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A GRINDING INVESTIGATION ON ORE FROM BEAVERLODGE MINES, LIMITED, SASKATCHEWAN

by

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MINERAL PROCESSING DIVISION

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Mines Branch Investigation Report IR 60-57

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SUMMARY OF RESULTS

A higher reduction ratio was obtained in grinding with balls in water than with balls in solution. The same trend was noticed when the balls were replaced with rods.

An increase in the pulp density also affected the reduction ratio, which was higher when using balls in water than when using balls in solution. An identical trend was evident when the balls were replaced with the rods.

The amount of power required was relatively constant until a speed of 85% of critical was reached, at which point there was a marked increase in the power consumption.

The calculated work indices followed the power factor trend.

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INTRODUCTION

Eldorado Mining and Refining Limited requested the Mines Branch in Ottawa to institute a program of grinding tests on ore from the property of Beaverlodge Mines Limited, located in northern Saskatchewan.

It was specifically desired to determine if possible the differences between grinding the ore in water and grinding the ore in an alkaline solution, which was supplied to the Mines Branch by Eldorado Mining and Refining Limited.

Test Method and Apparatus

All of the tests were batch tests and were done in a 20 x 30 in. Universal grinding mill. A variable speed attachment was installed so that the speed of the mill could be changed within very wide limits. A kilowatt-hour meter was used to measure the total power input to the mill.

The tests were split into two sections, one in which balls were used and the other in which rods were used as the grinding medium. Approximately 600 lb of steel were used in each test. The two tables which follow give the size distribution of the ball and rod charges.

TABLE 1

Size Distribution of Ball Charge

Size in.	Number used	Weight lb
2½	140	297
2	140	210
1½	140	91
	420	598.0

TABLE 2

Size Distribution of Rod Charge

Size in.	Number used	Weight lb
$2\frac{1}{2}$	8	335
2	7	152.5
$1\frac{1}{2}$	8	113.4
	23	600.9

The results of 48 tests are reported in each of which 100 lb of ore were ground for 45 minutes at 45, 60 and 75 per cent solids using water or solution and 600 lb of balls or rods as the grinding charge at mill speeds of 50, 60, 72 and 85 per cent of the critical speed.

DEFINITION OF SYMBOLS

In this investigation the same terms and symbols were employed as were used by F. C. Bond in the development of his Third Theory of Comminution, namely:

F = 80 per cent passing size in the feed expressed in microns,

P = 80 per cent passing size in the product expressed in microns,

R_r = reduction ratio = F/P,

W = work required in kwh per short ton, to reduce a material from F to P,

W_i = work index. It is the amount of work required in kwh/ton to reduce a material from infinite size to 80 per cent passing 100 microns.

These terms are related in the following formula, which is given by the Third Theory of Comminution.

$$W_i = W \frac{(\sqrt{F})}{(\sqrt{F}-\sqrt{P})}\sqrt{\frac{P}{100}}$$

SHIPMENTS AND SAMPLING

Two shipments of ore were received at the Mines Branch:

No. 1 - received on July 20, 1959, weighed 1 ton,

No. 2 - " " August 14, 1959, " 2 tons.

Each shipment was thoroughly mixed by coning and quartering and a sample cut out for a screen analysis.

The grinding tests were started using the ore in the No. 1 shipment and completed with the ore in the No. 2 shipment.

Screen analyses of the two shipments were as follows:

TABLE 3

Screen Test on Ore Shipments

Mesh Size	Sample No. 1 Wt. %	Sample No. 2 Wt. %
+6 mesh	58.5	46.5
-6 +10 "	19.0	20.8
-10 +20 "	8.9	10.6
-20 +48 "	7.1	10.7
-48 +65 "	1.6	2.2
-65 +100 "	1.5	2.4
-100 +150 "	1.0	1.5
-150 +200 "	0.7	1.2
-200 "	1.7	4.1

DETAILS OF INVESTIGATION

In each of the tests a 100 lb charge of ore was placed in the grinding mill with the required weight of balls or rods. To this charge was added a sufficient weight of water or solution to obtain the density required. The mill speed was regulated by a rheostat and the test was allowed to run for 45 minutes.

During a test, power readings were taken continuously for 15 minutes, commencing 20 minutes after the start of the test.

At the end of each test the pulp was washed out of the mill, filtered and dried, and three samples were cut out for screen tests.

The results of all of the tests are summarized in the two tables which follow.

