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LABORATORY INVESTIGATION INTO THE PELLETIZABILITY OF MOUNT WRIGHT SPECULAR HEMATITE CONCENTRATE

by

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Metals Reduction and Energy Centre

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G.N. Banks* and C.J. Payne**

SUMMARY

Laboratory pelletizing experiments were performed on Mt. Wright specular hematite concentrates at different finenesses in attempts to produce dry pellets with compressive strengths of 50 lb or more. These experiments indicated that air-dried pellets, with 20 to 25-lb compressive strengths, could be readily produced from this concentrate by using 3/4 per cent bentonite as a binder. This compressive strength could be increased to about 50 lb by firing the pellets at 1000°C. Significant changes in the grinding fineness of the concentrate made little difference to the pelletizability or the compressive strength of the air-dried pellet. In fact, samples of 43% minus 325-mesh concentrate pelletized as readily and produced air-dried pellets with compressive strengths as great as 85% minus 325-mesh concentrate.

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BACKGROUND

In November, 1970, four samples of Mount Wright specular hematite concentrate were received from the Mineral Processing Division of the Mines Branch. These samples had been ground to a specified size and concentrated magnetically to reduce their silica content. The original Mt. Wright spiral concentrate sample had been received from the Steel Company of Canada with the request that pelletizing experiments be performed to determine the minimum grind necessary to produce pellets of sufficient strength to be handled in a Stelco-Lurgi reduction kiln. It was suggested that a dry-pellet compressive strength of 50 lb would be required.

EXPERIMENTAL WORK

Raw Material

The four samples of ground concentrate were sampled for screen analyses. These samples were hand-sieved to 500-mesh (25-micron) size in the Pyrometallurgical Laboratory and the minus 325-mesh (44-micron) fraction from each sample was submitted to the Mineral Processing Division for particle size determination by micro-mesh sieves as well as by Coulter Counter. The results of these sieve analyses are given in Table 1.

The binders used in the pelletizing of these concentrate samples were a standard commercial Wyoming bentonite and a reagent-grade calcium hydroxide powder.

Procedure

The following general procedure was used to produce pellets for testing:

1. Iron ore concentrate was mixed with the desired quantity of binder in a Hobart mixer for 1/2 hour.

2. Seed pellets (3 1/2 to 4-mesh size) were made from this mixture in a balling tire. The balling tire consists of an 8 x 20-inch rubber tire, affixed to a variable-speed drive, which was rotated at 50 rpm for these tests.

3. In each test, the mixture was fed for 4 1/2 minutes (by hand) onto 100 g of seed pellets in the balling tire. Sufficient moisture was sprayed into the tire to form green pellets of the desired final moisture

TABLE 1

Screen Analyses of Specular Hematite Samples

Sieve Designation		Per Cent Weight Retained (Cumulative)						
Canadian Standard Screen Number	Sieve Opening (Microns)	Original Specular Hematite Spiral Concentrate	- Ground and Reconcentrated Samples					
			Sample No. 1			Sample No. 2		
			Hand Sieve	Micro-Mesh	Coulter Counter	Hand Sieve	Micro-Mesh	Coulter Counter
20	841	5.2	-	-	-	0.4	-	-
30	595	52.5	-	-	-	1.6	-	-
40	420	66.0	-	-	-	2.1	-	-
50	297	72.5	-	-	-	2.3	-	-
70	210	82.0	-	-	-	2.6	-	-
100	149	90.0	0.1	-	-	3.1	-	-
140	105	92.5	0.5	-	-	4.2	-	-
200	74	97.4	0.8	-	-	19.4	-	-
270	53	99.1	6.2	-	-	35.5	-	-
325	44	99.7	14.2	-	-	46.7	-	-
-	40	-	-	-	22.7	-	-	56.8
400	37	-	22.5	-	31.3	54.4	-	60.3
-	30	-	-	-	45.9	-	-	70.7
500	25	-	45.2	-	58.8	71.0	-	78.1
-	22	-	-	50.9	65.7	-	83.3	83.5
---	20	-	-	-	70.8	-	-	86.1
-	15	-	-	-	81.6	-	-	91.2
-	11	-	-	69.9	89.3	-	89.3	94.7
-	10	-	-	-	91.0	-	-	95.2
-	5	-	-	79.9	97.9	-	93.5	98.7
-	4	-	-	-	99.1	-	-	99.2
-	3	-	-	-	99.8	-	-	99.7
-	2	-	-	91.0	100.0	-	100.0	100.0
Blaine Surface Area (cm^2/g)		—	1411			810		

TABLE 1 (Cont'd)

