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MINES BRANCH INVESTIGATION REPORT IR 61-103

PILOT PLANT INVESTIGATION OF IRON ORE SAMPLE 'E' FROM KUKATUSH MINING CORPORATION (1960) LIMITED, KUKATUSH, ONTARIO

by

P. D. R. MALTBY & L. L. SIROIS

MINERAL PROCESSING DIVISION

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SUMMARY OF RESULTS

Cobbing at 3/8 in. showed that only 10% of the original feed was magnetically discarded. Cobbing at 20 M showed that over 25% of the original feed was discarded with a loss of 5.4% of the iron in the original sample.

In a series of pilot plant tests it was found that by grinding the ore in one stage of rod milling and in two stages of ball milling to about 93% minus 325 M, a concentrate could be produced meeting premium grade pellet specifications. In Test 7 a concentrate assaying 66.5% Fe and 7.04% SiO_2 was made at a recovery of 88.2% of the iron in the original feed. It was possible to clean this concentrate using a Jeffrey-Steffensen separator and a Wade hydroseparator to 68% Fe and 5.28% SiO_2, retaining 82.6% of the iron in the original sample. Ratio of concentration from crude ore for this concentrate was 2.59:1.

Further analyses were done on the concentrate produced in Test 2 that showed it contained 0.025% TiO_2, 0.029% S, and 0.018% P.

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TABLES

INTRODUCTION

The purpose of the investigation was to find out if a concentrate suitable for premium grade products could be made by conventional grinding and magnetic separation from the sample of ore submitted.

Shipment

A carload of 60 tons of iron ore was received at the Mines Branch for pilot plant testing on July 26, 1961. The ore was said to be representative of the 'E' orebody of the property at Kukatush, Ontario, of Kukatush Mining Corporation (1960) Limited, 2100 Drummond Street, Montreal 25, P.Q. The ore was coarser-grained and of better grade than the sample of 'F' ore tested previously and described in Investigation Report IR 61-85.

Sample Analysis

All analyses in connection with this investigation were done by the Analytical Chemistry Subdivision, Mineral Sciences Division, Mines Branch, Ottawa.

Outline of Investigation

The methods used for beneficiation of the sample were decided on with Mr. T. B. Counselman of Behre, Dolbear and Company, 11 Broadway, New York, consultants to Kukatush Mining Corporation. Mr. Counselman was present at the Mines Branch during most of the pilot plant tests.

Preliminary cobbing tests showed that the ore could be best cobbed at 10 or 20 M. Some laboratory tests showed that a grind of about 94% minus 325 M was needed to produce a concentrate of 67% Fe with less than 6% SiO_2, using a Jeffrey-Steffensen separator.

In the pilot plant Test 1, the crude ore was treated by standard taconite methods. The flowsheet for Test 1 is shown in Figure 6. In Test 2, the concentrate produced from Test 1 was reground and retreated. A further laboratory test using a Jeffrey-Steffensen separator was done on the final concentrate to discover the maximum Fe grade obtainable at the given grind.

In Test 3 a first stage run was done using a similar flowsheet to Test 1. Concentrate from Test 3 was upgraded in Test 4, with a further Jeffrey-Steffensen treatment on the concentrate. In Tests 5 and 6, further crude ore was treated. This concentrate was upgraded in Tests 7 and 8, and shipped for pelletizing tests.

MINERALOGY*

The iron ore consists of magnetite-rich, chert-rich and jasper bands (see Figure 1). The magnetite-rich bands are composed of magnetite, chert, calcite, goethite, minnesotaite, stilpnomelane and chlorite. The magnetite occurs as masses in some of the magnetite-rich bands (see Figure 2), and as disseminated grains that range between 10 microns and 100 microns in diameter in other magnetite-rich bands (see Figure 3). The magnetite content of the massive magnetite-rich bands is estimated to be about 80% to 95% magnetite but the magnetite content of the other magnetite-rich bands

*Internal Report MS-61-84 of the Mineral Sciences Division, Mines Branch, by W. Petruk, Mineralogy Section.

is much lower. Chert is the principal gangue mineral and it generally contains inclusions of dusty magnetite. However, the chert immediately surrounding larger magnetite grains does not contain much dusty magnetite (see Figure 4) and, occasionally, it contains a few blades of minnesotaite and grains of chlorite.

The chert-rich bands contain inclusions of dusty magnetite and occasional small grains of magnetite, calcite, minnesotaite, chlorite, and pyrite (see Figure 5). The amount of dusty magnetite in the chert is relatively uniform within each band but the amount of magnetite present varies considerably from band to band.

The jasper bands contain occasional magnetite grains and, of course, owe their red colour to the presence of very finely divided hematite. It is to be noted that the magnetite bands adjacent to the jasper contain scattered grains of hematite.

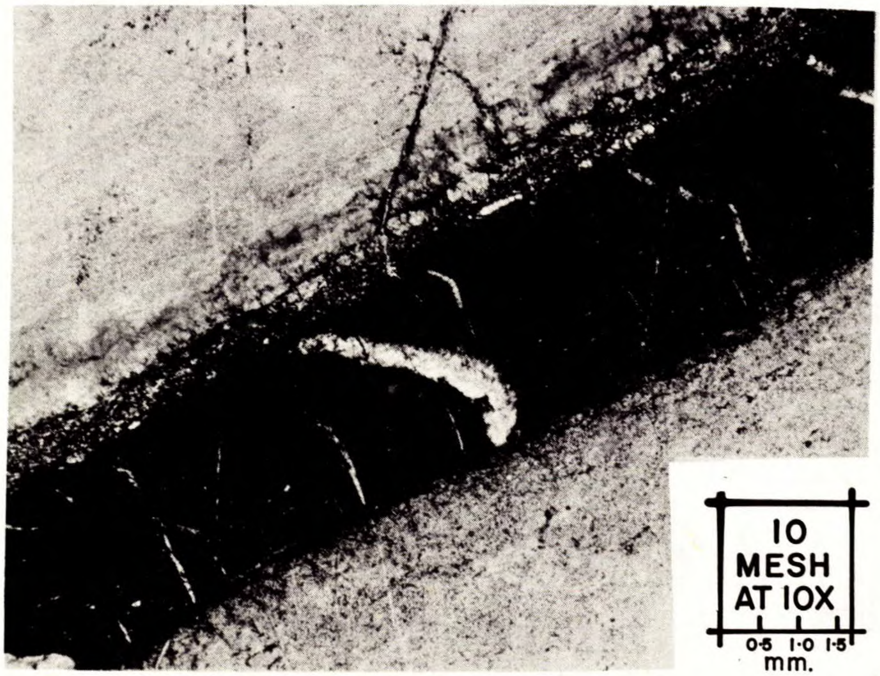

Figure 1 - Photomicrograph of a thin section showing one magnetite-rich band (black) and two chert-rich bands (white with tiny black spots).

