TR16_297_302

R.632. Concentration of chromite by flotation.

This investigation is an extension of project R.626 (see p. 275) in which some preliminary metallurgical testing was done on a sample of chromite-bearing sand obtained from a sluice box in the Northern Chromite N.L. treatment plant. Investigation R.626 indicated that concentration by froth flotation was a feasible method of treatment and the work undertaken on this sample was designed to extend and reinforce this finding.

SAMPLE

The material was received in nine separate but unlabelled bags; each bag was stated to be a sample from a different costean. The samples ranged from fine sands to gravelly material containing fairly large (75 mm) quartz pebbles. Clay was present in varying degrees and chromite content (visually estimated) varied over a wide range.

A test sample was made up by taking equal grabs from each bag after mixing.

ASSAYS

As in R.626, chromite determinations on the various products were generally done by magnetic separation, as no other magnetic minerals were present. Some very fine and very coarse products not amenable to magnetic separation were assayed chemically, as were all products from some selected tests.

PRELIMINARY TREATMENT AND SIZING

The comparatively large test sample (90 kg approximately) was slacked in water and hand screened on ⅛ inch and 10# to discard sizes which appeared relatively barren of chromite. The -10# pulp was then screened on a 60# Hummer vibrating screen. Hummer oversize was hand screened on 22 and 44# and the Hummer undersize (-60#) was deslimed by hydraulic cyclone.

The following fractions were obtained.

Fraction	*% Weight*	*% Chromite*	*% Chromite Distribution*
+⅛ inch	12.5	1.4 (C)	0.7
+10#	4.7	0.8 (C)	0.2
+22#	6.0	4.2 (M)	1.1
+44#	6.5	32.7 (M)	8.9
+60#	3.1	54.1 (M)	7.0
Cyclone U/F	56.6	33.2 (M)	78.5
Cyclone O/F	10.6	8.2 (C)	3.6
Total	100.0	23.9	100.0

(M) magnetic assays; (C) chemical assays

The above table does not represent a precise sizing of the material but is the result of preliminary metallurgical treatment to obtain products for further testing and examination.

A sizing analysis was obtained by making up a weighed composite of the above material and sizing by wet and dry screening after dispersion and agitation.

This sizing analysis is as follows:

Fraction	*% Weight*	*% Chromite*	*% Chromite Distribution*	*Cum. Chromite Distribution*
+⅛ inch	12.5	1.4 (C)	0.7	0.7
+10#	4.7	0.8 (C)	0.2	0.9
+22#	3.5	5.4 (M)	0.8	1.7
+44#	4.0	22.8 (M)	3.8	5.5
+60#	5.5	48.2 (M)	11.1	16.6
+100#	10.6	42.9 (M)	19.0	35.6
+200#	20.2	33.4 (M)	28.2	63.8
+300#	4.6	37.0 (M)	7.1	70.9
C/S1	2.4	98.3 (M)	9.9	80.8
C/S2	3.6	29.2 (M)	4.4	85.2
C/S3	5.4	16.5 (M)	3.7	88.9
C/S4	5.5	12.7 (M)	2.9	91.8
C/S5	3.2	19.0 (M)	2.5	94.3
O/F	14.3	9.5 (D)	5.7	100.0
Comp. Head	100.0	28.9	100.0	

(M) magnetic assay; (C) chemical assay; (D) derived assay

CONCENTRATION OF CHROMITE BY FLOTATION

Development of Treatment Method

The -60# cyclone underflow obtained from the preliminary slacking, sizing and desliming treatment was used in the flotation testing.

Several preliminary tests using reagent combinations shown to be effective in R.626 were carried out. The results were not in accordance with those obtained before and were characterised by poor selectivity and high reagent consumption. Chromite grades and recoveries in concentrates were unacceptably low. The poor results were found to be caused by excessive amounts of clay-like slimes in the flotation feed consuming large quantities of reagent and causing slimy voluminous froths with consequent loss of selectivity in the operation.

A secondary desliming by decantation from the flotation cell improved the condition but continual production of slime from attrition during conditioning and flotation continued to depreciate the results.

It was found necessary therefore to institute a stage of scrubbing (high pulp density agitation) and thorough desliming before flotation to achieve acceptable and reproducible results and keep reagent consumption down to reasonable levels. The addition of 1 to 2 lb per ton of Calgon was helpful in effecting thorough dispersion of the slime for subsequent decantation.

