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MINES BRANCH INVESTIGATION REPORT

IR 73-9 December, 1972

AN INVESTIGATION TO UPGRADE A CONCENTRATE PRODUCED FROM THE SPIRAL-PLANT TAILINGS OF THE IRON ORE COMPANY OF CANADA, LABRADOR CITY, NEWFOUNDLAND

by

G.O. Hayslip

Mineral Processing Division

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AN INVESTIGATION TO UPGRADE A CONCENTRATE PRODUCED FROM THE SPIRAL PLANT TAILINGS OF THE IRON ORE COMPANY OF CANADA, LABRADOR CITY, NEWFOUNDLAND

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SUMMARY OF RESULTS

A low-grade concentrate produced from Iron Ore Company of Canada spiral-plant tailings was successfully treated by shaking tables to produce a final concentrate containing 67.04% Sol Fe with a recovery of 78.3% of the Sol Fe from the low-grade concentrate.

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The Iron Ore Company of Canada operates a concentrating plant to recover specular hematite and magnetite by means of Humphreys spirals and magnetic separators at its Carol Mining Division, Labrador City, Newfoundland. The recovery of specular hematite by Humphreys spirals is low, so the company is investigating methods to reduce the loss of iron units.

Investigations have been conducted by several companies using different types of equipment. One company, using equipment known as the Lamflo concentrator, has been successful in producing a low-grade concentrate with high recovery. The Mines Branch was asked to assist in upgrading a concentrate produced by this method and to upgrade a sample of the original plant tailing.

Shipments

Twenty-five pounds of plant tailings was received from the Iron Ore Company of Canada, Labrador City, Labrador, on March 14, 1972. Twenty-five pounds of material labelled Lamflo cleaner concentrate was received from CARPCO Research and Engineering, Inc., Jacksonville, Florida, on March 20, 1972.

Sampling and Analysis

Samples were riffled out of each shipment for test purposes and for gravimetric and size analyses. The analysis of each shipment was calculated from the products of the various tests. All gravimetric analyses were done by the Mineralogy Section, all chemical analyses were done by the Analytical Chemistry Sub-Division, Mineral Sciences Division, Mines Branch.

Characteristics of the Material

Screen analyses were made of each shipment of material and a gravimetric analysis was made on each size fraction. From the results of these analyses,

it can be determined that the main losses in the spiral tailings are in the minus 100-mesh material and that over half of the lost iron values are available for recovery at an acceptable grade. Gravimetric analyses of the Lamflo cleaner concentrate showed that, in 50.3 per cent of the weight, 84 per cent of the iron is available for recovery at a grade of 65.4 per cent soluble iron.

Microscopic examination of the intermediate float fraction, i.e. between 2.96 and 3.33 in specific gravity, showed that some of this material is composed of middling particles of hematite and gangue. X-ray diffraction analysis of some of this intermediate material showed it to be a manganiferous iron carbonate. Results of these gravimetric and chemical analyses are given in Tables 1 and 2.

TABLE 1

Iron Ore Company Spiral Plant Tailings

Mesh, Tyler	Gravimetric Analysis									Size-Assay		
	Float @ 2.96 sp gr			Float @ 3.33 sp gr			Sink @ 3.33 sp gr			Wt %	Sol Fe* %	Distn Fe %
	Wt %	Sol Fe %	Distn Fe %	Wt %	Sol Fe %	Distn Fe %	Wt %	Sol Fe %	Distn Fe %			
+ 14	0.3	3.70	0.1	0.1	20.45	0.1	0.1	37.70	0.3	0.5	13.8	0.5
+ 20	0.7	2.58	0.1	0.5	19.24	0.7	0.4	38.48	1.1	1.6	16.8	1.9
+ 28	1.1	3.64	0.3	0.8	14.74	0.9	0.5	40.10	1.5	2.4	14.9	2.7
+ 35	2.6	4.26	0.8	1.6	13.12	1.5	0.6	42.34	1.8	4.8	12.0	4.1
+ 48	5.3	3.96	1.6	1.8	11.54	1.5	0.5	45.44	1.7	7.6	8.5	4.8
+ 65	10.8	3.56	2.8	2.0	10.56	1.5	0.7	49.04	2.5	13.5	7.0	6.8
+100	16.6	2.82	3.5	1.9	9.24	1.3	1.0	53.98	4.0	19.5	6.1	8.8
+150	12.5	2.20	2.1	1.2	7.90	0.7	1.1	56.20	4.6	14.8	6.7	7.4
+200	9.3	1.41	1.0	0.9	7.02	0.4	1.8	59.26	7.9	12.0	10.5	9.3
+325	6.2	1.20	0.5	0.8	5.92	0.4	3.8	64.34	18.0	10.8	23.8	18.9
+400	1.6	1.02	0.1	0.3	7.14	0.1	2.2	66.50	10.8	4.1	36.6	11.0
-400	2.6	6.72	1.3	1.3	7.74	0.7	4.5	65.56	21.8	8.4	38.4	23.8
Totals*	69.6	2.75	14.2	13.2	10.3	9.8	17.2	59.9	76.0	100.0	13.6	100.0