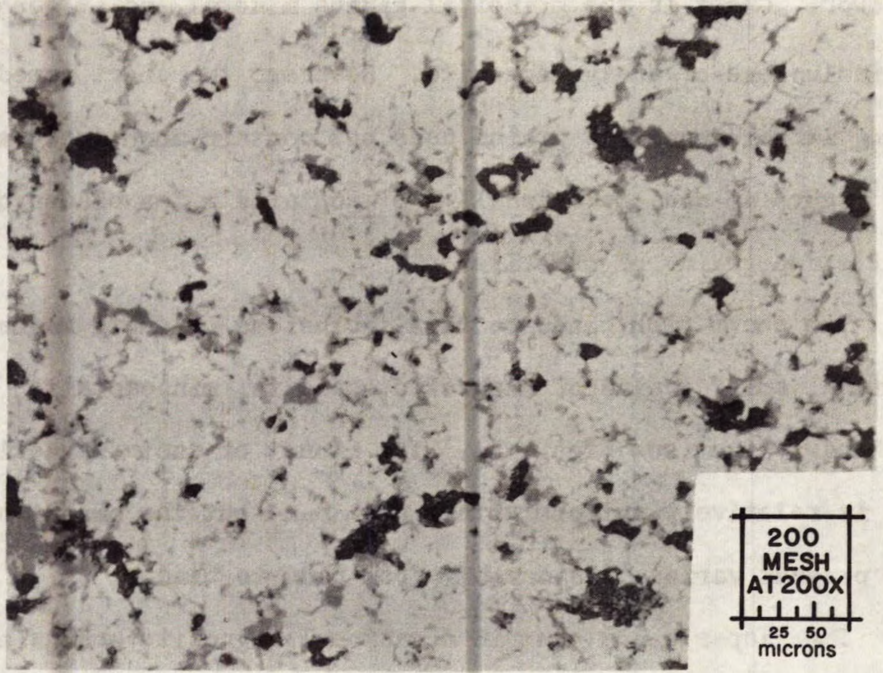

Figure 2 - Photomicrograph of a polished section showing a field of massive magnetite (white). The grey areas are gangue and the black spots are pits in the polished surface.

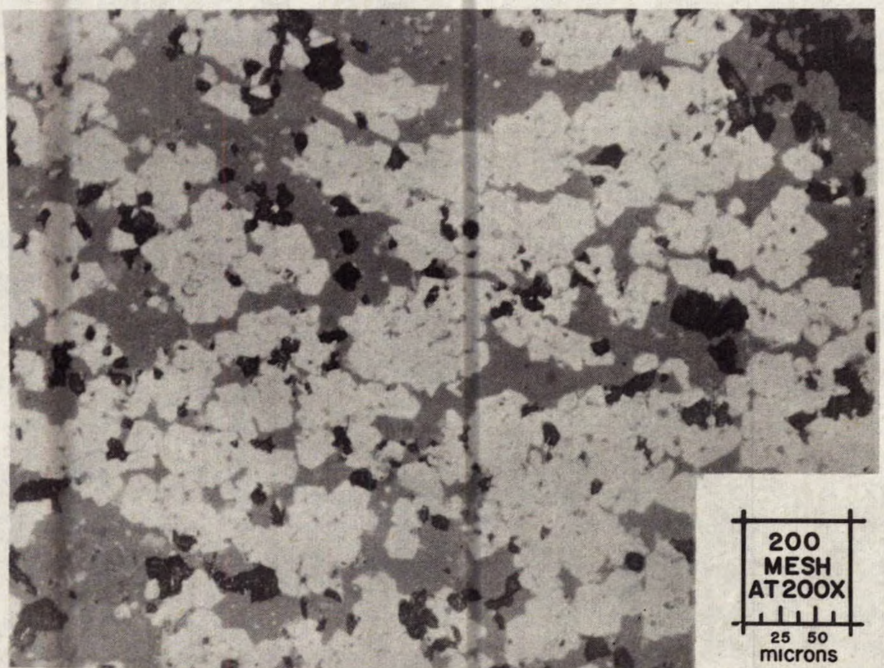

Figure 3 - Photomicrograph of a polished section showing a field of disseminated magnetite (white). The grey areas are gangue and the black spots are pits on the polished surface.

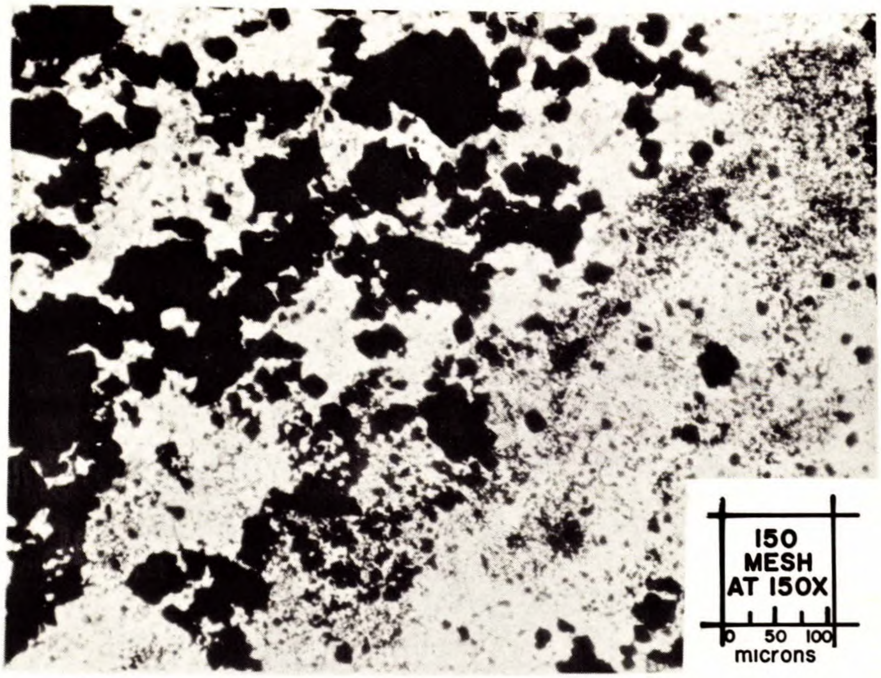

Figure 4 - Photomicrograph of a thin section showing a field of chert that does not contain much dusty magnetite adjacent to large magnetite grains, and a field of chert that contains dusty magnetite where there is less disseminated magnetite.

