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GRINDING INVESTIGATIONS ON IRON CONCENTRATES FROM THE QUEBEC CARTIER MINING COMPANY, MONTREAL, QUEBEC

by

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MINERAL DRESSING AND PROCESS METALLURGY DIVISION

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SUMMARY OF RESULTS

The following preliminary estimates for grinding Quebec Cartier iron concentrates in commercial ball mills were deduced:

Work index, W_i, for grinds to 90% -200 mesh, 23.34 kwh/short ton, equivalent to 26.14 kwh/long ton.

Power required for grinding from F = 660 microns to:

(a) 80% -270 mesh = 25.7 kwh/long ton

(b) 90% -270 mesh = 28.4 kwh/long ton

The wear of steel forged balls when grinding from F = 660 microns to:

(a) 80% -270 mesh = 4.29 lb/long ton

(b) 90% -270 mesh = 4.73 lb/long ton

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INTRODUCTION

The grinding tests on Quebec Cartier concentrates were requested by Mr. F. J. McMulkin, Research and Development Engineer, Dominion Foundries and Steel Company, Limited, Hamilton, Ontario. The purpose of these tests was to determine the power and steel consumptions in grinding the Quebec Cartier concentrates to 80% and 90% -270 mesh. The tests were made by Mr. W. S. Jenkins, Scientific Officer, Mineral Dressing and Process Metallurgy Division, under the supervision of the writer.

In determining the work index, W_i, for the Quebec Cartier concentrates, a method enunciated by the writer in his discussion on F. C. Bond's[1] paper was used. In this method, grinding tests on the unknown ore are made in parallel with an ore the work index of which is known.

DETAILS OF GRINDING INVESTIGATION TESTS

In the present experiments, the ore, of which the work index was known, was crushed to all -10 mesh, the size of Quebec Cartier concentrates. From both products, samples were cut out for screen analysis of feed including several 2000 g samples for grinding tests. The same laboratory ball mill was used for all grinding tests. After a few pilot tests to determine the time required for obtaining a product of just over 90% passing 200 mesh with Quebec Cartier concentrates, grinding tests were made on two samples of each product at the predetermined time, 1 hr in this case. Products were screened in duplicate by wet and dry methods, and -325 mesh (43 micron) fractions from each duplicate screen analysis of the products were combined and

infrasized. The sizing analysis results were averaged and plotted on log-log paper, from which 80% passing points were determined.

Since the Mines Branch infrasizer is set for materials of 2.65 specific gravity, and the specific gravity of Quebec Cartier concentrates, consisting of hematite and magnetite, is about 5, the infrasizer nominal microns were reduced as follows for the fractions obtained from -325 mesh fraction of the concentrates:

40 μ to 32 μ

28 " to 23 "

20 " to 16 "

14 " to 11½ "

10 " to 8 "

Table 1 shows the sizing analyses of feeds and Table 2 the sizing analyses of products.

TABLE 1

Feed to Ball Mill

Mesh	Q. C. Concentrates % Passing	Known Ore % Passing
10	99.5	100.0
14	97.3	88.1
20	88.4	75.8
28	71.9	64.7
35	51.2	54.5
48	34.0	45.9
65	20.9	38.3
100	10.6	31.8
150	4.7	26.7
200	1.7	22.5

TABLE 2

Product

Q. C. Concentrates Size	% Passing	Known Ore Size	% Passing
100 mesh	99.1	100 mesh	99.7
150 "	96.8	150 "	97.9
200 "	90.0	200 "	91.7
325 "	65.7	325 "	79.2
32 microns	50.8	40 microns	74.0
23 "	37.7	28 "	61.7
16 "	27.8	20 "	50.6
11½ "	20.1	14 "	41.3
8 "	14.2	10 "	33.1

Table 3 shows the data obtained from the above screen analyses:

TABLE 3

	Known Ore	Q. C. Concentrates
Feed, F, microns	930	660
Product, F, microns	45	54
Reduction ratio, $R_r = F/P$	20.67	12.22
W_i, kwh/short ton	19.5*	23.34

* Determination by Allis-Chalmers laboratories, Milwaukee, Wisc., U.S.A., for a grind to all -200 mesh.

ESTIMATED POWER CONSUMPTIONS

Knowing the work index, W_i, the power consumption, W, in grinding the ore from feed size, F, to product size, P, can be calculated from Bond's[1] formula:

$$W = W_i \frac{\sqrt{F} - \sqrt{P}}{\sqrt{F}} \sqrt{\frac{100}{P}} = W_i \frac{\sqrt{R_r} - 1}{\sqrt{R_r}} \sqrt{\frac{100}{P}}$$

The product, 80% passing, for a grind to 90% -270 mesh can be obtained by drawing a straight line through 53 micron (270 mesh) 90% passing point parallel to the log-log plot of the Quebec Cartier product. From this, P at a grind of 90% -270 mesh = 46 microns.

Table 4 shows the results obtained.

TABLE 4

Power Consumptions in Grinding Q. C. Concentrates

Grind	F, μ	P, μ	R_r	W, kwh/s.t.	W, kwh/l.t.
80% -270 mesh	660	53	12.45	23.0	25.7
90% -270 mesh	660	46	14.35	25.3	28.4

BALL CONSUMPTIONS

The wear of forged steel balls has been estimated by Bond[1] at 1 lb/7 kwh consumed in grinding. Djingheuzian[2], using the data from numerous Canadian operating ball mills, estimated the ball wear at 1 lb/5 kwh consumed in grinding. Assuming the average between these two, one will have 1 lb of steel/6 kwh consumed in grinding.

Table 5 shows the estimated ball consumptions.

TABLE 5

Forged Steel Ball Consumptions

F, μ	P, μ	Steel Consumption, lb/l.t.
660	53	4.29
660	46	4.73

CONCLUSIONS

The above figures are only estimates of two basic parameters in grinding, namely power consumption and ball consumption. However, they indicate the relation in operating costs between grinding -10 mesh Quebec Cartier concentrates to 80% and 90% -270 mesh. Table 6 shows the operating costs of power and balls.

TABLE 6

Cost of Power and Balls

Grind	R_r	Cost of power per l.t. at 0.6¢ / kwh	Cost of balls per l.t. at 8¢ / lb	Total cost of power and balls per l.t.
80% -270 mesh	12.45	15.42	34.32	49.7
90% -270 mesh	14.35	17.04	37.84	54.9

Increase in cost of power and steel per long ton when grinding Quebec Cartier concentrates to 90% -270 mesh, over that of 80% -270 mesh, is 5.2¢.

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LED/DV

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1. Bond, F. C., "Crushing and Grinding Calculations", C.I.M., Trans., Vol. LVII, 1954, pp. 286-292.

2. Djingheuzian, L. E., "A Study of Operating Data from Ball Mills Operating in Quebec, Ontario, Manitoba and British Columbia", C.I.M., Trans., Vol. LX, 1957, pp. 290-304.