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CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

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MINES BRANCH INVESTIGATION REPORT IR 62-116

REMOVAL OF IMPURITIES FROM PRODUCTS SUBMITTED BY THE STEEL COMPANY OF CANADA, LIMITED, HAMILTON, ONTARIO

by

P. D. R. MALTBY

MINERAL PROCESSING DIVISION

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SUMMARY OF RESULTS

Three different products were submitted to the Mineral Processing Division for the removal of impurities and the increase in iron content. Tests were first done on a sample of Open Hearth Precipitator Dust. No satisfactory results were obtained using mechanical separation techniques.

Tests on a sample of "S-L fines" resulted in a concentrate containing 0.98% silica and 1.58% insoluble at a grade of 94.2% iron. This concentrate contained 70.7% of the feed weight at a recovery of 75.4% of the iron in the original feed.

Tests were done on two different samples of specular hematite concentrate. A concentrate containing 0.32% silica and 61.4% of the original feed weight was produced using a Jones high intensity wet magnetic separator. Flotation tests on another sample of specular hematite concentrate lowered the silica content from 5.5% to 0.36%. Concentrate weight recovery was 84.2% of the original feed. Cost of flotation reagents was estimated at $0.29/ton of product. In a second test a concentrate containing 0.21% SiO_2 was produced. Concentrate weight recovery was 64.1% of the original feed.

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INTRODUCTION

Purpose of the Investigation

Three samples were submitted for testing. Two samples were by-products from Stelco processes. It was desired to find out whether the impurities could be removed sufficiently from either of these products so that the resulting concentrate could be profitably used. The third product was a sample of specular hematite concentrate. It was desired to lower the silica content in this sample to approximately 0.25% silica.

Shipment

Two drums of 'Open Hearth Precipitator Dust' weighing approximately 50 lb and one drum of 'S-L Fines' weighing approximately 25 lb were received at the Mines Branch on March 2, 1962, from Mr. J. G. Sibakin, Manager, Research and Development, The Steel Company of Canada, Limited. A sample of specular hematite concentrate originally from Wabush Iron Co., weighing approximately 15 lb, was brought from Hamilton later in the month by D. E. Pickett, following discussion with Mr. J. C. McKay.

Analysis

The chemical analyses shown in this investigation were made by the Analytical Chemistry Sub-Division, Mineral Sciences Division, Mines Branch. Analysts were D. J. Charette, J. Hole, E. Mark, F. W. Brethour, R. W. Buckmaster, R. Craig and R. McAdam.

Object of Investigation

In a letter, Mr. Sibakin stated the source and tonnages involved of the dust and S-L fines. The dust is collected from Open Hearth stack gases by electrostatic precipitators. Eventually, about 100 tons of dust each day will be accumulated. The dust contains undesirable amounts of zinc, lead and copper as oxides and possibly as sulphides, and it was desired to develop an economic purification process, so that the purified dust could be agglomerated by sintering or pelletizing and charged to the blast furnace.

The S-L fines are that part of the magnetic discharge of the direct reduction kiln which has a particle size of minus $\frac{1}{4}$ in. It was desired to find out if the gangue minerals present in the fines could be removed to produce a relatively pure iron powder.

The Company was interested in discovering if a very low silica iron concentrate could be produced as suitable feed for the direct reduction or powder pyrometallurgical industries. It was suggested that specular hematite concentrate from Quebec-Labrador would be the best material to try. Accordingly, a small sample of Wabush concentrate, from a Company stockpile, was brought to Ottawa for testing. The concentrate was obtained from the crude ore by gravity separation using Humphreys spirals.

RESULTS

Tests on Open Hearth Precipitator Dust

The dust was examined by the Mineralogy Section, Mineral Sciences Division*. Examination of a polished surface showed that the majority of the material was well below 10 microns in size, with a few grains in sizes varying up to 200m. The larger grains appeared to be round globules consisting of magnetite or magnetite and hematite combined. No natural pyrite or sphalerite were detected. A chemical analysis was submitted by the Company and is shown in Table 1.