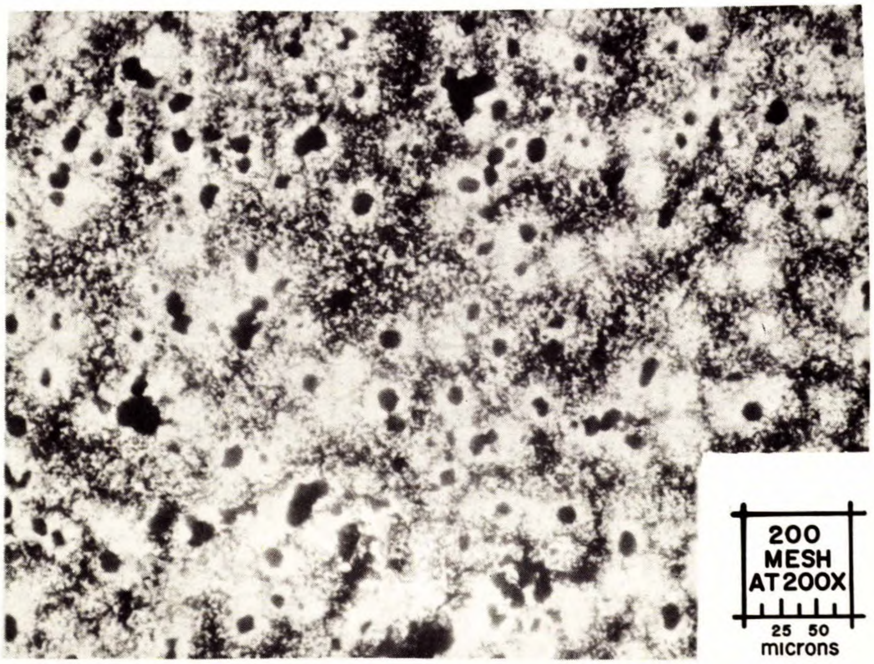

Figure 5 - Photomicrograph of a thin section of a chert band. The chert contains grains of magnetite and a considerable amount of dusty magnetite (black). It can readily be seen that the chert in the immediate vicinity of the larger magnetite grains does not contain much dusty magnetite.

TEST PROCEDURE AND RESULTS

Preliminary Cobbing Tests

Dry Cobbing

About 300 lb of crude ore was passed over a belt with a magnetic head pulley. The ore was crushed to minus 3/8 in. and the magnet was set at maximum amperage of 17 amp. Two tests were run, the only variable being the distance of the splitter plate from the belt. Results of cobbing are shown in Table 1.

TABLE 1

Results of Cobbing at 3/8 in.

Product	Splitter Setting	Weight %	Analysis %		Distn %	
			Sol Fe	Mag Fe	Sol Fe	Mag Fe
Conc	$1\frac{1}{4}$ in.	89.8	36.38	32.3	97.4	98.6
Tail		10.2	8.60	3.92	2.6	1.4
Feed*		100.0	33.55	29.4	100.0	100.0
Conc	$1\frac{3}{4}$ in.	95.4	35.32	31.3	99.0	99.0
Tail		4.6	7.70	2.77	1.0	1.0
Feed*		100.0	34.05	30.0	100.0	100.0

* calculated

Wet Cobbing

A sample of 15 lb of crude ore was crushed to minus 20 M and passed over a small Crockett wet belt separator. Results of this test are shown in Table 2.

TABLE 2

Results of Cobbing at 20 M

Product	Weight %	Analysis %		Distn %	
		Sol Fe	Mag Fe	Sol Fe	Mag Fe
Conc	74.7	43.12	39.7	94.6	99.0
Tail	25.3	7.22	1.16	5.4	1.0
Feed*	100.0	34.04	30.0	100.0	100.0

* calculated

From the results shown in Tables 1 and 2, it was decided that the crude ore should be first cobbed at 10 or 20 M in the pilot plant tests.

Preliminary Concentration Tests

The Crockett concentrate, shown in Table 2, was split into 3 parts and ground for 20, 40 and 60 min. Each ground product was passed through a Jeffrey-Steffensen separator and the concentrate was cleaned in a Wade hydroseparator. The results of these tests are shown in Tables 3, 4 and 5. Settings were No. 1 drum 2.2 amp, No. 2 drum 1.2 amp, No. 3 drum 0.7 amp. Wade upflow was 70 ft/hr.

TABLE 3

Results of Concentration After 20 Min Grind

Product	Weight %	Analysis %		Distn %	
		Sol Fe	Mag Fe	Sol Fe	Mag Fe
Jeff tail	34.0	7.24	1.60	6.0	1.4
" midd	8.2	33.28	31.8	6.7	6.8
Wade o'flow	1.4	54.56	54.2	1.9	1.9
" spigot	56.4	61.76	61.5	85.4	89.9
Feed*	100.0	40.8	38.6	100.0	100.0

* calculated

Ratio of concentration from crude feed = 2.37:1

Feed size - 59.6% minus 325 M

TABLE 4

Results of Concentration After 40 Min Grind

Product	Weight %	Analysis %		Distn %	
		Sol Fe	Mag Fe	Sol Fe	Mag Fe
Jeff tail	34.3	7.16	1.64	5.7	1.4
" midd	9.3	40.96	39.8	8.9	9.0
Wade o'flow	1.1	51.70	51.4	1.3	1.4
" spigot	55.3	65.36	65.3	84.1	88.2
Feed*	100.0	43.0	40.9	100.0	100.0