*Calculated

TABLE 2

Lamflo Cleaner Concentrate

Mesh, Tyler	Gravimetric Analysis									Size-Assay		
	Float @ 2.96 sp gr			Float @ 3.33 sp gr			Sink @ 3.33 sp gr			Wt %	Sol Fe* %	Distn Fe %
	Wt %	Sol Fe %	Distn Fe %	Wt %	Sol Fe %	Distn Fe %	Wt %	Sol Fe %	Distn Fe %			
+ 14	Tr	8.88	Tr	0.1	18.36	0.1	0.4	35.78	0.4	0.5	32.3	0.5
+ 20	0.1	5.45	Tr	0.3	14.24	0.1	1.7	37.66	1.6	2.1	32.8	1.7
+ 28	0.2	9.82	0.1	0.5	15.84	0.2	1.7	41.88	1.8	2.4	33.8	2.1
+ 35	0.1	5.66	Tr	0.5	9.92	0.1	1.4	47.54	1.7	2.0	36.0	1.8
+ 48	0.6	11.26	0.2	0.9	10.36	0.2	3.2	55.16	4.5	4.7	41.0	4.9
+ 65	1.3	5.08	0.2	0.7	10.10	0.2	2.7	60.48	4.5	4.7	37.7	4.9
+100	4.9	4.98	0.6	1.6	9.18	0.4	5.8	63.62	9.4	12.3	33.2	10.4
+150	7.8	3.26	0.6	1.1	9.14	0.3	6.0	61.70	9.4	14.9	27.2	10.3
+200	7.3	2.84	0.5	1.3	7.50	0.2	7.5	65.36	12.5	16.1	32.3	13.2
+325	6.5	1.79	0.3	1.7	7.12	0.3	15.7	66.92	26.7	23.9	45.0	27.3
+400	0.7	1.28	Tr	0.3	12.28	0.1	4.0	67.78	6.9	5.0	55.1	7.0
-400	0.1	20.45	0.1	2.7	17.96	1.2	8.6	66.78	14.6	11.4	54.8	15.9
Totals*	29.6	3.4	2.6	11.7	11.5	3.4	58.7	62.7	94.0	100.0	39.2	100.0

*Calculated

Outline of Investigation

Tabling tests were made on samples of the Lamflo cleaner concentrate using different circuits in an attempt to obtain the best results. The material was treated both without preparation and after screening and grinding the oversize material. Both open and closed circuits were tried.

Additional tabling and jigging tests were made on samples of the original plant tailing. Tabling tests resulted in either preconcentrates or finished concentrates.

DETAILS OF INVESTIGATION

Lamflo Cleaner Concentrate

Seven tabling tests were run on samples of Lamflo Cleaner Concentrate. In all of the tests the feed rate was about 60 pounds per hour. The table was set at the same slope for all tests and only the wash water was adjusted for each test.

Test 1 was done on a sample of untreated Lamflo concentrate. Due to the presence of large grains of a light-coloured mineral which lowered the grade of the concentrate, the amounts of material cut out for the concentrate and middling products were reduced. This produced a concentrate of acceptable grade but the recovery was low. The results of the test are given in Table 3.

TABLE 3

Results of Tabling, Test 1

Product	Weight, %	Assay, % Sol Fe	Distn, % Sol Fe
Table conc	33.5	65.50	56.6
" middling	24.5	51.04	32.2
" tailing	42.0	10.33	11.2
Feed (calcd)	100.0	38.78	100.0

To overcome the effect of the large grains of undesired material, the products were sampled, recombined, and the minus 35-mesh material was screened out. The oversize was stage-ground to pass 35 mesh, combined with the fines, and then passed over the table under conditions similar to Test 1. This test produced a higher grade of concentrate with higher recovery but lowered the grade and recovery in the middling fraction. The overall recovery of iron units was the same for the two tests. The results of Test 2 are given in Table 4.

