Dr. J. Convey
pa.

CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 61-147

SEMI-AUTOGENOUS GRINDING TESTS ON AN IRON ORE FROM CAN-FER MINES LIMITED, ~~KOWKASH~~ KUKATUSH, ONTARIO

by

P. D. R. MALTBY & D. E. PICKETT

MINERAL PROCESSING DIVISION

NOTE: THIS REPORT RELATES ESSENTIALLY TO THE SAMPLES AS RECEIVED. THE REPORT AND ANY CORRESPONDENCE CONNECTED THEREWITH SHALL NOT BE USED IN FULL OR IN PART AS PUBLICITY OR ADVERTISING MATTER.

COPY NO. 6

DECEMBER 14, 1961

~~Industrial Confidential~~

Mines Branch Investigation Report IR 61-147

SEMI-AUTOGENOUS GRINDING TESTS ON AN IRON ORE FROM CAN-FER MINES LIMITED, ~~KONKASH~~, ONTARIO,
KukaTOSA.

by

P. D. R. Maltby* and D. E. Pickett**

SUMMARY OF RESULTS

Autogenous pebble milling tests were conducted on approximately 2 tons of iron ore. The desired fineness of 95% -325 mesh was easily exceeded and observation of the pebble charge indicated that the crude ore lumps would be very satisfactory grinding media. Concentration tests indicated that the grade of concentrate would be satisfactory and that the recovery of iron would be approximately the same as when using conventional ball milling. The scale of the test did not yield power or capacity data for design considerations.

*Scientific Officer and **Head, Ferrous and Associated Ores Section, Metallic Minerals Sub-Division, Mineral Processing Division, Mines Branch, Department of Mines and Technical Surveys, Ottawa, Canada.

INTRODUCTION

Purpose of the Investigation

An investigation* has been reported on the testing and pilot plant beneficiation of iron ore from Can-Fer Mines Limited, ~~Kowkash~~, Kukatosh. Ontario, in which the ore was ground by conventional rod and ball mills. Since the cost of steel balls appeared to be a major cost item, the present investigation was initiated to determine whether the ore could be ground to the required fineness (approx. 95% -325 mesh) using lumps of ore as pebbles in the secondary grinding stage instead of steel balls, the process commonly known as "semi-autogenous" grinding, or "pebble milling".

Shipment

On completion of the pilot plant beneficiation tests using conventional grinding about 15 tons of Can-Fer ore remained. At the request of H. L. Isaacs, President, Can-Fer Mines Limited, part of this ore was used for the semi-autogenous grinding tests.

Location of Property

The ore deposit from which the ore shipments were obtained is the Jeffrey ore deposit in the Central Onaman iron formation about six miles west of ~~Kukatush~~ ~~Kowkash~~ Kukatosh, which is west of Nakina, Ontario, on the main line of the C. N. Railway.

---

* Mines Branch Investigation Report IR 61-41.

Analysis

All chemical analysis of products was conducted by the Analytical Chemistry Sub-Division, Mineral Sciences Division, Mines Branch.

GENERAL PROCEDURE

The mill used for the autogenous or pebble grinding tests was a Denver overflow discharge mill, 30 in. diameter by 48 in. long, driven by a 10 hp motor. Crude ore lumps ranging in size from 2 to 4 in. were selected by hand from the pile and used to make up the autogenous charge. In actual mill practice, ore lumps would be screened from the crusher product ahead of the fine crushing and rod milling circuits. The initial pebble charge was made up by charging 900 lb of ore lumps to the mill and grinding for one hour. At the end of this time the ore lumps were rounded into "pebbles" filling the mill to about 50% of its volume.

To prepare the feed ore sample for the tests, part of the 15 ton sample was crushed to minus 3/8 in. and ground in a 3 ft by 6 ft rod mill in closed circuit with a 20 mesh screen and a single drum of a Dings magnetic cobbing separator. The resulting magnetic concentrate was used as feed for the pebble grinding tests.