TABLE 1

Analysis of Open Hearth Precipitator Dust

Component	%
Fe (total)	58.2
FeO	1.2
SiO_2	2.42
Al_2O_3	0.46
CaO	1.20
MgO	0.68
P	0.096
Mn	0.38
C	0.114
S	1.27
Pb	0.71
ZnO	4.26

* From Internal Report MS-62-50 by Dr. M. H. Haycock.

With a sample of this nature, magnetic separation appeared to be the best possible solution. A sample was treated separately by a Ball-Norton dry belt magnetic separator, a Jeffrey-Steffensen 3-drum wet magnetic separator, and a Jones high intensity wet magnetic separator. Separation in all these tests was poor. The results of the separation using a Ball-Norton separator are shown in Table 2, and the results, using a Jones separator, are shown in Table 3. Only 1% of the feed weight was collected in the Jeffrey-Steffensen concentrate, the remainder being in the middling, 1.8%, and the tailing, 97.2%. The products from this test were not analysed.

TABLE 2

Results Using Ball-Norton Separator

Product	Weight %	Analysis %*	
		Pb	Zn
Conc	97.0	0.78	2.83
Tail	3.0	0.61	2.25
Feed	100.0		

* From Internal Report MS-AC-62-337.

TABLE 3

Results Using Jones Separator

Product	Weight %	Analysis %**			Distn %
		Sol Fe	Pb	Zn	Sol Fe
0 amp conc	25.2	61.40	0.53	2.43	26.4
0 " midd	47.1	57.20	0.79	2.89	46.0
0 " tail	27.7	58.39	1.08	3.35	27.6
Feed*	100.0	58.6			100.0

* calculated

** From Internal Report MS-AC-62-337.

Tests on S-L Fines

A chemical analysis and screen analysis were done by the Company on a sample of the 'fines'. The results are shown in Tables 4 and 5.

TABLE 4

Chemical Analysis of S-L Fines

Component	%
Fe (total)	90.80
FeO	1.50
Fe (metallic)	86.80
Fe_2O_3	2.50
S	0.022
C	0.19
SiO_2	3.22
Al_2O_3	0.49
CaO	0.45
MgO	1.48

It was desired, if possible, to make a concentrate containing at least 98% total Fe with less than 0.015% S, 0.25% SiO_2, and a total gangue content less than 1%.

TABLE 5

Size Distribution of S-L Fines

Size	Weight %	Cum Weight %
+6m	13.6	
-6m+10m	47.7	61.3
-10m+20m	27.7	89.0
-20m+35m	8.4	97.4
-35m+65m	2.1	99.5
-65m	0.5	

A 2000 g sample was pulverized to minus 65m and was ground in a ball mill for one hour. The ground sample was treated by a Jeffrey-Steffensen magnetic separator, and the concentrate was cleaned in a hydroseparator using an upflow rate of 60 ft/hr. The results are shown in Table 6.

TABLE 6

Preliminary Treatment of S-L Fines

Product	Weight %	Analysis % **					Distn % Sol Fe
		Sol Fe	Met Fe	SiO_2	Insol	S	
Jeffrey tail	7.1	20.8					1.7
" midd	4.1	71.66					3.4
Hydroseparator o'flow	3.8	82.2					3.5
Hydroseparator spigot	85.0	94.26	90.2	1.0	1.92	0.023	91.4
Feed*	100.0	87.7					100.0

* calculated

** From Internal Report MS-AC-62-256.

The results of a screen test on the hydroseparator spigot product are shown in Table 7.

TABLE 7

Size Distribution of Hydroseparator Spigot Product

Size	Weight %	Cum Weight %
+100	1.5	
-100+150	20.7	22.2
-150+200	37.7	59.9
-200+325	31.3	91.2
-325	8.8	
Total	100.0	

A further test was done in which a 2000 g sample was ground for 2 hours after pulverizing to minus 65m, and then was treated by the same procedure. The results of this test are shown in Table 8.