* calculated

Ratio of concentration from crude feed = 2.42:1

Feed size - 83.7% minus 325 M

TABLE 5

Results of Concentration After 60 Min Grind

Product	Weight %	Analysis %		Distn %	
		Sol Fe	Mag Fe	Sol Fe	Mag Fe
Jeff tail	38.5	7.50	1.08	6.8	1.1
" midd	6.0	38.48	36.1	5.5	5.4
Wade o'flow	1.3	57.50	57.0	1.8	1.9
" spigot	54.2	67.02	67.0	85.9	91.6
Feed*	100.0	42.3	39.6	100.0	100.0

* calculated

Ratio of concentration from crude feed = 2.47:1
Feed size - 93.9% minus 325 M

Pilot Plant Tests

Test 1

Using the flowsheet shown in Figure 6, crude ore was fed at 3/8 in. to the rod mill at a nominal rate of 2 tons/hr. The rod mill discharge passed over a 10 M Sweco screen and the oversize was returned to the head end of the rod mill. The undersize was fed to one drum of the Dings 2-drum separator and the non-magnetic tailing was rejected. The Dings concentrate was pumped to an Akins classifier and the sands fed to the ball mill for grinding. The ball mill discharge was fed to the Dings 3-drum separator for cleaning, and the tailing was rejected. The Dings cleaner concentrate was washed in a Denver cone and then stored in a collecting cone. The collecting cone spigot product was pumped to a cyclone, the cyclone spigot product being returned for further ball mill grinding. The cyclone overflow was washed and remagnetized by the second drum of the Dings 2-drum separator. The remagnetized product was cleaned in the Siphon sizer and the spigot product filtered and stored in drums. The results of Test 1 are shown in Table 6. The magnetic iron assays were calculated from Davis tube tests on each product after pulverizing to minus 200 M.

The results of screen tests from Test 1 are shown in Table 7.

