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CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 64-17

DETERMINATION OF THE WORK INDEX ON A GOLD ORE FROM NORBEAU MINES (QUEBEC) LTD., CHIBOUGAMAU, QUEBEC

by

T. F. BERRY

MINERAL PROCESSING DIVISION

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COPY NO. 5

FEBRUARY 21, 1964

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SUMMARY OF RESULTS

The work index (W_i) of a sample of gold ore from Norbeau Mines (Quebec) Ltd., was 19.9 obtained by comparing the ore with two ores whose work indices were known.

Using this value for the work index the power required for a ball mill to grind 200 tons/day of this ore from 80% -3/8 in. to 80% -150 mesh was calculated to be 193.5 H.P.

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INTRODUCTION

On December 2, 1963, Mr. H. W. Hughes, Mill Superintendent, Malartic Gold Fields Limited, Malartic, Quebec, asked the Mines Branch to determine the work index (W_i) on a sample of ore from Norbeau Mines (Quebec) Ltd.

Shipment and Location of Property

About 50 lb of ore was received from Norbeau Mines (Quebec) Ltd., which is a gold prospect in the Chibougamau district of north-western Quebec.

Investigative Procedure

The method presently used at the Mines Branch to calculate the work index (W_i) of an ore is based on comparative batch grinding tests. Two ore samples of which the Bond work index of one is known are ground under the same conditions for the same time. Screen tests are done on the feed to the mill and on the ground pulp. The screen tests are plotted on log-log paper and the 80% passing size in microns of the feed and ground product is noted.

DETAILS OF INVESTIGATION

Four 2000 g samples of -10 m material were obtained from each of two gold ores of known work indices (W_i) and from Norbeau Mines (Quebec) Ltd. A screen test was done on each ore and a screen and infrasizer test was done on the products from 15, 20 and 30 min grinds. The results were as follows.

Results of Grinding Tests for W_i Calculations

Mesh Size	Comparison Ore A								Comparison Ore B								Norbeau Mines (Quebec) Ltd.							
	Feed		15 min		20 min		30 min		Feed		15 min		20 min		30 min		Feed		15 min		20 min		30 min	
	% ret	% pass	% ret	% pass	% ret	% pass	% ret	% pass	% ret	% pass	% ret	% pass	% ret	% pass	% ret	% pass	% ret	% pass	% ret	% pass	% ret	% pass	% ret	% pass
+ 10 mesh	--	100.0	--	--	--	--	--	--	--	100.0	--	--	--	--	--	--	--	100.0	--	--	--	--	--	--
+ 14 "	17.4	82.6	--	--	--	--	--	--	15.9	84.1	--	--	--	--	--	--	9.9	90.1	--	--	--	--	--	--
+ 20 "	21.8	60.8	--	--	--	--	--	--	19.9	64.2	--	--	--	--	--	--	18.6	71.5	--	--	--	--	--	--
+ 28 "	13.8	47.0	--	100.0	--	--	--	--	12.2	52.0	--	--	--	--	--	--	17.5	54.0	--	--	--	--	--	--
+ 35 "	9.8	37.2	0.9	99.1	--	100.0	--	--	9.3	42.7	--	100.0	--	--	--	--	13.5	40.5	--	100.0	--	100.0	--	--
+ 48 "	7.0	30.2	2.8	96.3	0.3	99.7	--	100.0	6.6	36.1	0.2	99.8	--	100.0	--	--	9.3	31.2	0.7	99.3	0.1	99.9	--	100.0
+ 65 "	5.9	24.3	9.6	86.7	2.8	96.9	0.3	99.7	5.8	30.1	1.1	98.7	0.2	99.8	--	100.0	8.0	23.2	5.1	94.2	1.6	98.3	0.2	99.8
+ 100 "	4.8	19.5	17.0	69.7	11.0	85.9	2.6	97.1	4.6	25.7	5.8	92.9	2.6	97.2	0.6	99.4	6.5	16.7	16.2	78.0	9.0	89.3	2.6	97.2
+ 150 "	3.5	16.0	14.4	55.3	15.2	70.7	8.6	88.5	3.2	22.5	10.4	82.5	7.0	90.2	2.8	96.6	4.7	12.0	18.0	60.0	16.1	73.2	9.0	88.2
+ 200 "	2.6	13.4	11.5	43.8	14.6	56.1	13.8	74.7	2.6	19.9	12.2	70.3	11.0	79.2	7.1	89.5	3.6	8.4	16.4	43.6	18.3	54.9	16.0	72.2
+ 50 microns	13.4	--	3.2	40.6	5.4	50.7	5.2	69.5	19.9	--	3.6	66.7	3.9	75.3	3.0	86.5	8.4	--	4.6	39.0	6.2	48.7	5.6	66.6
+ 40 "	--	--	8.0	32.6	10.3	40.4	13.8	55.7	--	--	11.5	55.2	13.2	62.1	13.2	73.3	--	--	12.7	26.3	15.6	33.1	19.1	47.5
+ 28 "	--	--	6.4	26.2	8.6	31.8	11.7	44.0	--	--	11.1	44.1	13.6	48.5	14.0	59.3	--	--	8.4	17.9	10.2	22.9	13.8	33.7
+ 20 "	--	--	5.5	20.7	7.1	24.7	9.3	34.7	--	--	11.0	33.1	12.2	36.3	14.5	44.8	--	--	5.6	12.3	7.0	15.9	9.8	23.9
+ 14 "	--	--	4.1	16.6	5.6	19.1	6.9	27.8	--	--	8.2	24.9	8.9	27.4	11.1	33.7	--	--	3.6	8.7	4.6	11.3	6.9	17.0
+ 10 "	--	--	3.2	13.4	5.6	13.5	5.4	22.4	--	--	6.3	18.6	7.0	20.4	8.9	24.8	--	--	2.4	6.3	3.1	8.2	4.5	12.5
- 10 "	--	--	13.4	--	13.5	--	22.4	--	--	--	18.6	--	20.4	--	24.8	--	--	--	6.3	--	8.2	--	12.5	--
Total	100.0	--	100.0	--	100.0	--	100.0	--	100.0	--	100.0	--	100.0	--	100.0	--	100.0	--	100.0	--	100.0	--	100.0	--

