This document was produced
by scanning the original publication.

Ce document est le produit d'une
numérisation par balayage
de la publication originale.

DECLASSIFIED
INDUSTRIAL CONFIDENTIAL
DATE
AUTHORIZED BY

CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 58-203

KILN DRYING OF IRON ORE FROM THE IRON ORE COMPANY OF CANADA

by

G. N. BANKS and R. A. CAMPBELL

MINERAL DRESSING AND PROCESS METALLURGY DIVISION

NOTE: THIS REPORT RELATES ESSENTIALLY TO THE SAMPLES AS RECEIVED. IT SHALL NOT, NOR ANY CORRESPONDENCE CONNECTED THEREWITH, BE USED IN PART OR IN FULL AS PUBLICITY OR ADVERTISING MATTER.

COPY NO. 12

NOVEMBER 18, 1958

Declassified
Déclassifié

Mines Branch Investigation Report IR 58-203

KILN DRYING OF IRON ORE FROM THE IRON ORE COMPANY OF CANADA

by

G. N. Banks[A] and R. A. Campbell[A]

SUMMARY OF RESULTS

1. Drying tests were performed in a rotary kiln on two types of fine wet ore from the property of the Iron Ore Company of Canada.

2. A pelletized product containing 5-6% moisture was obtained from each of the two types of ore, but only when the kiln temperature was in the range of 100 to 125°C.

3. Because the kiln which was available was not designed for operating at such low temperatures, suitable drying conditions could not be sustained. Good product was obtained only during the cooling period when the kiln burner was turned off and feeding was being continued. As a result no meaningful data regarding fuel consumption could be obtained.

4. Even the best pellets obtained had rather poor mechanical strength.

[A] Scientific Officers, Mineral Dressing and Process Metallurgy Division, Mines Branch, Department of Mines and Technical Surveys, Ottawa, Canada.

BACKGROUND

In June 1958, The Iron Ore Company of Canada, Shefferville, Que., requested that drying tests on samples of their iron ore be performed at the Mines Branch.

In their current mining operations the Company obtains a large quantity of ore which is too wet and of too fine a particle size for direct shipment. The iron content of the material is sufficiently high to yield high-grade iron ore when it is dried. The Company wished to investigate the feasibility of kiln drying this ore which contains about 16% water, to yield a product containing 5-6% water. It was hoped that during this operation the material would be agglomerated into pellets or balls, by the rolling action in the kiln. An important objective in the tests would be to obtain data on the fuel consumption, to permit some preliminary estimates to be made of the cost of such a kiln-drying operation.

The ore for the drying tests consisted of two types, the first known as "yellow ore", and the second as "red ore". Typical screen, chemical and moisture analyses of these two types of ore were supplied by the Company. These data are given in Tables 1 and 2. The samples were identified by the Company as follows:

Yellow ore ..... No. T 14556

Red ore ..... No. T 14557

TABLE 1

Typical Screen and Chemical Analyses of Ores (wet basis)

Screen Size	Yellow Ore (T 14556)			Red Ore (T 14557)		
	Percent by weight	Fe (%)	SiO_2 (%)	Percent by weight	Fe (%)	SiO_2 (%)
+ $\frac{3}{4}$ inch	15.40	60.70	1.84	1.83	62.99	2.88
- $\frac{3}{4}$ inch +4 mesh	30.19	60.13	1.77	6.68	64.53	3.02
- 4 mesh+14 mesh	14.59	60.30	1.36	23.13	64.61	3.23
- 14 mesh +28 mesh	10.28	60.06	1.48	19.68	64.04	3.73
- 48 mesh +200 mesh	8.26	60.06	1.60	17.46	63.55	4.50
-200 mesh	21.28	58.59	2.75	31.22	61.77	6.06

TABLE 2

Typical Moisture Analyses of Ores (wet basis)

Screen Size (Inches)	Yellow Ore (T 14556)		Red Ore (T 14557)	
	Percent by weight	Moisture (%)	Percent by weight	Moisture (%)
+1	7.73	7.51	2.89	18.22
-1 +$\frac{3}{4}$	6.15	9.03	3.89	15.85
-$\frac{3}{4}$ +$\frac{1}{2}$	10.59	10.73	7.74	15.80
-$\frac{1}{2}$	75.53	18.82	85.48	16.34
Average moisture content		16.49		16.33

EXPERIMENTAL WORK

Pretreatment of Ore

Approximately three tons of each type of ore were received, in sealed drums, for the investigation. Although the Company had tried to obtain representative samples, it was noted when the drums were opened that the material in each drum had settled, and that the amounts of supernatant water varied considerably in the different drums. The supernatant water was decanted from each drum and weighed. The amounts of supernatant liquid obtained from each drum, expressed as a percentage of the original weight of the wet ore, are given in Table 3. These data show that the

TABLE 3

Water Decanted from Drums of Ore (percent)

Yellow Ore		Red Ore	
Drum No.	Water Decanted (% of original wet weight)	Drum No.	Water Decanted (% of original wet weight)
1	0.9	1	4.4
2	7.4	2	3.7
3	3.4	3	5.0
4	9.7		
5	1.4		
6	4.0		
7	3.0		

percentage of supernatant water varied widely among the different drums, particularly in the case of the yellow ore.