TABLE 4

Results of Tabling, Test 2

Product	Weight, %	Assay, % Sol Fe	Distn, % Sol Fe
Table conc	41.8	67.62	72.7
" middling	13.4	46.80	16.1
" tailing	44.8	9.76	11.2
Feed (calcd)	100.0	38.90	100.0

Similar tests, 3 and 4, were run in the presence of company officials with somewhat similar results. Test 3 was done on untreated feed and Test 4 was done on minus 35-mesh material. The results of Tests 3 and 4 are given in Tables 5 and 6.

TABLE 5

Results of Tabling, Test 3

Product	Weight, %	Assay, % Sol Fe	Distn, % Sol Fe
Table conc	41.3	66.28	69.2
" middling	14.8	41.88	15.6
" tailing	43.9	13.68	15.2
Feed (calcd)	100.0	39.58	100.0

TABLE 6

Results of Tabling, Test 4

Product	Weight %	Assay, % Sol Fe	Distn, % Sol Fe
Table conc	41.7	67.79	71.9
" middling	16.3	38.28	15.9
" tailing	42.0	11.42	12.2
Feed (calcd)	100.0	39.31	100.0

To determine the maximum concentrate recovery it was decided to recirculate the middling product back to the table. For this test,the feed was screened on 35 mesh and the oversize was ground as in Tests 2 and 4. By recirculating the middling fraction,it was possible to take a smaller cut of concentrate material and thus improve the grade of concentrate. A small amount of material remaining at the end of the test was called the middling

product but it could be included in the table concentrate if desired. The results of Test 5 are given in Table 7.

TABLE 7

Results of Tabling, Test 5

Product	Weight, %	Assay, % Sol Fe	Distn, % Sol Fe
Table conc	44.6	67.19	77.0
" middling	2.5	47.92	3.1
Combined conc + midd*	47.1	66.18	80.1
Table tailing	52.9	14.66	19.9
Feed (calcd)	100.0	38.93	100.0

*Calculated

Screening all of the feed to the table, in actual operation would necessitate handling a very large tonnage, so it was desired to investigate other alternatives. The idea of tabling and then screening out the coarse material from the products was suggested, so a size-assay analysis was made of the concentrate and middling products from Test 3. The results of these analyses are given in Tables 8 and 9.

TABLE 8

Size-Assay Analysis of Table Concentrate, Test 3

Mesh, Tyler	Weight, %	Assay, % Sol Fe	Distn, % Sol Fe
+ 35	5.0	44.44	3.4
+ 48	2.8	60.98	2.6
+ 65	6.3	63.84	6.1
+100	8.8	63.92	8.6
+150	10.9	63.44	10.6
+200	12.7	65.56	12.7
-200	53.5	68.44	56.0
Total (calcd)	100.0	65.43	100.0

TABLE 9

Size-Assay Analysis of Table Middling, Test 3

Mesh, Tyler	Weight, %	Assay, % Sol Fe	Distn, % Sol Fe
+ 35	12.6	33.58	10.4
+ 48	5.9	41.40	6.0
+ 65	7.2	36.58	6.5
+100	11.1	36.76	10.0
+150	13.9	36.46	12.5
+200	17.7	37.04	16.1
-200	31.6	49.58	38.5
Total (calcd)	100.0	40.68	100.0

From the results of the size-assay analyses of the table products it is apparent that little would be gained by screening. The removal of the plus 35-mesh material would increase the grade of the concentrate by about 1% with a loss of 3.4% in iron recovery. Screening of the middling product at any mesh size would not make any effective difference.

Gravimetric and chemical analyses of the middling product from Test 4 showed that this product is largely made up of iron-bearing and carbonate-

bearing minerals. The results of the gravimetric and chemical analyses are given in Table 8.

TABLE 8

Gravimetric and Chemical Analyses of Table Middling, Test 4

Product	Weight, %	Assay, %		Distn, % Sol Fe
		Sol Fe	CO_2	
Float @ 2.96 sp gr	24.80	2.05	1.46	1.3
" @ 3.33 " "	11.68	7.30	38.76	2.3
Sink @ 3.33 " "	63.52	57.04	6.51	96.4
Total (calcd)	100.00	37.59		100.0

Both the iron and carbonate units would be useful in the final concentrate, so it was decided to do the tabling without any screening and grinding. Another test was conducted similar to previous tests except that a larger middling cut was made. This middling product was then repassed over the table to make a second set of products. In this test initial tailing losses were low but unfortunately the concentrates were below acceptable grade. All of the products were recombined and the test was repeated. The second attempt was successful with grades of concentrate above the required level with the recovery near the maximum obtainable. The results of these tests are reported in Tables 9 and 10.