TABLE 8

Further Treatment of S-L Fines

Product	Weight %	Analysis % **				Distn % Sol Fe
		Sol Fe	Met Fe	SiO2	Insol	
Jeffrey tail	5.3	28.48				1.7
" midd	1.7	83.84				1.5
Hydroseparator o'flow	4.5	90.20				4.5
" spigot	88.5	95.08	91.95	1.08	1.92	92.3
Feed *	100.0	91.15				100.0

* calculated

** From Internal Report MS-AC-62-436.

The hydroseparator spigot product was ground for a further 2 hours and was re-treated by magnetic separator and hydroseparator with the results shown in Table 9.

TABLE 9

Re-treatment of Hydroseparator Spigot Product

Product	Weight %	Analysis % **			Distn % Sol Fe
		Sol Fe	SiO2	Insol	
Jeffrey tail	3.5	48.58			1.8
" midd	3.3	87.16			3.1
Hydroseparator o'flow	13.3	92.50	0.88		13.4
" spigot	79.9	94.20	0.98	1.58	81.7
Feed *	100.0	92.2			100.0

* calculated

** From Internal Report MS-AC-62-530.

Based on the original feed sample, the hydroseparator spigot contained 70.7% of the weight at a recovery of 75.4% of the iron in the original sample.

A screen test was done on the hydroseparator spigot product with the results shown in Table 10.

TABLE 10

Size Distribution of Hydroseparator Spigot Product

Size	Weight %	Cum Weight %
+150	2.0	
-150+200	13.8	15.8
-200+325	58.3	74.1
-325	25.9	
Total	100.0	

Tests on Specular Hematite Concentrates

A 15 lb sample of spiral concentrate was received for removal of silica. The Company was interested in obtaining a product containing a silicon content of 0.25% maximum. Two methods seemed applicable -- grinding and concentration using a Jones high intensity wet magnetic separator, and grinding followed by cationic silica flotation.

Tests Using the Jones Separator

Half the sample, which was all minus 28m, was cobbed on a Ball-Norton dry belt magnetic separator, and the concentrate treated at various amperages on a Jones separator. The results are shown in Table 11.

TABLE 11

Preliminary Separation Results

Product	Weight %	Analysis % SiO_2 **	Distn % SiO_2
B-N conc	5.6	1.24	2.9
Jones 0 amp conc	3.3	1.94	2.5
" 5 " "	38.5	0.96	15.2
" 10 " "	42.0	0.92	16.0
" 10 " midd	7.9	8.56	28.0
" 10 " tail	2.7	31.92	35.4
Feed*	100.0	2.43	100.0

* calculated

** From Internal Report MS-AC-62-433.

The feed at 5 amp was made up from the 0 amp middling and tailing products, and at 10 amp from the 5 amp middling and tailing products.

The 5 and 10 amp concentrates were combined and ground in a ball mill for 5 minutes. The ground product was then re-treated in a Jones separator with the results shown in Table 12.

TABLE 12

Re-treatment of 5 and 10 amp Concentrates

Product	Weight % of orig feed	Analysis % SiO_2 **	Distn % of orig feed SiO_2
Jones 10 amp conc	71.2	0.54	14.6
" 10 " midd	7.6	2.64	7.7
" 10 " tail	1.7	13.40	8.9
Feed*	80.5	1.01	31.2

* calculated

** From Internal Report MS-AC-62-530.

The 10 amp concentrate was dried, was pulverized to minus 100m, and was repassed on a Jones separator at 10 amp. The results are shown in Table 13.

TABLE 13

Retreatment of 10 amp Concentrate

Product	Weight % of orig feed	Analysis % SiO_2 **	Distn % of orig feed
Jones 10 amp conc	61.4	0.32	5.9
" 10 " midd	6.5	2.04	4.0
" 10 " tail	3.3	4.68	4.7
Feed*	71.2	0.68	14.6

* calculated

** From Internal Report MS-AC-62-661.

A screen test was done on the final 10 amp concentrate with the results shown in Table 14.

TABLE 14

Size Distribution of Final 10 amp Concentrate

Size	Weight %	Cum Weight %
+150	39.0	
-150+200	25.6	64.6
-200+325	19.0	83.6
-325	16.4	
Total	100.0	

The remaining half of the sample was pulverized to minus 100m and was treated by a Jones separator at 0 amp, the middling and tailing then being repassed at 10 amp. The results are shown in Table 15.

