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BENEFICIATION OF NAIRNE PYRITE CALCINES.

FIRST REPORT.

By
L.J. Weir.

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C O N T E N T S.

Abstract.

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ABSTRACT.

Magnetic separation, flotation concentration and gravity concentration/size classification methods were tested for the beneficiation of Nairne-pyrite calcines.

Magnetic separation following a reducing roast produced a concentrate assaying 62.1 per cent. Fe at a recovery of 96.2 per cent.

Magnetic treatment of unreduced material gave high concentrate grade but low recovery, while flotation concentration and cyclone treatment gave low grades and recoveries.

1. SUMMARY.

Distribution of iron in the various size fractions of the calcine, although lower in the fine sizes, was too even to obtain beneficiation by size classification. A hydrocyclone test was carried out to investigate the possibility of a combination of size classification and gravity concentration, but the results were not encouraging.

Magnetic treatment of the calcine gave a concentrate assaying 59.7 per cent. Fe at a recovery of 49.6 per cent. Grinding the calcine increased the magnetic concentrate grade at the expense of recovery; for example, increasing the percentage of minus 300 mesh material from 54.5 to 77.5, raised the concentrate grade to 63.1 per cent. Fe, but the recovery decreased to 40.0 per cent.

Magnetic treatment of a calcine reduced at 650° C. gave a concentrate grade of 62.1 per cent. Fe at a recovery of 96.2 per cent. Grinding of reduced material did not raise the magnetic product grade significantly, and recovery decreased slightly.

Roasts carried out at lower temperatures showed that efficient reduction took place at 550°C, but when the calcine was roasted at 450°C, recovery decreased to 92.4 per cent. At 350°C, virtually no reduction occurred.

Flotation using a tall oil collector emulsion gave little upgrading in a rougher concentrate, and was not investigated further.

2. INTRODUCTION.

Sulphuric Acid Limited, Birkenhead, requested that preliminary investigations into the beneficiation of the calcine from the roasting of Nairne pyrite concentrates be undertaken with the object of producing a marketable iron concentrate. Although no specific value was set, a concentrate grade of at least 60 per cent. Fe was aimed for.

3. MATERIAL EXAMINED.

Approximately 500 pounds of calcine from current production was received.

4. EQUIPMENT USED.

The following items of equipment were used in test work:-

(a) Haultain infrasizer.

(b) Glass laboratory cyclone (Solid-Liquid Separations Ltd)

(c) 500 grm. laboratory ball mill.

(d) Davis tube magnetic separator.

(e) Electric muffle furnace, (0-1,400°C).

(f) Fagergren laboratory flotation machine.

(g) B.S.S. laboratory screens.

5. EXPERIMENTAL PROCEDURE.

The calcine included agglomerated lumps of unroasted pyrite and these were removed by screening the head sample at 18 mesh. All tests reported refer to the minus 18 mesh fraction.

A sizing was carried out on the head sample, and the distribution of iron in the size fractions determined.

A hydrocyclone test was carried out on a portion of the head sample.

Magnetic separation tests were carried out on the calcine as received, and after grinding to three degrees of fineness. Similar tests were made on calcine roasted in a reducing atmosphere. Roasting temperatures were varied to determine optimum conditions.

A flotation test was carried out on ground calcine after high density conditioning with a tall oil emulsion.

6. CONDITIONS AND RESULTS:

6.1 Sizing:

During sampling of the calcine, a number of coarse lumps of partially reduced pyrite were noticed. The material was screened on 18 mesh and the oversize, approximately 1.4 per cent of the sample, rejected as being likely to cause anomalous results in ./3..

6.1 (Cont).

the small portions of sample being taken for test work.

A sizing analysis of the screened sample is given in Table 1.

Table 1.

Feed Sizing.

Size.	Weight %.	Fe.%.	Distribution Fe %.
+ 72 mesh	4.4	48.2	4.0
+100 "	7.2	55.2	7.6
+150 "	8.4	58.3	9.3
+200 "	15.9	59.2	17.9
+300 "	9.6	56.9	10.4
+ 31 microns	9.2	61.5	10.8
+ 22 "	12.8	44.0	10.7
+ 15 "	8.1	47.7	7.3
+ 11 "	4.9	49.7	4.6
+ 8 "	2.4	49.7	2.4
- 8 "	17.1	46.0	15.0
	100.0	52.5	100.0

6.2 Cyclone Treatment:

A batch test was conducted using a 2.5 inch diameter glass laboratory cyclone under the conditions given in Table 2.