Screen Analyses of Specular Hematite Samples

Sieve Designation		Per Cent Weight Retained (Cumulative)					
Canadian Standard Screen Number	Sieve Opening (Microns)	Ground and Reconcentrated Samples					
		Sample No. 3			Sample No. 4		
		Hand Sieve	Micro-Mesh	Coulter Counter	Hand Sieve	Micro-Mesh	Coulter Counter
20	841	0.3	-	-	0.3	-	-
30	595	0.8	-	-	1.0	-	-
40	420	1.1	-	-	1.3	-	-
50	297	1.4	-	-	1.6	-	-
70	210	2.1	-	-	1.8	-	-
100	149	2.8	-	-	2.2	-	-
140	105	3.4	-	-	2.6	-	-
200	74	5.4	-	-	4.0	-	-
270	53	18.8	-	-	23.2	-	-
325	44	32.9	-	-	36.6	-	-
-	40	-	-	38.9	-	-	43.6
400	37	43.5	-	44.3	44.0	-	45.2
-	30	-	-	60.4	-	-	62.9
500	25	67.2	-	69.8	65.7	-	72.1
-	22	-	75.6	75.5	-	75.9	75.9
-	20	-	-	78.9	-	-	79.4
-	15	-	-	87.6	-	-	87.6
-	11	-	93.3	93.3	-	93.0	93.0
-	10	-	-	94.0	-	-	94.3
-	5	-	98.3	98.3	-	98.9	99.0
-	4	-	-	99.0	-	-	99.4
-	3	-	-	99.7	-	-	99.7
-	2	-	100.0	100.0	-	100.0	100.0
Blaine Surface Area (cm^2/g)		950			1022		

content and pellet size. The formed pellets were allowed to roll for one minute, then removed from the tire and screened to retain the 1/2 to 3/8-inch size.

4. Samples of the freshly formed pellets were taken for (a) moisture determination, (b) green drop-strength, (c) green compressive strength, (d) oven-dried (1100°C) compressive strength, (e) air-dried compressive strength and (f) fired compressive strengths at firing temperatures of 500, 800, 1000 and 1300°C in a laboratory muffle furnace.

The green drop-strength of the pellets was determined by dropping 10 pellets individually from a height of 18 inches onto a steel plate and then determining the average number of drops required to break the pellet. The compressive strength of green pellets was determined by testing 10 pellets, individually, on an Allis-Chalmer's Pelletester machine. The average strength for the 10 pellets was determined and then recalculated on the basis of 1/2-inch pellets, using the hypothesis that the compressive strength varied directly as the square of the pellet diameter. The dry and fired compressive strengths were determined on a modified Dietert sand-core testing machine. In each case, the average compressive strength for 10 pellets was reported on the basis of 1/2-inch pellets.

EXPERIMENTAL RESULTS

Pelletizing Naturally Ground Concentrates

The results of pelletizing the four naturally ground samples of specularite concentrate are outlined in Table 2. Each test reported in this table represents the average of three tests done under similar pelletizing conditions. On the basis of per cent minus 325-mesh size (44 microns), No. 1 sample is the finest concentrate (86.8% minus 325-mesh) and No. 2 sample is the coarsest concentrate (53.3% munus 325-mesh). No. 3 and No. 4 samples analyzed 67.1% and 63.4 minus 325-mesh, respectively (see Table 1). In all cases, the material balled quite readily to form pellets of the required size.

Comparison of these tests (see Table 2) indicates that, when no binder is used, the resulting green, dried, and fired pellet strengths will be too low for normal handling procedures. If 1/2% bentonite binder is used in the mix, the resulting pellet compressive strengths are increased considerably, but attain only 26 lb at firing temperatures of 1000°C. The use of 3/4% bentonite binder in the pelletizing mix increases the fired pellet strength to about 25 lb at 500°C and, in one case (sample No. 3), to 50 lb at 1000°C firing temperature. If 5% lime is used as a binder the pellet strengths appear to be decreased.

This is especially true in the 800 to 1000°C firing range, where the pellet compressive strength decreases to 10 lb or less. The pellet strength is recovered at 1300°C firing temperature. There appears to be very little significant difference in the overall pelletizing properties of these various natural grinds of concentrates.