TABLE 15

Treatment of Feed at Minus 100m

Product	Weight %	Analysis % **		Distn %
		Sol Fe	SiO_2	Sol Fe
Jones 0 amp conc	10.0	67.5		10.0
" 10 " "	70.2	70.0	0.47	72.5
" 10 " midd	12.1	62.5		11.1
" 10 " tail	7.7	56.8		6.4
Feed*	100.0	67.82		100.0

* calculated

** From Internal Report MS-AC-62-774.

Flotation Tests

After completion of the Jones separator tests, none of the original sample of specular hematite was left. Accordingly, flotation tests were done on a sample of specular hematite concentrate taken from a stockpile at the Mines Branch. In previous work it had been discovered that, in the presence of iron minerals, cationic flotation of silica was best when done on particles finer than 150m. Accordingly, in all the tests the samples were first ground all minus 150m.

After several preliminary tests had been done, the most promising reagents appeared to be a combination of Rosin Amine D Acetate (RADA) as collector and a mixture of 50% pine oil, 2.5% Aerosol OT 100, and 47.5% water by volume (PoA) as frother. The feed was first conditioned with dextrine WW82.

A 2000 g sample was ground wet to minus 150m and was split into 2 parts. The first fraction was pulped in a 1000 g Agitair laboratory flotation cell and was conditioned for 5 minutes with 2 lb of dextrine/ton. After conditioning 0.2 lb of RADA and 0.2 lb of PoA/ton were added and a froth was floated for 5 minutes. The results are shown in Table 16.

TABLE 16

Results of Silica Flotation

Product	Weight %	Analysis % **		Distn %
		Sol Fe	SiO_2	Sol Fe
Froth	15.8	45.57		10.9
Concentrate	84.2	69.62	0.36	89.1
Feed*	100.0	65.82		100.0

* calculated

** From Internal Report MS-AC-62-1274.

The froth product was cleaned once with no satisfactory results. Reagent cost would be $0.29/ton of product.

The second fraction was also conditioned with 2 lb dextrine/ton for 5 minutes. After conditioning 0.3 lb of RADA and 0.3 lb of PoA/ton were added and a froth was floated for 5 minutes. In an effort to improve the recovery, the froth product was cleaned twice with no additional reagents. The results are shown in Table 17.

TABLE 17

Results of Further Silica Flotation

Product	Weight %	Analysis % **		Distn %	
		Sol Fe	SiO_2	Sol Fe	SiO_2
Froth	8.5	34.69	49.9	4.4	76.8
2nd Cl conc	9.0	61.97	10.56	8.5	17.2
1st Cl conc	18.4	69.20	0.84	19.3	2.7
Conc	64.1	69.78	0.28	67.8	3.3
Feed*	100.0	65.98	5.52	100.0	100.0

* calculated

** From Internal Report MS-AC-62-1274.

A combination of the last two products shows a grade of 69.65% Fe with 0.40% SiO_2. A screen test was done on the concentrate shown in Table 16 with the results shown in Table 18.

TABLE 18

Size Distribution of Concentrate From Flotation

Size	Weight %	Cum Weight %
-100+150m	0.5	
-150+200m	16.6	17.1
-200+325m	38.0	55.1
-325m	44.9	
Total	100.0	

CONCLUSIONS

Attempts to recover iron and eliminate impurities from the Open Hearth Precipitator dust by mechanical means failed. A more promising method to treat the dust might be by reduction in a kiln.

Some upgrading of the S-L fines was obtained by grinding and magnetic separation. However, due to the large amount of metallic iron present, very little grinding actually took place. Most of the energy was dissipated in altering the shape of the iron particles.

Promising results were obtained in removing silica from samples of specular hematite concentrates. The flotation process appeared better than high intensity wet magnetic separation due to its flexibility and higher concentrate recoveries. Flotation results could probably be improved by further testing in laboratory and pilot plant.

PDRM:EBM