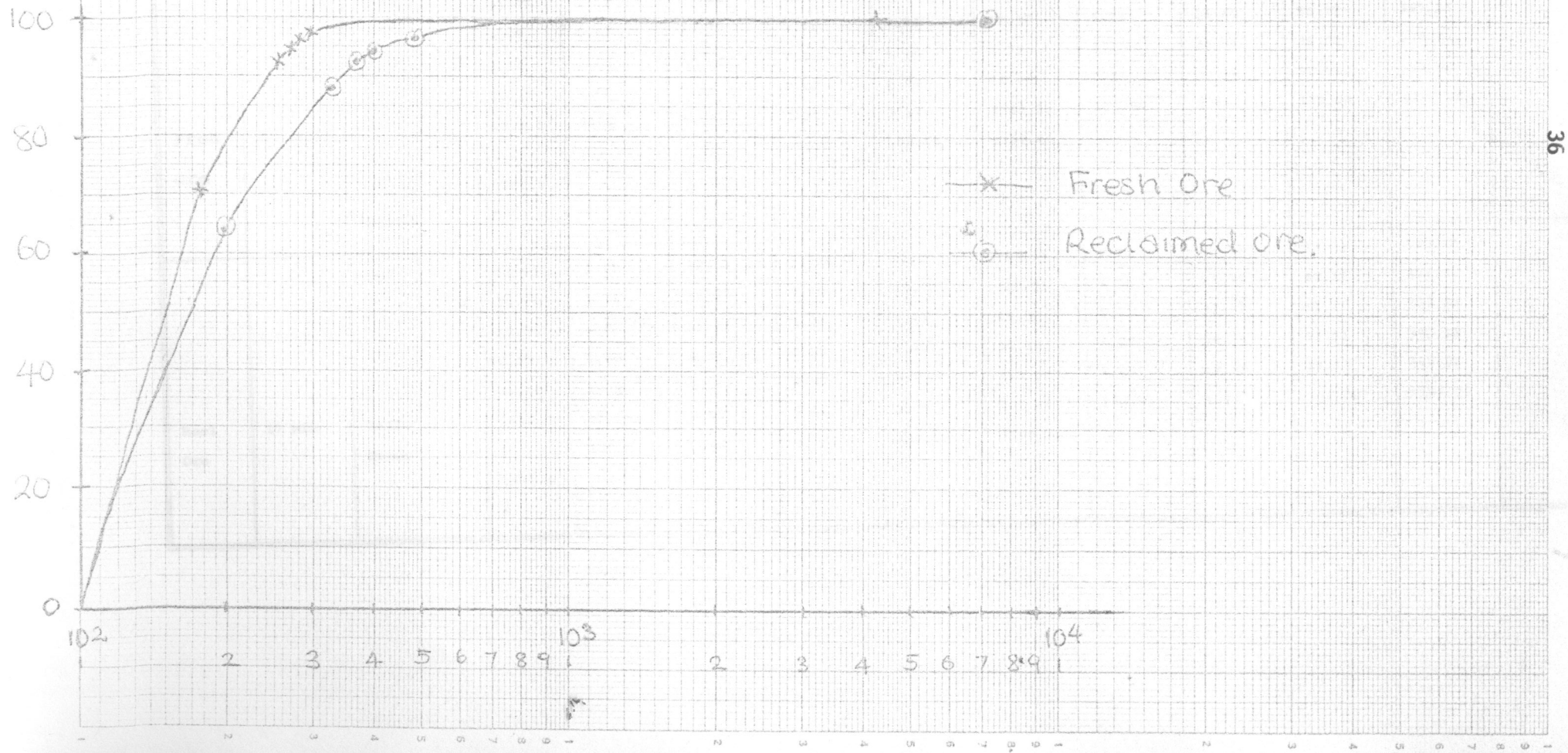

Table 9: Calculation of a Release Curve for fresh and Reclaimed Ore.