TABLE 2

Comparative Laboratory Pelletizing Tests With Various Grinds

of Mount Wright Specular Hematite Concentrate

Binder	No Binder				1/2% Bentonite				3/4% Bentonite				5% Lime	
Sample No.	1	2	3	4	1	2	3	4	1	2	3	4	2	3
Moisture (%)	8.6	8.6	8.3	8.7	9.7	9.6	9.3	9.7	11.1	10.9	10.5	10.6	9.1	9.0
Drop-Strength (drops)	2.6	2.1	2.5	2.6	3.7	2.9	2.9	4.1	8.0	4.5	4.6	6.6	3.7	3.8
**Green Comp. Strength (lb)	0.8	0.5	0.4	0.4	2.0	1.4	1.8	2.0	3.1	1.4	2.2	2.4	-	0.7
Oven Dried Comp. Strength (lb)	-	0.9	-	-	12.1	14.8	15.8	16.0	21.8	20.5	22.6	19.0	12.2	11.3
Air-Dired Comp. Strength (lb)	-	1.0	-	-	11.0	14.8	15.4	15.4	20.6	20.0	24.1	19.6	19.1	14.7
Fired Comp. Strength (lb)														
Fired at 500°C	-	-	-	-	14	15	18	17	25	22	25	21	20	18
" 800°C	-	-	-	-	21	20	22	22	33	25	31	30	1	5
" 1000°C	-	4	-	-	24	26	26	26	43	36	52	34	4	10
" 1300°C	77	43	31	84	134	103	145	134	216	150	176	178	360	177

**Pelletester not working well -- these recorded green-ball compressive strengths may be lower than actual.

Pelletizing Artifically Prepared Samples

Two samples of concentrate were prepared by mixing various proportions of sized product. Sample 5 was prepared by mixing the original unground sample of specular hematite with sample No. 1 in a 50/50 ratio to give a fairly coarse overall grind (43% minus 325-mesh). Sample No. 6 was prepared by mixing together predetermined weights of the various size fractions to give a product containing about 50% minus 325-mesh. The calculated screen analyses of these two samples are given in Table 3.

TABLE 3

Calculated Screen Analyses of Prepared Concentrate Samples

Sieve Designation		Per Cent Weight Retained (Cumulative)	
Canadian Standard Screen Number	Sieve Opening (Microns)	Sample No. 5	Sample No. 6
20	841	2.6	0
30	595	26.2	5.9
40	420	33.0	11.9
50	297	36.2	17.8
70	200	41.0	22.8
100	149	45.1	28.7
140	105	46.5	33.7
200	74	49.1	39.6
270	53	52.6	45.2
325	44	56.9	50.8
Per Cent Passing 325-mesh		43.1	49.2

Green, dired, and fired pellets were produced from these two prepared concentrate samples, using the procedure previously outlined. The results of these tests are outlined in Table 4.

TABLE 4

Comparative Laboratory Pelletizing Tests with Artificially Prepared Samples of Specular Hematite Concentrates

Binder	3/4% Bentonite		5% Lime	3/4% Bent. +5% Lime
Sample No.	5	6	5	5
Moisture (%)	8.5	9.4	7.0	7.7
Drop-Strength (18-in. drops)	10.8	14.6	7.8	11.2
Green Comp. Strength (lb)	1.1*	3.4	1.9	2.2
Oven-Dried Comp. Strength (lb)	23.2	22.9	19.6	13.4
Air-Dried Comp. Strength (lb)	22.9	24.3	26.6	21.2
Fired Comp. Strength (lb)				
Fired at 500°C	27	26	20	20
" 800°C	30	30	5	6
" 1000°C	51	57	10	10
" 1300°C	363	336	360	232

*Pelletester not working well -- this recorded green-ball compressive strength may be lower than actual.

In all cases, these prepared samples formed pellets as readily as the samples of naturally ground concentrates. Comparisons of the pellet strengths tabulated in Table 4 with those in Table 2 indicate that the pellets produced from the prepared concentrate samples have an equal or higher compressive strength than those produced from the naturally ground concentrates. The drop strengths of the green pellets, produced from these prepared samples, are significantly higher than those of the pellets, formed from the naturally ground samples. This is probably due to the more plastic nature, of pellets produced from the prepared samples, which resulted in greater deformation before the pellets broke. Pellet compressive strengths of 50 lb were not obtained on pellets that had been fired under 1000°C. The use of 5 % lime binder, as in previous cases, appears to lower the compressive strength of pellets fired in the range between 500 and 1000°C.

CONCLUSIONS

Variations in natural grinds between 87 and 53% minus 325-mesh make insignificant differences to the overall pelletizing properties of this sample of Mount Wright spiral hematite concentrate.

Mixing ground products of this concentrate to give fairly coarse overall grinds between 43 and 50% minus 325-mesh results in products which pelletize as readily as the naturally ground products and which give green pellets that have superior drop-strengths.

The use of a lime binder to pelletize these concentrates results in a significant lowering of the compressive strength of pellets fired between 500 and 1000°C.