This minus 20 mesh cobbed concentrate was fed to the pebble mill for $10\frac{1}{2}$ hours at a nominal feed rate (damp) of 300 lb/hr. Ore lumps were added every hour to make up the pebbles consumed by grinding. The mill discharge was fed to a 3-drum Dings magnetic separator and the magnetic concentrate was pumped to a hydrocyclone classifier. The classifier sand product was returned to the pebble mill and the classifier cyclone overflow was the finished product from the continuous tests.

Laboratory tests were made on the cyclone overflow to produce a finished concentrate since the tonnage produced by pebble grinding was not large enough to treat in the pilot scale equipment.

DETAILS OF INVESTIGATION

Preliminary Rod Milling and Cobbing

The results of the rod milling and of cobbing on the single-drum Dings magnetic separator are given in Table 1. The product was slightly lower in grade than the Dings concentrates produced in the rod milling and cobbing stage of the tests conducted on the original shipment.

TABLE 1

Results of Preliminary Rod Milling and Cobbing

(a) Metallurgy

Product	Weight %	Analysis Sol Fe %	Distn Sol Fe %
Dings conc	64.2	39.58	91.8
Dings tail	35.8	6.33	8.2
Rod Mill Feed	100.0	27.75*	100.0

*calculated

(contd)

(b) Screen Size Distribution of Dings Concentrate

Mesh	Weight %
+20	0.2
-20 +28	1.1
-28 +35	3.2
-35 +48	6.7
-48 +65	7.0
-65 +100	9.9
-100 +150	8.2
-150 +200	7.0
-200 +325	10.9
-325	45.8

Pebble Milling

On November 22, the dry feed rate to the pebble mill was 285 lb/hr and pebble consumption (or lump ore make-up) was 20 lb/hr. However, the pebble charge was low at the end of the day. On November 23, the dry feed rate was 290 lb/hr and the lump ore addition was 30 lb/hr. The pebble charge was at a normal level at the end of the test.

During the test, timed samples were taken of the products. These were weighed and analysed for soluble iron and silica as required. Screen tests were made on some samples. At the end of the test the pebble charge was screened and the fractions were weighed to determine the distribution of pebble sizes.

The results of the pebble grinding tests are given in the following tables:

TABLE 2

Pebble Milling Test Data

Product	November 22		November 23	
	Measured Rate lb/hr	Analysis Sol Fe %	Measured Rate lb/hr	Analysis Sol Fe %
Dry feed	285	41.20	290	-
Pebbles	20	-	30	-
Dings conc	1060	58.32	1120	58.29
" tail	79	8.21	104	8.17
Cyclone spigot	930	57.49	1082	57.37
" o'flow	95	59.52	38	56.7*

* calculated from laboratory test (see Table 6 below)

TABLE 3

Size Distribution of Nov. 22 Products

Mesh	Crude feed % Wt	Dings conc % Wt	Dings tail % Wt	Cyclone Spigot % Wt	Cyclone o'flow % Wt
+35	4.8	-	-	-	-
-35 +48	6.4	-	-	-	-
-48 +65	8.3	1.3	4.8	1.3	-
-65 +100	9.8	2.6	5.3	3.0	-
-100 +150	7.7	4.3	6.3	4.9	-
-150 +200	7.6	7.8	7.3	8.5	0.2
-200 +325	12.6	21.3	13.8	22.4	1.1
-325	42.8	62.7	62.5	59.9	98.7
	100.0	100.0	100.0	100.0	100.0

TABLE 4

Size Distribution of Nov. 23 Products

Mesh	Dings conc Wt %	Cyclone spigot Wt %
+65	1.4	1.5
-65 +100	2.7	3.0
-100 +150	5.0	5.7
-150 +200	8.4	9.7
-200 +325	24.8	27.2
-325	57.7	52.9
	100.0	100.0

TABLE 5

Size Distribution of Final Pebble Charge

Size Fraction in.	Weight in Size Fraction	% Wt
+3	0	
-3 +2	410	49.3
$-2\ +1\frac{1}{2}$	283	34.0
$-1\frac{1}{2}\ +1$	102	12.2
$-1\ +\frac{1}{2}$	35	4.2
$-\frac{1}{2}\ +\frac{1}{4}$	2	0.2
$-\frac{1}{4}$	1	0.1
Total	833	100.0

Note: Sp gr of pebbles in each of the three fractions between 3 in. and 1 in. was determined as 3.1.