TABLE 4

Summary of Results of Batch Grinding with Rods

Test No.	Wt. % Solids	Grinding Medium	Speed % Critical	F(Microns) 80% Pass.	P(Microns) 80% Pass.	F/P R_r	W kwh/T	W_i
1	45	Solution	50	6000	300	20.0	1.96	4.37
2	60	"	"	"	340	17.6	2.00	4.58
3	75	"	"	"	320	18.8	2.00	4.52
4	45	Water	"	"	260	23.1	2.00	4.07
5	60	"	"	"	275	21.8	2.01	4.24
6	75	"	"	"	320	18.8	2.02	4.69
7	45	Solution	60	"	275	21.8	1.99	4.15
8	60	"	"	"	255	23.5	2.00	4.02
9	75	"	"	"	230	26.1	1.99	3.75
10	45	Water	"	"	231	26.0	2.03	3.84
11	60	"	"	"	228	26.3	2.02	3.79
12	75	"	"	"	235	25.5	2.02	3.86
13	45	Solution	72	6600	230	28.7	1.91	3.56
15	60	"	"	"	225	29.3	1.91	3.51
18	75	"	"	"	250	26.4	1.91	3.75
19	45	Water	"	"	200	33.0	1.87	3.20
20	60	"	"	"	205	32.2	1.93	3.35
21	75	"	"	"	241	27.4	1.99	3.82
22	45	Solution	85	6000	205	29.3	2.44	4.06
23	60	"	"	"	215	27.9	2.51	4.31
24	75	"	"	"	200	30.0	2.51	3.99
25	45	Water	"	"	180	33.3	2.51	3.86
26	60	"	"	"	195	30.8	2.58	3.93
27	75	"	"	"	190	31.6	2.58	3.75

TABLE 5

Summary of Results of Batch Grinding with Balls

Test No.	Wt. % Solids	Grinding Medium	Speed % Critical	F(Microns) 80% Pass.	P(Microns) 80% Pass.	F/P R_r	W kwh/T	W_i
28	45	Solution	50	6000	260	23.1	2.00	4.06
29	60	"	"	"	260	23.1	2.03	4.13
30	75	"	"	"	270	22.2	2.11	4.40
31	45	Water	"	"	235	25.5	1.98	3.80
32	60	"	"	"	250	24.0	2.00	3.95
33	75	"	"	"	220	27.3	2.02	3.68
34	45	Solution	60	"	220	27.3	1.99	3.62
35	60	"	"	"	210	28.6	1.98	3.53
36	75	"	"	"	195	30.8	1.99	3.39
37	45	Water	"	"	200	30.0	1.99	3.44
38	60	"	"	"	185	32.4	1.98	3.27
39	75	"	"	"	175	34.3	1.99	3.17
40	45	Solution	72	6600	205	32.2	1.97	3.12
42	60	"	"	"	180	36.7	1.96	3.14
45	75	"	"	"	175	37.7	2.02	3.19
46	45	Water	"	"	184	35.9	1.86	3.03
47	60	"	"	"	180	36.7	1.92	3.08
48	75	"	"	"	160	41.2	2.08	3.11
49	45	Solution	85	6000	170	35.3	2.44	3.82
50	60	"	"	"	145	41.4	2.51	3.58
51	75	"	"	"	135	44.4	2.51	3.43
52	45	Water	"	"	160	37.5	2.51	3.77
53	60	"	"	"	145	41.4	2.58	3.68
54	75	"	"	"	130	46.2	2.58	3.45

CONCLUSIONS

An increase in the reduction ratio was more noticeable when grinding with balls than with rods.

In those tests in which balls and water were used, a higher reduction ratio was evident than in those tests in which balls and solution were used. The same trend was evident when tests were done using rods and water and rods and solution.

At the same time, as the pulp density was increased from 45 to 75 per cent solids, a slightly higher reduction ratio was observed when grinding with balls in water than with balls in solution. As before the same trend was noticed but at a slightly lower level, when rods were used for grinding in water and solution.

It was noticed that the amount of power required in kwh/ton remained relatively constant as the speed of the mill was increased until 85% of the critical speed was reached, at which point there was a substantial increase in the amount of power used.

This appears to be in line with the accepted theory which indicates that there should be a steady increase in the amount of power required for grinding as the speed of the mill approaches 100% of critical. At some point below 100 per cent of the critical speed the power required passes through a maximum and then decreases as the ball or rod charge tends to centrifuge.

The work indices followed the power trend since the R_r and P factors did not figure appreciably in the calculations.

The conclusions drawn here are more or less self-evident, in that the differences between grinding in water and grinding in solution with either rods or balls have been shown.

TFB:EBM