Table 2.

Cyclone Test Conditions.

Vortex Finder Diameter	inches....	5/32
Underflow Diameter	"	1/16
Feed........................	%solids....	5
Overflow....................	% "	0.6
Underflow...................	% "	35

Results of the test are given in Table 3.

Table 3.

Cyclone Test Results.

Size.	Weight %.	Fe %.	Distribution Fe %.
Overflow	18.2	44.3	83.0
Underflow	81.8	48.5	17.0
	100.0	47.7	100.0

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6.3 Magnetic Separation:

6.3.1 Treatment of Unground and Ground Calcine:

Samples of both unground material and calcine ground in a laboratory ball mill at 60 per cent. solids for 5, 15, and 30 minutes, were separated in a Davis Tube machine. Sizings of the respective grinds are given in Table 4.

Table 4.

Sizing of Ground Calcine.

Mesh	Grinding Time (Minutes)		
	5	15	30
	Weight %.	Weight %.	Weight %.
+ 52	0.2	Nil	Nil
+ 72	0.7	0.1	Nil
+ 100	3.6	0.6	0.3
+ 150	6.9	2.1	0.6
+ 200	16.4	12.1	7.5
+ 300	14.7	15.2	14.1
- 300	57.5	69.9	77.5
	100.0	100.0	100.0

Conditions used for magnetic separation are given in Table 5.

Table 5.

Davis Tube Magnetic Separation Conditions.

Feed Rate (grms/min)	Approx. 5
Water Flow Rate (litres/min)..	" 2
Coil Current (amps)	1.0
Stroke Frequency(cycles/min)..	80

Results of magnetic treatment are given in Table 6.

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Table 6.

Results of Magnetic Treatment of Calcine.

Test	Product	Weight %.	Fe%.	Distribution Fe%
1 - Unground	Magnetics	42.8	59.7	49.6
	Non-magnetics.......	57.2	45.3	50.4
		100.0	51.5	100.0
2- Ground 5 mins.	Magnetics	36.7	61.8	43.9
	Non-magnetics.......	63.3	45.8	56.1
		100.0	51.7	100.0
3- Ground 15 mins.	Magnetics...........	34.5	60.3	41.2
	Non-magnetics	65.5	45.3	58.8
		100.0	50.5	100.0
4- Ground 30 mins.	Magnetics...........	32.8	63.1	40.0
	Non-magnetics.......	67.2	46.2	60.0
		100.0	51.7	100.0

6.3.2 Treatment of Unground and Ground Roasted Calcine.

6.3.2.1 Tests at a fixed roasting temperature.

Charges of calcine weighing 500 grams, held in a stainless steel container, were maintained at a temperature of 650°C. in an electric muffle furnace for two hours, and then allowed to cool slowly. Coal gas was passed through the container during both roasting and cooling, to provide a reducing atmosphere. Reduced calcine was ground using conditions identical to those used for the unreduced calcine.

Sizings of the ground material are given in Table 7.

Table 7.

Sizing of Ground Reduced Calcine.

Mesh	Grinding Time (minutes) 5	15	30
	Weight %	Weight %	Weight %
+ 52	0.3	0.2	0.1
+ 72	1.5	1.6	0.2
+ 100	4.4	4.1	1.5
+ 150	6.8	5.0	2.1
+ 200	16.2	13.4	8.6
+ 300	13.5	13.3	12.9
- 300	57.3	62.4	74.6
	100.0	100.0	100.0

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The conditions used in magnetic treatment were similar to those given in Table 5.

Results are given in Table 8.

Table 8.

Results of Magnetic Treatment of Calcine reduced at 650°C.