M.O.G, 52%-75μm (Fresh ore) and 56%-75μm (Reclaimed Ore)

ORE TYPE	GRIND TIME	FRACTION MM		Wt (g)	Wt %	GRADE %tcU	Wt of Cu (g)	Recov %	Unit Wt	Cum Wt%	Cum grade	Cum Recov	Cum Unit Wt	
Frsh Ore	16 min	Conc	1	81.40	4.14	39.47	32.13	69.67	176.21	4.14	39.47	69.67	176.21	
			2	33.75	1.72	29.92	10.10	21.90	73.02	5.86	36.67	91.57	249.23	
			3	8.27	0.42	20.72	1.71	3.70	17.90	6.28	35.60	95.27	267.13	
			4	1.75	0.09	19.62	0.34	0.74	3.79	6.37	35.38	96.01	270.92	
			5	21.25	1.08	2.16	0.46	1.00	46.08	7.45	30.56	97.01	317.00	
		Tails		1819.97	2.55	0.08	1.38	2.99	3946.16	100.00	2.35	100.00	4257.86	
		Heads		1966.39	100.00	2.35	46.12	100.00	4257.86	-	-	-	-	
Recl Ore	17 min	Conc.	1	53.65	2.71	32.13	17.24	62.49	195.44	2.71	32.13	62.49	195.44	
			2	35.40	1.79	20.02	7.09	25.70	128.91	4.50	27.32	88.19	324.35	
			3	12.25	0.62	10.38	1.27	4.60	44.58	5.12	25.27	92.79	368.93	
			4	2.80	0.14	6.98	0.20	0.72	10.18	5.26	24.78	93.51	379.11	
			5	31.40	1.59	2.39	0.75	2.72	113.81	6.85	19.59	96.23	492.92	
		Tails		1842.05	93.15	0.06	1.04	3.77	706.84	100.00	1.40	100.00	7199.76	
		Heads		1977.55	100.00	1.40	27.59	100.00	7199.76	-	-	-	-	

EXAMPLE OF THE CALCULATION OF A RELEASE CURVE

i) Weight Percent, Wt%

$$Wt\% = \frac{\text{Weight of Concentrate floated}}{\text{Total weight of one treated}} \times 100$$

ii) Weight of Copper (g) = $\frac{\text{Conc. grade} \times \text{Weight floated}}{100}$

iii) Recovery (%) = $\frac{\text{Weight of Copper metal in conc.}}{\text{Total weight of copper in ore}}$

Considering fresh ore and taking conc. 1 as an example:

$$Wt\% = \frac{81.40_g}{1966.39_g} \times 100\% = 4.14\%$$

$$\text{Wt of Cu.(g)} = \frac{39.47 \times 81.40_g}{100} = 32.13g\ Cu$$

$$\text{Recovery} = \frac{32.13_g}{46.12_g} \times 100\% = 69.66\%TCu$$

$$\text{Unit Wt} = \frac{81.40_g}{46.12_g} \times 100 = 176.50$$

Table 5(a): pH optimisation data for Mufulira Reclaimed Ore

pH	Fraction	Wt %	Grade %TCu	TCu (g)	Cum Grade	Recov (%)	Cum Recov (%)
	Rougher	7.04	17.82	25.06	17.82	85.05	85.05
7.84	Scav	5.54	1.16	1.28	9.86	4.36	89.41
	Tails	87.42	0.18	3.12	1.47	10.59	100.00
	Total	100.00	1.47	29.46	-	100.00	-
	Rougher	6.65	19.20	24.99	19.20	85.58	85.58
8.10	Scav	8.61	1.02	1.72	10.21	5.89	91.47
	Tails	84.74	0.15	2.49	1.49	8.53	100.00
	Total	100.00	1.49	29.20	-	100.00	-
	Rougher	6.81	18.80	24.73	18.80	86.44	86.44
9.08	Scav	7.78	1.25	1.87	11.04	6.57	93.01
	Tails	85.41	0.12	1.99	1.47	6.99	100.00
	Total	100.00	1.47	28.42	-	100.00	-
	Rougher	7.65	18.51	27.81	18.51	89.15	89.15
10.16	Scav	6.90	1.25	1.70	11.50	5.45	94.60
	Tails	85.45	0.10	1.68	1.59	5.40	100.00
	Total	100.00	1.59	31.20	-	100.00	-
	Rougher	8.16	16.33	26.13	16.33	88.79	88.79
11.40	Scav	6.14	1.47	1.77	10.62	6.03	94.88
	Tails	85.60	0.09	1.52	1.50	5.18	100.00
	Total	100.00	1.50	29.43	-	100.00	-
	Rougher	8.05	16.32	25.74	16.32	88.79	88.79
12.07	Scav	6.45	0.74	0.93	9.94	6.03	94.88
	Tails	85.50	0.17	2.91	1.51	5.18	100.00
	Total	100.00	1.51	29.58	-	100.00	-
	Rougher	6.95	18.15	25.18	18.15	86.44	87.44
13.10	Scav	8.04	0.45	0.72	9.46	2.47	89.91
	Tails	85.01	0.17	2.94	1.46	10.00	100.00
	Total	100.00	1.46	29.13	-	100.00	-