The data given in Tables 1 and 2 show that both types of ore contained a relatively small proportion of $+\frac{3}{4}$ in. material. Most of this $+\frac{3}{4}$ in. material consisted of small pieces of rock which had adequate strength to withstand shipment and, in the case of the yellow ore at least, contained considerably less water than the finer material. Consequently a decision was made to screen out the $+\frac{3}{4}$ in. material, and to direct the efforts in the drying investigation toward the treatment of the $-\frac{3}{4}$ in. material.

Treatment of Yellow Ore

Each of the seven drums of yellow ore was weighed, the supernatant water was decanted and weighed as previously described, and the remaining solid material was passed over a $\frac{3}{4}$ in. screen. The $+\frac{3}{4}$ in. material so obtained was weighed, sampled, and stored. In the case of drums No. 1 and No. 2 the supernatant water from each was then mixed with the $-\frac{3}{4}$ in. material from the corresponding drum. The material so obtained from each drum was weighed into 100 lb lots and sampled frequently while it was being fed to the drying kiln, to provide a composite sample from each drum for a moisture determination.

The kiln used was about 2 ft in diameter and about 20 ft long, lined with fireclay brick, and heated by the combustion of natural gas. The temperature was measured by means of a chromel-alumel thermocouple inserted at about the hottest part of the kiln. The kiln discharge was sampled frequently, separate samples being

taken for each change in operation.

After processing two drums of the yellow ore, it became obvious that a more uniform moisture content in the feed was desirable. In order to obtain this, all of the supernatant water obtained from the remaining five drums of ore was divided equally among the $-\frac{3}{4}$ in. materials obtained from these drums.

The weight distribution between the $+\frac{3}{4}$ in. and the $-\frac{3}{4}$ in. fractions, and the moisture contents of each, for the seven drums of yellow ore, are given in Table 4.

During the feeding of the first drum of yellow ore, the feed rate used was about 450 lb/hr, and the maximum temperature in the kiln remained at about 360 °C to 380 °C. The product obtained under these conditions was much too dry (containing less than 1% moisture). The feed rate was then increased to about 800 lb/hr in the hope of obtaining a product with a higher moisture content. This higher feed rate lowered the temperature from about 360 °C to about 325 °C but the kiln product still contained less than 1% moisture, and at this feed rate the wet ore began to clog the feed end of the kiln. A feed rate of about 650 lb/hr was found to be the maximum rate at which the kiln would handle this type of ore. During the feeding of the fourth and fifth drums, more adjustments were made to the burner to decrease the heat input, and the temperature decreased to about 225 °C for a time. However, the kiln discharge still contained less than 1% moisture under these conditions. At the start of drum No. 6,

TABLE 4

Weight Distributions and Moisture Contents of Yellow Ore

(Calculated on wet basis)

Drum No.	Total Weight wet ore (lbs)	$+\frac{3}{4}$" Fraction		$-\frac{3}{4}$" Fraction (Includes Decanted Water)	
		Weight (Percent of original)	Moisture Content (%)	Weight (Percent of original)	Moisture Content (%)
1	871	15.5	10.1	84.5	17.3
2	917	11.8	8.9	88.2	24.0
3	892	17.5	10.1	82.5	19.2)
4	900	15.1	9.5	84.9	20.5)
5	928	16.7	10.1	83.3	20.8)[A]
6	924	17.5	8.7	82.5	20.4)
7	913	17.7	9.0	82.3	20.5)
Total	6345				
Average		16.0	9.4	84.0	21.0

[A] Decanted water obtained from drums No. 3 to 7 was divided equally among the $-\frac{3}{4}$ in. fractions, to give each drum about the same moisture content.

the burner was turned off, while feeding was continued. Under these conditions, the temperature gradually dropped and the moisture content of the discharge gradually increased. A product in the form of pellets, and containing about 5% moisture was obtained at about the time when the kiln temperature was in the range of 110-125°C. While the burner was off, feeding gradually became more difficult until finally the kiln became so badly plugged that the operation had to be discontinued.

A summary of the kiln operating data is shown in Table 5. A screen analysis was made of the best product obtained while the burner was off. The results of this analysis are given in Table 6.

Even the best pellets obtained could be crushed rather easily between the fingers, and shattered readily when dropped on a concrete floor from a height of about 12 in.