Laboratory Tests

Since the cyclone overflow could not be considered a final product, laboratory tests were made on a sample of cyclone overflow from the Nov. 23 run using the laboratory Jeffrey-Steffensen 3-drum magnetic separator and the 6 in. Wade hydroseparator. The Jeffrey-Steffensen concentrate was treated in the hydroseparator to produce a final concentrate. Results of this test are given in Table 6.

TABLE 6

Results of Laboratory Tests
to Produce Final Concentrate

Product	Weight %	Analysis Sol Fe %	Distn Fe %
Jeffrey tail	7.8	16.54	2.3
" midd	12.6	37.29	8.3
Hydrosep. o'flow	7.0	29.68	3.7
" spigot	72.6	66.84	85.7
Cyclone o'flow	100.0	56.7*	100.0

* calculated

The final product (hydroseparator spigot product) analysed 5.96% SiO_2, so would be acceptable as pelletizing concentrate. Its size distribution was 0.5% +200 M, 2.8% -200 +325 M, and 96.7% -325 M.

Calculation of Power Requirements

Since the power lost in the mill drive using the small mill would be out of proportion to the actual power used in grinding, direct power readings on the mill were impractical. It was planned to calculate the required power from the size distribution of the mill products and the grinding Work Index, Wi, of the material. The Wi was determined as 14.5 kwh/short ton for the cobbed concentrate by laboratory grinding in parallel with an ore of known work index. This is a reasonable value since the Wi for the crude ore was determined as approximately 10 by Allis Chalmers laboratories and the magnetite itself has a Wi of about 20.

However, since the circulating load to the mill was not established, the power required to grind the 20 mesh feed to 95% -325 mesh could not be calculated. Assuming the mill was grinding the combined tonnage of the final tail and final concentrate products, the power requirement was estimated at 20 kwh/ton with a possible error of 5 kwh/ton, more or less.

CONCLUSIONS

From the results of the test there is no doubt that the cobbed rod mill product could be ground to the required fineness by pebble milling using the ore lumps as a source of pebbles. The size distribution of the final pebble charge, Table 5, indicated that no troublesome "chip" load at about $\frac{1}{4}$ in. would develop, and that there would be a good range of pebble sizes to grind all sizes of feed. Normal pebble consumption (207 lb/ton of feed) and the rounded shape of the final pebbles also indicated that the ore pebbles would be efficient grinding media.

The grade of concentrate obtained after final separation was the same as obtained from the conventional grinding product. However, the screen size distribution was finer by about 2% at 325 mesh. If this product can be dewatered without difficulty, this would be no disadvantage. It is probable that the sub-screen size distribution may be coarser than the ball milling product and filtering may be easier.

It is clear from Table 2 that the circuit was not at equilibrium when the samples were taken as the Dings tailing and the cyclone overflow do not add up to the feed rate. The circulating load had not levelled off by the end of the test on Nov. 23. Calculation of recovery was not attempted since balancing of product weights would not be justified. Also, the calculated cyclone overflow analysis, obtained from Table 6, does not balance with the cyclone feed and spigot analyses. However, the tailing product tonnages and analyses are approximately the same as for the conventional pilot test.

Assuming that the Dings tailing on Nov. 22 is a reasonable fraction of the feed at 72%, then from the weight recoveries in Tables 1 and 6, the ratio of concentration would be approximately 3.3 which is slightly higher than the ratio obtained previously.

Since the circulating load was not balanced in the grinding circuit, it was not possible to make a calculation of the power requirements. Experience has shown that there is a slight increase in power requirement using pebble milling but this is not significant when compared with the saving over steel ball costs.

The tests were observed by Mr. D. Isbister and Mr. B. Allen of Can-Fer Mines Limited, Toronto, Ontario.

PDRM:DEP:EBM