Table 5(b): pH optimisation data for Mufulira Fresh Ore

pH	Fraction	Wt %	Grade %TCu	TCu (g)	Cum. Grade	Recov (%)	Cum Recov (%)
	Rougher	7.46	22.75	33.56	22.75	86.96	86.96
8.10	Scav	5.82	2.31	2.66	13.79	6.89	93.79
	Tails	86.72	0.14	2.40	1.95	6.21	100.00
	Total	100.00	1.95	38.62	-	100.00	-
	Rougher	7.20	25.96	35.67	25.96	87.38	87.38
9.41	Scav	9.92	1.89	3.57	12.02	8.75	96.13
	Tails	82.88	0.10	1.58	2.14	3.87	100.00
	Total	100.00	2.14	40.82	-	100.00	-
	Rougher	4.96	33.00	32.11	33.00	78.72	78.72
10.20	Scav	8.72	4.09	6.99	14.57	17.14	95.86
	Tails	86.32	0.10	1.69	2.08	4.14	100.00
	Total	100.00	2.08	40.79	-	100.00	-
	Rougher	7.73	23.78	36.41	23.78	86.34	86.34
11.31	Scav	7.50	2.41	3.58	13.25	8.49	94.83
	Tails	89.77	0.13	2.18	2.13	5.17	100.00
	Total	100.00	2.13	42.17	-	100.00	-
	Rougher	9.15	21.16	37.79	21.16	90.58	90.58
12.06	Scav	6.13	0.85	1.02	13.02	2.44	93.02
	Tails	84.72	0.18	2.91	2.14	6.98	100.00
	Total	100.00	2.14	41.72	-	100.00	-
	Rougher	8.26	20.40	33.64	20.40	91.29	91.29
13.01	Scav	7.38	1.21	1.78	11.35	4.51	92.99
	Tails	84.36	0.08	1.35	1.84	7.06	100.00
	Total	100.00	1.84	36.77	-	100.00	-

SIPX/PAX DOSAGE (g/t)		ROUGHER			SCAVENGER			Cum. Grade	Cum. Recov %	Calculated Head grade
Rougher	Scav	Wt%	GRADE %TCu	Recov (%)	Wt%	GRADE %TCu	RECOV (%)	%TCu	(%)	%TCu.
10	30	5.25	24.08	90.67	4.95	1.35	4.81	13.04	95.48	1.39
20	30	5.95	21.15	92.23	5.97	1.04	4.54	11.07	96.77	1.36
40	30	6.56	18.76	93.51	4.45	0.92	3.11	11.55	96.62	1.35
60	30	7.40	18.05	93.81	3.85	0.91	2.45	12.18	96.26	1.42
20	10	5.15	23.80	92.58	5.16	1.22	4.73	12.50	97.31	1.34
20	20	6.35	19.84	94.20	4.83	0.87	3.14	11.65	97.34	1.34
20	40	7.11	18.59	92.76	4.94	0.88	3.11	11.56	95.91	1.40
20	60	6.01	20.23	92.16	5.21	1.13	4.47	11.36	95.63	1.33

Table 6 : Collector dosage Optimisation for reclaimed ore.