The sequence of operations then became:

(1) Scrub with 1-2 lb/ton Calgon for 5 minutes at a pulp density of 70-80% solids.

(2) Dilute, mix and decant slime fraction.

(3) Condition with reagents at pulp density of 70-80% solids.

(4) Rougher and cleaner flotation after dilution to 35-40% solids.

The tests leading up to establishment of the above procedure are not reported and in most cases were not assayed, visual observation being sufficient evidence of deficiencies in procedure.

All reported tests generally follow the procedure outlined.

Reagents

The best results obtained in R.626 were from tests using amine fortified with fuel oil as promotors. The work on this sample has been mainly directed to confirming the results of amine flotation and determination of optimum conditions with regard to pH, reagent combinations and quantities, conditioning and flotation times.

A few tests were done using oleic acid, fuel oil and Cyanamid reagent 825. Flotation was not as positive as with amine and recovery of coarse chromite was only partially achieved. This method was not persevered with but a typical test result is reported for comparative purposes.

Feed Sizes

The -60# cyclone underflow was used as feed for most flotation tests. In some tests a composite flotation feed was made up to include the correct proportions of +60# and +44# material to check recovery of coarser chromite by flotation. Desliming generally removed from the feed material a fraction of sizing 90% -C/S5, equivalent to -8 µm chromite and -12 µm quartz.

The sizings of various relevant materials are given on page 298.

TEST CONDITIONS

Test conditions are given in Table 1.

Table 1. TEST CONDITIONS

Test No.		Feed Size	Reagents (lb per ton)							pH	Time (minutes)	
			O.A.	F.O.	825	H_2SO_4	NaF	3035	Calgon		Cond.	Flot.
N9A	F1	-22#	2	4	2	0.5	2			4.5	5	8
	F2									5.5		5
N10	F1	-60#		3		1	2	1		2.6	5	3
	F2									3.5		3
N11	F1	-44#		3		1	2	1		2.6	5	3
	F2									3.4		3
N22	F1	-60#		1.5		2		0.5	1	2.4	1	3
	F2									3.4		2
N23	F1	-22#		3		2		1	1	2.5	1	3
	F2									3.5		2

Abbreviations used for reagents in Table 1:

O.A.	oleic acid
F.O.	fuel oil
825	Cyanamid reagent 825 (anionic sulphonate type promotor)
H_2SO_4	sulphuric acid (pH regulator and quartz depressant)
NaF	sodium fluoride (quartz depressant)
3035	Cyanamid reagent 3035 (undefined amine-cationic promotor)
Calgon	sodium hexametaphosphate (dispersant - wetting agent)

Note: In all tests reported, the flotation feed was submitted to a high density (70-80% solids) attrition scrub with 2 lb per ton of Calgon and deslimed before flotation.

TEST RESULTS

Magnetic Assays (M/A = approximate % chromite)

Test No. and Product		*% Wt*	*% M/A*	*% M/A Distn*
N9A	F2C	40.7	84	91
	F2T	2.2	15	trace
	F1T	50.4	5	7
	Slime	6.7	11	2
	F/D	100.0	38	100
N10	F2C	29.5	97	90
	F2T	2.4	12	1
	F1T	52.4	2	3
	Slime	15.7	11	6
	F/D	100.0	32	100
N11	F2C	31.9	98	92
	F2T	1.0	15	trace
	F1T	52.4	2	3
	Slime	14.7	11	5
	F/D	100.0	34	100

Chemical Assays

Test No. and Product		*% Wt*	*% Cr_2O_3*	*% Cr_2O_3 Distn*
N22	F2C	30.5	57.6	93.0
	F2T	2.8	11.9	1.8
	F1T	57.0	0.6	1.8
	Slime	9.7	6.7	3.4
	F/D	100.0	18.9	100.0
N23	F2C	32.2	55.9	93.4
	F2T	4.2	9.8	2.1
	F1T	54.0	0.4	1.1
	Slime	9.6	6.7	3.4
	F/D	100.0	19.3	100.0

Overall Metallurgical Balance, Test N23

On the basis of the make up of flotation feed, using the products obtained from the preliminary sizing and desliming, an overall metallurgical balance can be calculated.