TABLE 9

Results of Tabling, Test 6

Product	Weight, %	Assay, % Sol Fe	Distn, % Sol Fe
No. 1 Table conc	47.0	64.15	77.5
No. 2 Table conc	5.1	62.45	8.2
Total conc (calcd)	52.1	63.98	85.7
Table middling	3.1	32.77	2.6
No. 2 Table tailing	10.7	15.26	4.2
No. 1 Table tailing	34.1	8.54	7.5
Feed (calcd)	100.0	38.9	100.0

TABLE 10

Results of Tabling, Test 7

Product	Weight, %	Assay, % Sol Fe	Distn, % Sol Fe
No. 1 Table conc	33.2	67.00	57.7
No. 2 Table conc	11.8	67.15	20.6
Total conc (calcd)	45.0	67.04	78.3
Table middling	5.9	43.17	6.6
No. 2 Table tailing	9.1	22.98	5.4
No. 1 Table tailing	40.0	9.29	9.7
Feed (calcd)	100.0	38.5	100.0

Spiral Plant Tailings

Two table tests were run on samples of spiral plant tailings. One jigging test was reported also.

Table tests were run under conditions similar to those for the Lamflo cleaner concentrate. The first test produced a product similar to the one produced using the Lamflo concentrator. Grade was similar,but the overall recovery was lower although the ratio of concentration was higher.

The second test was run in the presence of company officials. A high-grade finished concentrate was removed, along with a low-grade middling product. Recoveries for the two tests were similar. Results of the tests are given in Tables 11 and 12.

TABLE 11

Results of Tabling, Test 8

Product	Weight, % %	Assay, % Sol Fe	Distn, % Sol Fe
Table conc	21.9	40.35	61.4
" middling	13.9	10.50	10.2
Combined conc + middling	35.8	28.76	71.6
Table tailing	64.2	6.36	28.4
Feed (calcd)	100.0	14.38	100.0

TABLE 12

Results of Tabling, Test 9

Product	Weight, %	Assay, % Sol Fe	Distn, % Sol Fe
Table conc	5.5	66.83	26.0
" middling	26.4	23.80	44.4
" tailing	68.1	6.16	29.6
Feed (calcd)	100.0	14.15	100.0

It had been requested that jigging be tried as a method of preconcentrating the iron units in the spiral tailings. An investigation done on somewhat similar material, with the objective of making a finished product, had shown that it was possible to produce a concentrate with acceptable

rougher grade although the recovery was low. In this investigation, the objective was to make a product similar to a Lamflo rougher concentrate, i.e., a low-grade scavenger concentrate with high recovery. Several tests were made but none was successful. Suitable jigging conditions which would recover sufficient material at a suitable grade could not be established. The jig operating conditions are given in Table 13, and the results of the test are shown in Table 14.

TABLE 13

Jig Operating Conditions

Jig type	Denver No. 1-M
Feed rate	5 lb/hour
Jig speed	250 rpm
" stroke	3/16 in.
Ragging	
Type	Steel shot
Size	1/8 in. 3/16 in.
Weight	80 g 60 g
Supporting Screen	10 mesh
Water	760 cc/min

TABLE 14

Results of Jigging Spiral Tailings, Test 10

Product	Weight, %	Assay, % Sol Fe	Distn, % Sol Fe
Jig conc + bed	29.3	19.35	39.6
Jig tailing	70.7	12.22	60.4
Feed (calcd)	100.0	14.31	100.0

CONCLUSIONS

Iron values in a Lamflo cleaner concentrate can be concentrated by tabling, without any additional treatment, into a product of the required specification. In batch testing, a second stage of treatment of a small amount of middling product was required to obtain maximum recovery. Continuous pilot-plant operation might show that this step is unnecessary.

The two-stage operation resulted in a final concentrate of 67.04 per cent Sol Fe grade with 78.3 per cent Sol Fe recovery. This recovery is equivalent to a recovery of over 91 per centof the available high-grade iron as determined in the gravimetric analysis of the Lamflo cleaner concentrate reported in Table 2. The recovery of iron units in the Lamflo cleaner concentrate, as related to the original spiral tailings, is not known, so the overall recovery of iron units from the spiral tailings cannot be calculated.

Tabling of the spiral tailings directly did not give as high a recovery as the Lamflo concentrator but the concentrate grade was higher and, with additional testing, equivalent results might be obtained. In one test, 26 per cent of the iron was recovered in a finished concentrate which would not require retreatment. However, considering space requirements and other factors, it is unlikely that tables can compare favourably with the Lamflo concentrator as a rough concentrator.

Jigging of the spiral tailings was not successful. The test appeared to be more of a sizing operation rather than a concentrating one. Additional testing should improve the results but, from previous experience with somewhat similar material, it is not expected that the results would be as good as those obtained with either the table or the Lamflo concentrator.

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