Treatment of Red Ore

Three drums of red ore were given the same pretreatment as was given to drums No. 3 to No. 7 inclusive of the yellow ore; i.e. the supernatant water was decanted from each and weighed, the solids were screened on a $\frac{3}{4}$ in. screen, and the decanted water was then divided equally among the three portions of $-\frac{3}{4}$ in. material to give approximately the same moisture content in each. The weight distributions between the $+\frac{3}{4}$ in. and the $-\frac{3}{4}$ in. fractions, and the moisture contents of each, for the two drums of red ore which were fed, are given in Table 7.

TABLE 5

Kiln Operating Data for Yellow Ore

Drum No.	Weight of Wet Feed	Feed Rate (lb/hr)	Gas Consumption (cu ft/hr)	Kiln Temp. °C	Moisture in Kiln Discharge (%)
1	736	468	400	380-360	<0.7
2	809	500-700	400	360-325	<0.7
3	736	400-800	400	325-280	<0.7
4	764	700	230	280-225	<0.7
5	773	650	230	225-325	<0.7
6	762	650	A---	325-150	<0.7
7	100	650	---	150-110	0.2 to 5.0

A Burner off at start of drum No. 6 - Discharging continued for 2 hr after feeding stopped.

Total Feed (dry wt.)	= 3697 lb
Product obtained (dry wt.)	= 1070 "
Spillage at feed end of kiln (dry wt.)	= 950 "
Unaccounted for[AA]	= 1677 "
Total gas consumption	= 1825 cu ft

AA Material remaining in kiln, dust losses, etc.

TABLE 6

Screen Analyses of Best Products Obtained

Size	Percent Weight	
	Yellow Ore	Red Ore
$+\frac{1}{2}$"	25.8	18.4
$-\frac{1}{2}$" $+\frac{1}{4}$"	43.5	34.4
$-\frac{1}{4}$" +6M	14.5	28.8
-6M +20M	9.9	12.6
-20M +48M	2.6	3.1
-48M +65M	0.6	0.6
-65M +100M	0.5	0.4
-100M +150M	0.4	0.3
-150M +200M	0.2	0.2
-200M	2.0	1.2

TABLE 7

Weight Distributions and Moisture Contents of Red Ore

(Calculated on wet basis)

Drum No.	Total Weight wet ore	$+\frac{3}{4}$" Fraction		$-\frac{3}{4}$" Fraction	
		Weight (Percent of original)	Moisture Content (%)	Weight (Percent of original)	Moisture Content (%)
1	1010	3.2	11.9	96.8	19.7
2	990	2.0	9.2	98.0	21.0
Total	2000				
Average		2.6	10.4	97.4	20.4

A feed rate of about 500 lb/hr was used at the start of this drying operation, and the kiln temperature stabilized at about 250 °C. Under these conditions the kiln product contained less than 1% moisture. After about 400 lb of ore had been fed, the feed end of the kiln became so badly clogged that the operation had to be stopped, and the kiln was washed out with water. When the drying operation was resumed, only the pilot light of the burner was used to supply heat, and the feed rate was kept at about 450 lb/hr. The kiln temperature stabilized at about 150 °C, but even under these conditions the moisture content of the discharge remained below 1%. The pilot light was then turned off, and as the kiln temperature decreased through the range of 125 °C to 110 °C, a pelletized product containing about 5% moisture was obtained. In all, only two drums of red ore were used. A summary of the kiln operation during the treatment of this ore is given in Table 8, and a screen analysis of the best product is shown in Table 6.

As was the case in the treatment of the yellow ore, even the best pellets obtained shattered quite readily when dropped from a height of about 12 in.

TABLE 8

Kiln Operating Data for Red Ore

Drum No.	Weight of Wet Feed	Feed Rate (lb/hr)	Gas Consumption (cu ft/hr)	Kiln Temp. (°C)	Moisture in Kiln Discharge (%)
1	978	500	400	100-250	<0.5
2	970	400-700	150	250- 60[A]	<0.5 to 9.2

A Burner turned off after feeding of drum No. 2 - Discharging continued for $5\frac{1}{2}$ hr.

Total feed (dry wt.)	= 1550 lb
Product obtained (dry wt.)	= 878 "
Spillage at feed end of kiln (dry wt.)	= 497 "
Unaccounted for[AA]	= 176 "
Total gas consumption	= 825 cu ft

AA Material remaining in kiln, dust losses, etc.

DISCUSSION

The results of the experiments indicate that a pelletized product containing about 5-6% moisture may be produced by drying either of these two types of ore in a kiln. This would take place only when the kiln temperature was very low e.g. in the range of 100°C to 125°C. Because the kiln which was used was not designed for operating at such low temperatures, suitable drying conditions could not be maintained during the experiments. Hence, no reliable data could be obtained regarding fuel consumption for the drying operation. By shutting off the burner while feeding was being continued, a kiln temperature of 125°C to 100°C was obtained briefly during the cooling period. During this period, some pelletized product with the desired moisture content was obtained from each of the ores. However, even

the best pellets obtained shattered quite readily, and it seems improbable that their mechanical strength would be adequate to withstand shipping from the Company's property to present ore markets.

GNB:RAC:CL