For Test *N23*, this is:

Product	*% Wt*	*% Chromite Distribution*	*% Cr_2O_3*
+22# Untreated	23.2	2.0	
-60# Cyclone O/F	10.6	3.6	
Cell Decant	6.4	3.2	
Total Slime	17.0	6.8	
Rougher FT	35.7	1.0	0.4
Cleaner FT	2.8	2.0	9.8
Cleaner Chromite Conc.	21.3	88.2	55.9

Sizings

	Equivalent particle diameter (μm)		*% Weight*				
Fraction	*Chromite*	*Quartz*	*1*	*2*	*3*	*4*	*5*
+52#	300	300	0.1				
+60#	250	250	0.3				13.7
+72#	210	210	1.8				
+100#	150	150	14.9			16.6	
+150#	105	105	20.0			16.9	
+200#	75	75	16.9			19.0	
+300	53	53	8.7			10.1	
C/S1	44	30	2.9			15.5	86.3
C/S2	35	24	4.9			6.4	
C/S3	24	16	9.3	0.1	trace	6.4	
C/S4	15	11	9.1	0.8	0.5	5.1	
C/S5	12	8	4.4	2.5	9.5	1.2	
O/F	<12	<8	6.7	96.6	90.0	2.8	
Total			100.0	100.0	100.0	100.0	100.0

Sizing No. 1 -60# cyclone underflow
No. 2 -60# cyclone overflow } slime fractions
No. 3 flotation cell decant }
No. 4 *N22* cleaner chromite concentrate
No. 5 *N23* cleaner chromite concentrate

SUMMARY

The samples were obtained from nine different costeans and the composition of ore submitted showed fairly wide variations both in chromite content and the type of associated gangue material. No magnetic minerals other than chromite were present to any significant degree.

The experimental work on the composite sample has shown that the overall chromite response to flotation is similar for each sample and that acceptable grades of chromite concentrate can be obtained by applying this method to the type of ore submitted provided that certain necessary conditions of feed preparation are complied with.

The tests have shown conclusively that thorough scrubbing and desliming of the ore is necessary before flotation. A five minute scrub at 70% solids using 2 lb per ton of Calgon was found to be effective in the bench work, and should be adequate in commercial treatment. A double desliming by hydraulic cyclone would probably be necessary to effect the required degree of desliming in a commercial operation.

Long conditioning time with reagents is not necessary provided it takes place in deslimed pulp at relatively high density (60 to 80% solids). This is necessary to emulsify the fuel oil. Conditioning for one minute was found to be adequate in the test work.

Flotation in both rougher and cleaner stages is rapid and highly selective using Aeromine 3035 fortified with fuel oil at a pH of between 2.5 and 3.5. The work has been confined to tests with Aeromine but other brand amines similarly constituted would probably be just as effective.

The size range of chromite recovered in flotation concentrates is from -22# to +8 µm. There is little chromite present in the +22# ore and it would not be feasible under any circumstances to economically recover -8 µm chromite. This means in effect that virtually all the recoverable chromite in the ore is retained in the flotation feed after pre-screening, scrubbing and desliming.

Chromite recoveries from feed so prepared are in excess of 90% at concentrate grades better than the specified 55% Cr_2O_3.

Reagent usage lies in the range 0.5 to 1.0 lb per ton of amine, 1.5 to 3 lb per ton of fuel oil (amine is soluble in fuel oil) and sufficient sulphuric acid to give a pH of between 2.5 and 3.5 in the flotation stages. The test work indicates that 1 to 2 lb per ton is adequate. The addition of 1.0 lb per ton of Calgon just prior to flotation promoted a better textured, persistent froth, which delivered freely over the cell lip. Without Calgon the froth was rather dry and did not deliver easily. The water used in the test work was from the Launceston City supply and a test using the water available at the mine would be necessary to check this influence on flotation conditions if consideration were to be given to establishing a commercial operation.

CONCLUSION

The work detailed has served to confirm the preliminary findings of investigation R.626 in that the Beaconsfield chromite responds readily to froth flotation.

In the sample tested some 90% of the total chromite lies in the size range where the application of flotation is not only feasible but actually necessary if high recoveries are to be achieved. This remark is made in the context that gravity concentration would be unlikely to achieve comparable results on the -300# fraction which contains some 30% of the total chromite.