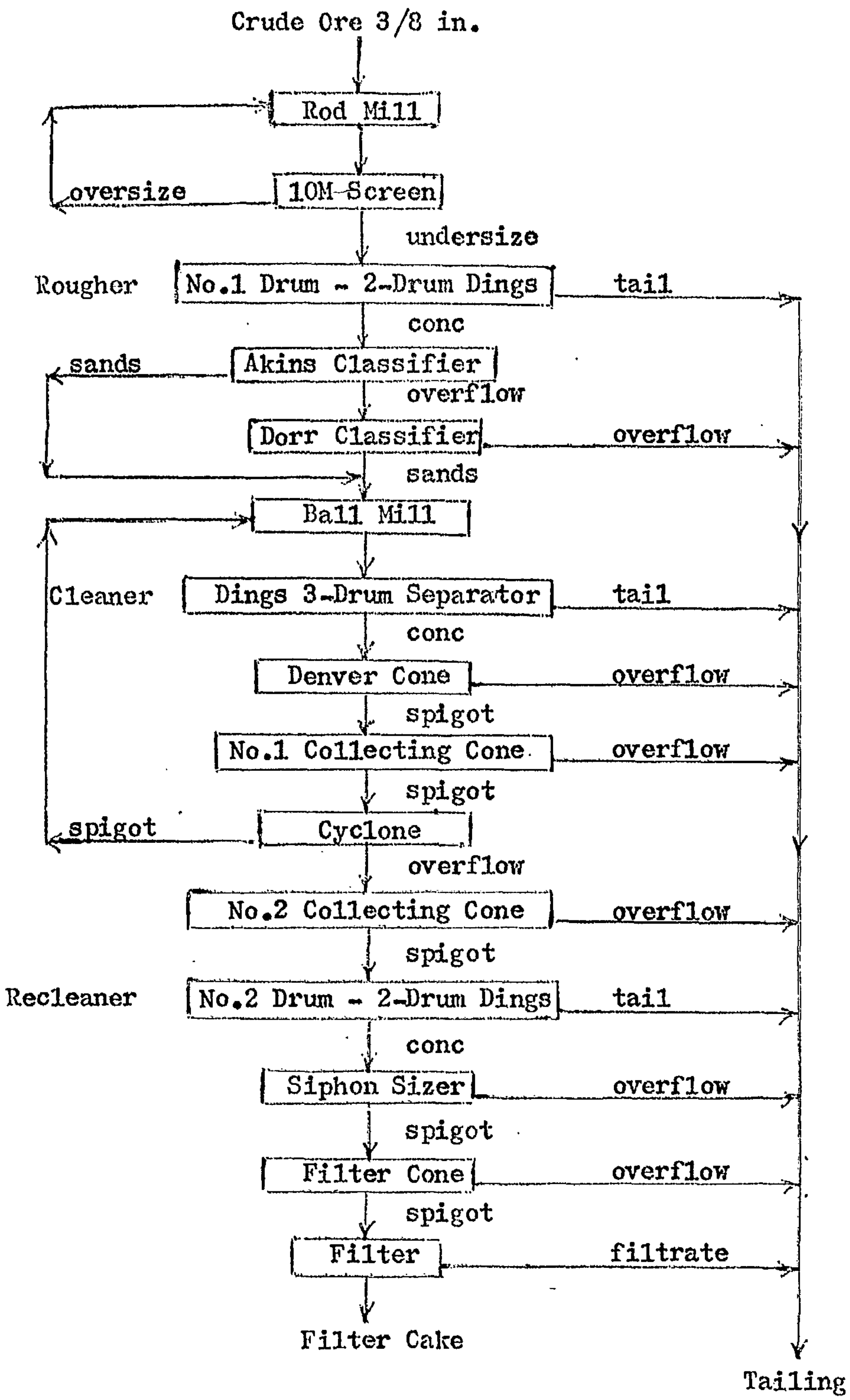

Figure 6 - Pilot Plant Flowsheet for Test 1

TABLE 6

Results of Pilot Plant Test 1

Product	Weight %	Solids %	Analysis %			Distn %	
			Sol Fe	Mag Fe	SiO_2	Sol Fe	Mag Fe
R.M. disch.		60.7	32.8				
10 M Screen Size	100.0		31.0	28.2		100.0	100.0
Dings R conc	69.3		43.4		36.88	94.3	
" " tail	30.7		5.9	0.93		5.7	1.0
Dorr class o'flow	6.8		6.4	0.0		1.4	
Dorr class sands	62.5		47.4			92.9	
B.M. feed			52.8			---	
" disch.	102.1	75.4	52.3			167.4	
Dings cl conc	91.5		57.7		17.98	165.5	
" " tail	10.6		5.6	0.87		1.9	0.3
Denver cone o'flow	1.9		6.0	0.77		0.4	0.1
Denver cone spigot	89.6		58.8			165.1	
No. 1 coll cone o'flow	0.7		7.2	0.91		0.1	0.05
No. 1 coll cone spigot	88.9		59.2			165.0	
Cyclone o'flow	49.3	13.3	58.6			90.5	
" spigot	39.6	77.8	60.0			74.5	
No. 2 coll cone o'flow	1.2		18.2			0.7	
No. 2 coll cone spigot	48.1		59.6			89.8	
Dings recl conc	47.7		60.0			89.7	
" " tail	0.4		9.9	1.78		0.1	0.05
Siphon sizer o'flow	1.4		8.2	1.23		0.3	0.1
Siphon sizer spigot	46.3		61.6	60.0	13.52	89.4	98.4
Filter cone o'flow	2.2		59.5	59.1		4.1	
Filter cone spigot	44.1		61.7			85.3	
Filter cake	44.1		61.8	61.6	13.38	85.4	

Ratio of concentration to the Siphon Sizer spigot = 2.16:1
The filter cake contained 8.[illegible]% moisture and 0.022% P.

TABLE 7

Results of Screen Tests on Test 1 Products

Mesh	Dings R Conc Weight %	R.M. Disch Weight %	B.M. Disch Weight %	Dings Cl Conc Weight %	Cyclone Spigot Weight %	Cyclone O'flow Weight %	Filter Cake Weight %
+28	2.0	2.6	-	-	-	-	-
+35	4.6	3.8	-	-	-	-	-
+48	8.0	7.1	-	-	1.1	-	-
+65	11.0	10.2	2.4	2.5	3.2	-	-
+100	12.8	11.6	5.0	5.8	8.2	0.4	0.8
+150	10.7	9.5	8.1	9.4	11.6	1.2	1.6
+200	9.0	8.2	11.8	12.8	17.7	3.0	4.5
+325	11.0	10.2	21.8	23.5	27.5	9.7	13.2
-325	30.9	36.8	50.9	46.0	30.7	85.7	79.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Test 2

It was decided to regrind the concentrate produced in Test 1, to discover what grade of concentrate could be made by further cleaning at a grind of approximately 90% minus 325 M.

First stage concentrate, in the form of wet filter cake, was fed to the ball mill at a rate of 1000 lb/hr. The ball mill ground in open circuit, and the discharge was fed to the Dings 3-drum separator. The Dings concentrate was then cleaned by a Denver cone, passed over the second drum of the Dings 2-drum separator, and further cleaned by the Siphon Sizer. The Siphon Sizer spigot product was stored in the filter cone and filtered. The results of Test 2 are shown in Table 8.

TABLE 8

Results of Concentrate Regrind - Test 2

Product	Weight %	Analysis %						Distn %
		Sol Fe	Mag Fe	SiO_2	TiO_2	S	P	Sol Fe
B.M. feed	46.2	61.74		12.50				89.4
" disch		61.54						--
Dings cl conc	43.7	64.84						88.8
" " tail	2.5	8.04	1.45	83.48				0.6
Den. cone o'flow		12.94						--
" " spigot	43.7	64.80		8.98				88.8
No.2 coil cone spigot		64.74						--
No.2 Dings conc	43.2	65.34		8.52				88.5
" " tail	0.5	15.22						0.3
Siphon Sizer o'flow		12.80						--
" " spigot	43.2	65.30	6.48	8.42	0.025	0.029	0.018	88.5
Filter cone o'flow		52.60						--
" " spigot		64.90						--
Filter cake		65.20						--

Ratio of concentration from crude ore = 2.31:1

Filter cake moisture = 10.1%

The results of screen tests run on Test 2 are shown in Table 9.

TABLE 9

Results of Screen Tests on Test 2 Products

Mesh	Denver Cone Spigot Weight %	No.2 Dings Conc Weight %	Siphon Sizer Spigot Weight %
+100	0.5	0.4	-
+150	0.7	0.6	0.4
+200	1.5	1.8	2.0
+325	5.6	6.1	5.0
-325	91.7	91.1	92.6
Total	100.0	100.0	100.0

A sample of 1500 g of Siphon Sizer spigot was treated by the combination of a laboratory Jeffrey-Steffensen separator followed by a Wade hydroseparator to determine the final grade and recovery possible.

The results of this test are shown in Table 10. Separator settings were No. 1 drum 2.2 amp, No. 2 drum 1.2 amp and No. 3 drum 0.7 amp. Upflow on the hydroseparator was 70 ft/hr.

TABLE 10

Further Upgrading of Siphon Sizer Spigot Product of Test 2

Product	Weight %	Analysis %		Distn % Sol Fe
		Sol Fe	SiO_2	
Jeffrey feed		65.5		
" midd	3.5	50.8		2.7
" tail	1.5	35.1		0.8
" conc	95.0	66.8	6.76	96.5
Wade o'flow	0.8	54.1		0.7
" spigot	94.2	67.0	6.26	95.8
Feed*	100.0	65.8		100.0

*calculated

Test 3

In this test crude ore was treated using the same flow-sheet as Test 1. Feed rate was set at approximately 3000 lb/hr and the 10 M screen on the rod mill discharge was changed to a 20 M screen. The rod and ball charges were both adjusted to 4000 lb as it was hoped that a one-stage test could produce a product of sufficient fineness to make an acceptable concentrate. The results of Test 3 are shown in Table 11.

Results of screen tests on Test 3 are shown in Table 12.