Test	Product	Weight %	Fe %	Distribution Fe %
5 - Unground	Magnetics...	83.3	62.1	96.2
	Non-magnetics	16.7	12.1	3.8
		100.0	53.7	100.0
6 - Ground 5 mins.	Magnetics.....	83.4	61.2	96.0
	Non-magnetics	16.6	12.7	4.0
		100.0	53.1	100.0
7- Ground 15 mins.	Magnetics....	84.7	60.0	96.5
	Non-magnetics	15.3	12.0	3.5
		100.0	52.6	100.0
8- Ground 30 mins.	Magnetics...	80.8	62.8	94.6
	Non-magnetics	19.2	15.1	5.4
		100.0	53.6	100.0

6.3.2.2 Tests at Various Roasting Temperatures.

Three further roasts at temperatures of 550°C, 450°C, and 350°C, respectively were carried out on 100 grm. charges of calcine.

Other conditions were similar to those used in previous tests.

The unground material was separated magnetically under the conditions given in Table 5. Results are given in Table 9.

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Table 9.

Results of Magnetic Treatment of Calcine reduced at different temperatures.

Test	Reduction Temperature	Product	Weight %	Fe%	Distribution Fe%
9	550°C	Magnetics ...	82.5	61.8	95.8
		Non-magnetics	17.5	12.9	4.2
			100.0	53.3	100.0
10	450°C	Magnetics ...	79.8	61.5	92.4
		Non-magnetics	20.2	20.0	7.6
			100.0	53.1	100.0
11	350°C.	Magnetics...	46.8	64.0	53.6
		Non-magnetics	53.2	48.8	46.4
			100.0	55.9	100.0

6.4 Flotation.

A 500 grm. charge of calcine was ground in a laboratory ball mill at 60 per cent solids for 30 minutes. The pulp was conditioned in a laboratory attritioner at 60 per cent solids for 20 minutes with a reagent addition of 4 pounds per ton, and floated at 15 per cent. solids. The rougher concentrate was not cleaned. The reagents added were:-

Fuel Oil	2.54	lb./ton
Pamak 1	1.27	" "
Napthenic Acid	0.13	" "
P 100	0.06	" "
Total..................	4.0	

Results are given in Table 10.

Table 10.

Results of Flotation with a Tall Oil Emulsion.

Product	Weight %.	Fe%.	Distribution Fe%.
Rougher tailing........	90.4	54.6	91.6
Rougher concentrate ...	9.6	47.4	8.4
	100.0	53.9	100.0

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7. DISCUSSION OF RESULTS.

Iron distribution in the various size fractions indicated that minor up-grading could be effected by size classification only at the expense of recovery. A cyclone test carried out on the basis that a combination of size classification and gravity concentration might improve the beneficiation was not successful.

Magnetic separation of unground calcine gave a concentrate grade of approximately 60 per cent. Fe at a recovery of approximately 50 per cent. Grinding of the material before magnetic treatment resulted in raising of the concentrate grade at the expense of recovery, which decreased to approximately 40 per cent. (Table 6.)

This effect was not so marked when material reduced at 650°C was treated. Recovery ranged from 94.6 per cent. to 96.5 per cent at a grade of between 60 and 62.8 per cent. Fe (Table 8). Grinding had no significant effect on grade or recovery.

A comparison of Table 4 and Table 7 shows that no significant reduction in hardness of the calcine was effected by roasting.

Magnetic separation of material roasted at various temperatures showed that satisfactory reduction was obtained below 650°C. Calcine roasted at 550°C. gave a recovery of 95.8 per cent. and roasting at 450°C. decreased the recovery to 92.4 per cent. at similar concentrate grade. Roasting at 350°C. gave a recovery of only 53.6 per cent, showing that virtually no reduction had taken place(Table 9)

Flotation of ground calcine gave very little upgrading(Table10).

8. CONCLUSIONS.

Size classification or gravity separation is not satisfactory for beneficiation of this material.

Assuming the efficiency of magnetic separation to be relatively high, it can be deduced that approximately 45 per cent. of the iron is present as magnetite and the balance as hematite. A high grade iron product can be produced by concentrating this magnetite.

Most of the hematite can be reduced to magnetite by roasting in a coal gas atmosphere under suitable conditions. Subsequent magnetic treatment is capable of producing a high grade iron product at high recovery.

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Grinding of feed for magnetic separation is not warranted.

Flotation of the iron mineral does not appear promising.

As products of test work were assayed for iron only, it is not known what decrease in silica content was effected by beneficiation.