From log-log graphs of per cent passing versus micron size, the following information was obtained:

Grind Time, min	Comparison Ore A			Comparison Ore B			Norbeau Mines (Quebec) Ltd.		
	F	P	R_r	F	P	R_r	F	P	R_r
15	1200	184	6.5	1100	95	11.6	960	152	6.3
20	1200	130	9.2	1100	78	14.1	960	123	7.8
30	1200	84	14.3	1100	47	23.4	960	86	11.2

where: F = 80% passing size of feed in microns.

P = 80% passing size of product in microns.

and $R_r = \frac{F}{P}$ = reduction ratio.

Calculation of Work Index (W_i) and Power Required (W)

In his*Third Theory of Comminution, F. C. Bond states that W, the work input in kwh/ short ton is equal to $W_i \left(\frac{10}{\sqrt{P}} - \frac{10}{\sqrt{F}}\right)$ where W_i = the work index. The work index is the kwh/ short ton required to reduce a material from theoretically infinite feed size to 80% passing 100 microns.

Since the work input was the same for samples ground for equal times, the equation $W_i \left(\frac{10}{\sqrt{P}} - \frac{10}{\sqrt{F}}\right)$ can be used to solve the unknown work index.

In the case of the 20 min grind using comparison ore A whose W_i is known to be 19.5 and substituting in the formula the values for P and F:

$$W_i \left(\frac{10}{\sqrt{123}} - \frac{10}{\sqrt{960}}\right) = 19.5 \left(\frac{10}{\sqrt{130}} - \frac{10}{\sqrt{1200}}\right)$$

and W_i = 20.1 kwh/ short ton.

*Fred C. Bond: The Third Theory of Comminution. AIME Trans., Vol. 193, p. 484, May 1952.

The following table shows the calculated results of the values of the work indices obtained for the Norbeau ore at the three grinding times when compared to ore A and ore B whose work indices were 19.5 and 13.4, respectively.

Comparison Ores		Norbeau Mines (Quebec) Ltd.		
A	B	15 min grind	20 min grind	30 min grind
19.5	--	18.2	20.1	20.9
--	13.4	20.3	19.5	20.8

Using the power formula of F.C. Bond $W = \frac{10\,W_i}{\sqrt{P}} - \frac{10\,W_i}{\sqrt{F}}$

and assuming the following conditions:

Average W_i = 19.9 kwh/short ton.

Feed rate = 200 tons/day = 8.3 tons/hr.

Feed size (F) = 95% - 1/2 in. - 80% - 3/8 in. = 9500 microns.

Product size (P) = 65% - 200 m - 80% -150 m = 105 microns.

then

$$W = 19.9\left(\frac{10}{\sqrt{105}} - \frac{10}{\sqrt{9500}}\right)$$

$$= 17.4 \text{ kwh/short ton}$$

and (17.4) (8.3) (1.34) = 193.5 H.P.

CONCLUSIONS

The average work index of the Norbeau ore when compared to two ores whose work index was known, was 19.9 kwh/short ton. The power required to grind 200 tons/day of ore from 80% -3/8 in. to 80% - 150 m was 193.5 H.P.

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TFB:DV