TABLE 11

Results of Pilot Plant Test 3

Product	Weight %	Analysis %			Dis'tn %	
		Sol Fe	Mag Fe	SiO_2	Sol Fe	Mag Fe
R.M. disch		33.7				
20 M Screen u'size	100.0	32.7	30.46		100.0	100.0
Dings R conc	69.4	45.2		33.92	94.5	
" " tail	30.6	6.0	1.3		5.5	1.3
Dorr class o'flow	4.7	6.40	0.0		0.9	
Dorr class sands	64.7	48.0			93.6	
B.M. feed	-	54.8			-	
" disch	140.2	55.0			232.3	
Dings cl conc	129.3	59.2		16.36	230.6	
" " tail	10.9	5.00	0.5		1.7	0.2
Denver cone o'flow	3.6	11.0			1.2	0.8
Denver cone spigot	125.7	60.6			229.4	
No.1 coll cone o'flow	0.9	5.70	0.4		0.2	
No.1 coll cone spigot	124.8	61.0			229.2	
Cyclone o'flow	49.3	61.0			90.5	
" spigot	375.5	61.0			138.7	
No.2 coll cone o'flow		14.0			-	
No.2 coll cone spigot	-	59.9			-	
Dings recl conc	48.9	61.4			90.4	
" " tail	0.4	4.30	0.0		0.1	
Siphon Sizer o'flow	0.4	8.80			0.1	
Siphon Sizer spigot	48.5	61.80	61.4	12.80	90.3	97.7
Filter cone o'flow	-	23.1			-	
Filter cake	-	63.2			-	

Ratio of concentration from crude ore = 2.06:1

TABLE 12

Results of Screen Tests on Test 3 Products

Mesh	Dings R Conc Weight %	Ball Mill Disch Weight %	Dings Cl Conc Weight %	Cyclone		Siphon Sizer Spigot Weight %
				O'flow Wt %	Spigot Wt %	
+28	1.0	-	-	-	-	-
+35	4.8	-	-	-	-	-
+48	8.8	-	-	-	0.8	-
+65	11.4	2.4	1.8	-	2.2	-
+100	12.2	4.2	4.7	0.6	6.3	0.6
+150	9.8	6.9	7.8	1.0	9.9	1.0
+200	8.4	11.0	12.7	2.6	15.5	2.7
+325	11.2	22.3	23.6	9.0	29.6	10.0
-325	32.4	53.2	49.4	86.8	35.7	85.7
Total	100.0	100.0	100.0	100.0	100.0	100.0

Test 4

From the results obtained in Test 3, it appeared to be necessary to regrind the concentrate before further cleaning in order to make a suitable grade. At a feed rate of 1000 lb/hr, filter cake from Test 3 was fed to the ball mill using the same flowsheet as Test 2 with No.1 Drum of the 2-drum Dings separator as a rougher ahead of the 3-drum Dings cleaner. Results of Test 4 are shown in Table 13.

TABLE 13

Results of Concentrate Regrind - Test 4

Product	Weight %	Analysis %			Distn as crude ore %	
		Sol Fe	Mag Fe	SiO_2	Sol Fe	Mag Fe
B.M. feed	48.5	62.6			90.3	97.7
" disch	-	62.6		11.52	90.3	
No.1 Drum conc	46.6	64.8		9.42	89.8	
" " tail	1.9	7.4	1.04		0.5	0.1
Dings cl conc	45.9	65.6		8.34	89.6	
" " tail	0.7	10.7	1.94		0.2	-
Denver cone o'flow	-	38.6			-	
Denver cone spigot	45.9	65.6		8.26	89.6	
No.2 coll cone o'flow	-	-			-	
No.2 coll cone spigot	45.9	65.6		8.10	89.6	
No.2 Drum conc	45.9	65.5		8.00	89.6	
" " tail	-	19.6			-	
Siphon Sizer o'flow	0.3	36.7			0.4	
Siphon Sizer spigot	45.6	65.8	65.8	7.62	89.2	97.6
Filter cake	-	65.7			-	

Ratio of concentration from crude ore = 2.19:1

A small sample of Siphon Sizer spigot was treated by the combination of a Jeffrey-Steffensen separator and a Wade hydroseparator. The results of this test are shown in Table 14.

TABLE 14

Further Upgrading of Siphon Sizer Spigot Product of Test 4

Product	Weight %	Analysis % Sol Fe	Distn as crude ore % Sol Fe
Jeffrey feed*	45.6	65.8	89.2
" tail	0.8	39.7	0.8
" midd	2.3	57.0	3.7
" conc	42.5	67.0	84.7
Wade o'flow	0.3	61.6	0.6
" spigot	42.2	67.2	84.1

* calculated

Ratio of concentration from crude ore = 2.37:1

Results of screen tests on Test 4 are shown in Table 15.

TABLE 15

Results of Screen Tests on Test 4 Products

Mesh	Ball Mill Disch Wt %	No.1 Drum Conc Wt %	Dings Cl Conc Wt %	No.2 Coil Cone Spigot Wt %	Siphon Sizer Spigot Wt %
+100	0.2	0.1	0.1	0.2	0.2
+150	0.3	0.4	0.3	0.3	0.3
+200	0.7	1.5	1.4	1.1	1.0
+325	5.2	5.4	5.3	5.2	5.0
-325	93.6	92.6	92.9	93.2	93.5
Total	100.0	100.0	100.0	100.0	100.0

Tests 5 and 6

From the previous tests it had been found that it was necessary to grind to 93% minus 325 M in order to produce a grade of concentrate meeting pellet specifications. It had also been found that in order to get this grind, two stages of ball mill grinding were necessary. The purpose, therefore, of running Tests 5 and 6 was to get steady mill conditions and produce sufficient concentrate for pelletizing tests. Both tests used the same flowsheet as Test 3 and were run on consecutive days. Test 5 was only run for 3 hours due to a breakdown of the bucket elevator. A feed rate of 3000 lb/hr was used for Test 5, and 4000 lb/hr for Test 6. An additional 600 lb of rods and 600 lb of balls were added to the mills in Test 6. In all tests the Dings separators were set at intensities of 10 amp. The Siphon Sizer upflow was 28 ft/hr. The results of Test 5 are shown in Table 16, and screen test results are shown in Table 17. The results of Test 6 are shown in Table 18. A special Jeffrey-Steffensen and Wade hydroseparator test was run on the Siphon Sizer spigot from Test 6 and the results are shown in Table 19.

The results of screen tests on Test 6 are shown in Table 20.

TABLE 16

Results of Pilot Plant Test 5

Product	Weight %	Solids %	Analysis % Sol Fe	Mag Fe	SiO_2	Distn % Sol Fe	Mag Fe
R.M. disch		61.4	33.1				
20 M screen u'size	100.0		34.2	31.08		100.0	100.0
Dings R conc	72.2		44.3		36.44	94.9	
" " tail	27.8		6.20	1.34		5.1	1.2
Dorr class o'flow	7.8		7.10	0.77		1.6	0.2
Dorr class sands	64.4		48.8			93.3	
B.M. disch	124.7	75.6	54.8			202.8	
" feed	--		54.9			-	
Dings cl conc	113.2		59.8		16.44	200.9	
" " tail	11.5		5.50	0.87		1.9	0.3
Denver cone o'flow	0.2		10.5	5.93		-	
Denver cone spigot	113.0		59.9		14.96	200.9	
No.1 coll cone o'flow	---		-			-	
No.1 coll cone spigot	--		60.0			-	
Cyclone o'flow	52.7		58.4		17.88	91.4	
" spigot	60.3		61.2			109.5	
No.2 coll cone o'flow	0.5		13.5			0.3	
No.2 coll cone spigot	52.2		58.8			91.1	
No.2 Drum conc	50.4		60.6		15.20	90.6	
" " tail	1.8		8.8			0.5	
Siphon Sizer o'flow	1.6		8.4			0.4	
Siphon Sizer spigot	48.8	23.1	62.3	61.95	12.48	90.2	97.3
Filter cone o'flow	--		11.0				
Filter cone spigot	--		-				
Filter cake	--		63.9				

Ratio of concentration from crude ore = 2.05:1

TABLE 17

Results of Screen Tests on Test 5 Products

Mesh	R.M.Disch Weight %	Dings R Conc Weight %	B.M. Disch Weight %	Dings Cl Conc Weight %	Cyclone O'flow Weight %	Cyclone Spigot Weight %	Siphon Sizer Spigot Weight %
+20	1.0	-	-	-	-	-	-
+28	1.5	1.4	-	-	-	-	-
+35	4.2	4.7	-	-	-	-	-
+48	7.2	8.0	-	-	-	-	-
+65	10.9	11.9	1.2	1.2	-	1.1	-
+100	11.3	12.6	3.6	3.7	-	3.4	0.2
+150	8.8	10.1	6.2	7.4	0.4	6.9	0.7
+200	8.2	8.4	11.0	11.8	1.2	14.0	2.2
+325	9.7	10.4	23.2	25.2	5.4	31.0	8.4
-325	37.2	32.5	54.8	50.7	93.0	43.6	88.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 18

Results of Pilot Plant Test 6

Product	Weight %	Solids %	Analysis %			Distn %	
			Sol Fe	Mag Fe	SiO_2	Sol Fe	Mag Fe
R.M. disch	-	63.4	32.98				
20 M screen u'size	100.0		35.20	31.6		100.0	100.0
Dings R conc	73.2		44.40		36.52	95.3	
" " tail	26.8		5.90	0.93		4.7	0.8
Dorr class o'flow	6.2		6.60	0.41		1.2	0.1
Dorr class sands	67.0		47.90			94.1	
B.M. feed	-		54.70			-	
" disch	147.9	76.9	54.24			236.2	
Dings cl conc	135.6		58.94		17.72	234.3	
" " tail	12.3		5.30	0.69		1.9	0.3
Denver cone o'flow	0.5		12.82	9.04		0.2	0.2
Denver cone spigot	135.1		59.10		16.20	234.1	
No.1 coll cone o'flow	0.5		5.80	0.68		0.1	
No.1 coll cone spigot	134.6		59.30			234.0	
Cyclone o'flow	53.7		58.40		17.78	91.9	
" spigot	80.9		59.90			142.1	
No.2 coll cone o'flow	0.2		10.20			-	
No.2 coll cone spigot	53.5		58.60			91.9	
No.2 Drum conc	51.6		60.40		15.52	91.4	
" " tail	1.9		8.70	0.82		0.5	0.1
Siphon Sizer o'flow	1.7		14.40			0.7	
Siphon Sizer spigot	49.9	25.9	62.0	61.50	13.28	90.7	97.5
Filter cone o'flow	1.3		16.8	10.1		0.6	0.4
Filter cone spigot	48.6		63.2			90.1	97.1
Filter Cake	48.6		63.2			90.1	97.1

Ratio of Concentration from crude ore = 2.06:1

TABLE 19

Further Upgrading of Siphon Sizer Spigot Product of Test 6

Product	Weight %	Analysis %			Distn as crude ore %	
		Sol Fe	Mag Fe	SiO_2	Sol Fe	Mag Fe
Jeffrey feed*	48.9	62.8	-	15.08	90.1	97.0
" midds	2.2	43.6	42.4		2.9	2.9
" tail	1.1	19.2	8.7		0.6	0.3
" conc	45.6	64.7		9.68	86.6	93.8
Wade o'flow	0.4	39.0	38.7	43.68	0.5	0.5
" spigot	45.2	65.0		9.36	86.1	93.3

* calculated

Ratio of concentration from crude ore = 2.21:1

TABLE 20

Results of Screen Tests on Test 6 Products

Mesh	R.M. Disch Weight %	Dings R Conc Weight %	B.M. Disch Weight %	Dings Cl Conc Weight %	Cyclone O'flow Weight %	Cyclone Spigot Weight %	Siphon Sizer Spigot Weight %
+28	3.4	1.7	-	-	-	-	-
+35	6.9	6.0	-	-	-	-	-
+48	9.6	9.9	-	-	-	0.8	-
+65	12.0	13.2	1.8	1.9	-	2.5	-
+100	11.0	12.9	5.3	5.4	0.3	7.8	0.3
+150	7.7	9.6	7.2	7.9	1.2	10.2	1.0
+200	7.0	7.8	12.4	12.5	3.6	17.9	2.7
+325	8.3	10.0	22.2	24.0	11.6	29.6	9.4
-325	34.1	28.9	51.1	48.3	83.3	31.2	86.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Tests 7 and 8

The purpose of Tests 7 and 8 was to upgrade the filter cake made in Tests 5 and 6 to suitable material for pelletizing. The flowsheet in each test was the same as Test 4, and the feed rate was 1000 lb/hr. The results of Test 7 are shown in Table 21, and include a Jeffrey-Steffensen and a Wade hydroseparator test made on a sample of Siphon Sizer spigot. The results of screen tests on Test 7 are shown in Table 22. The results of Test 8, together with a Jeffrey-Steffensen and a Wade hydroseparator test are shown in Table 23. The results of screen tests on Test 8 are shown in Table 24.

TABLE 21

Results of Concentrate Regrind - Test 7

Product	Weight %	Analysis %		Distn as crude ore % Sol Fe
		Sol Fe	SiO_2	
B.M. feed	-	64.8		-
" disch	43.7	64.5	9.60	88.8
No.1 Drum conc	42.7	65.9	7.90	88.6
" " tail	1.0	6.30		0.2
Dings cl conc	42.1	66.6	7.02	88.4
" " tail	0.6	15.4		0.2
Denver cone o'flow	0.1	31.6		0.1
Denver cone spigot	42.0	66.7	6.88	88.3
No.2 coll cone o'flow	-	-		-
No.2 coll cone spigot	-	66.4	7.32	-
No.2 Drum conc	41.9	66.8	6.86	88.2
" " tail	0.1	19.3		0.1

(cont'd)

TABLE 21 (concl'd)

Results of Concentrate Regrind on Test 7

Product	Weight %	Analysis %		Distn as crude ore % Sol Fe
		Sol Fe	SiO_2	
Siphon Sizer o'flow	-	63.2	11.46	-
" " spigot	-	66.6	6.56	88.2
Filter cone o'flow	-	34.2		-
" " spigot	-	66.5		-
" cake	-	66.5	7.04	88.2
Jeffrey feed*	41.7	67.2		88.2
" tail	0.5	38.0	44.20	0.5
" midds	2.2	60.4		4.1
" conc	39.0	67.9	5.50	83.6
Wade o'flow	0.4	62.4	12.46	1.0
" spigot	38.6	68.0	5.28	82.6

Filter cake moisture = 11.4 %.

Ratio of concentration from crude ore to Wade spigot = 2.59:1

*Laboratory results correlated to the pilot plant test results.

TABLE 22

Results of Screen Tests on Test 7 Products

Mesh	B.M. Disch Weight %	No.1 Drum Conc Weight %	No.2 Drum Conc Weight %	Siphon Sizer Spigot Weight %
+100	0.2	0.3	-	0.1
+150	0.2	0.2	0.2	0.2
+200	0.5	1.0	0.6	1.2
+325	3.2	4.3	3.9	3.8
-325	95.9	94.2	95.3	94.7
Total	100.0	100.0	100.0	100.0

TABLE 23

Results of Concentrate Regrind - Test 8

Product	Weight %	Analysis %			Distn %	
		Sol Fe	Mag Fe	SiO_2	Sol Fe	Mag Fe
B.M. disch	48.8	63.0		11.90	90.1	97.0
No.1 Drum conc	47.3	64.8		9.34	89.8	
" " tail	1.5	6.5			0.3	
Dings cl conc	46.1	65.8		8.38	88.9	
" " tail	1.2	24.25	17.7		0.9	0.7
Denver cone o'flow	-	26.8	24.2		-	
Denver cone spigot	-	65.21		8.32	-	
No.2 coll cone o'flow	-	-			-	
No.2 coll cone spigot	-	65.7			-	
No.2 Drum conc	45.8	66.1		8.00	88.7	
" " tail	0.3	19.0			0.2	
Siphon Sizer o'flow	0.5	36.0			0.5	
Siphon Sizer spigot	45.3	66.4		7.58	88.2	
Filter cone o'flow	-	35.8			-	
Filter cone spigot	-	66.0			-	
Filter cake	-	66.1			-	
Jeffrey feed	45.8	65.9			88.7	
" tail	0.7	39.0		43.10	0.8	
" midds	2.7	58.15		17.72	4.5	
" conc	42.4	66.90		6.28	83.4	
Wade o'flow	0.5	58.84		16.38	1.0	
" spigot	41.9	67.00	67.0	6.02	82.4	90.6

Filter cake moisture = 11.2 %.

Ratio of concentration from crude ore to Wade Spigot = 2.39:1.

TABLE 24

Results of Screen Tests on Test 8 Products

Mesh	B.M. Disch Weight %	No.1 Drum Conc Weight %	No.2 Drum Conc Weight %	Siphon Sizer Spigot Weight %
+100	0.2	-	0.2	-
+150	0.3	0.2	0.2	0.3
+200	0.8	1.2	1.0	1.0
+325	3.9	4.7	5.0	4.2
-325	94.8	93.9	93.6	94.5
Total	100.0	100.0	100.0	100.0

Laboratory Grinding Tests

Two grinding tests of 21 min and 35 min were done on a 2000 g sample of the ore to determine the Work Index. The results were compared with those obtained with an ore of known Work Index. It was found that with a 21 min grind, the Work Index was 14.0 kwh/ton, and with a 35 min grind, the Work Index was 14.4 kwh/ton. A detailed description of the tests has been reported.*

* Test Report, Mineral Processing Division, No. MPT-61-89, by R. G. Ratzlaff and D. E. Pickett.

CONCLUSIONS

By using a standard taconite flowsheet, it was found possible to produce a concentrate meeting premium grade pellet specifications from a sample of 'E' ore. This was done by grinding 3/8 in. ore in one stage of rod milling, and two stages of ball milling with several stages of magnetic separation and hydroseparation. Grinding to approximately 93% minus 325 M was required to produce a concentrate containing 6% SiO_2 or less. The ratio of concentration from crude ore to final concentrate was low -- of the order of 2.5:1.

Cobbing tests on the crude ore showed that there was little weight discarded as tailing at 3/8 in. It was found that the best size for cobbing the crude ore was on the rod mill discharge product at 10 M or 20 M.

Although the final grade of concentrate was obtained by a laboratory magnetic separator and a laboratory hydroseparator, it is believed that if a suitable cleaner type pilot plant separator had been available for inclusion in the flowsheet instead of the single Dings drum used in the pilot run, the same results would have been obtained. Also, in a continuous operation a full size Siphon Sizer would remove the troublesome siliceous middling resulting from the dusty magnetite-chert bands much more effectively than the small intermittent pilot plant sizer. A coarser grind would, therefore, yield comparable concentrates and cake moisture would be reduced.

PDM:EBM