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OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 64-77

ROASTING AND MAGNETIC SEPARATION OF IRON ORE CONCENTRATE FROM CREST EXPLORATIONS, LTD., Y. T.

by

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EXTRACTION METALLURGY DIVISION

COPY NO. 5

AUGUST 27, 1964

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R.L. Sachdeva and G.V. Sirianni*

SUMMARY

Four samples of iron ore concentrates prepared in the Mineral Processing Division from ore submitted by Crest Explorations Limited were treated by roasting in natural gas and magnetic separation in an attempt to further upgrade them. One of the concentrates, which was 99% plus 48 mesh was upgraded from 57.2% Fe to 65.3% Fe with an iron recovery of 88.5% without any treatment prior to roasting. No improvement in grade or recovery was obtained when this concentrate was ground to -48 mesh before roasting. When it was ground to -100 mesh before roasting the recovery of iron in the magnetic concentrate increased to 95.6% but the grade decreased to 64% Fe.

Identical results were obtained whether the roasting was performed for 1 hour at 800°C or for 1/2 hour at 850°C.

In all cases the phosphorus content of the magnetic concentrates was high (0.2 to 0.3% P) and the investigation was discontinued pending further work by the Mineral Processing Division to try to decrease the phosphorus content of the concentrates by their procedures.

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INTRODUCTION

Correspondence was exchanged between Dr. C.D.A. Dahlstrom, General Manager of Crest Explorations Ltd. and Dr. K.W. Downes, Chief of the Extraction Metallurgy Division in July and August, 1963. This correspondence confirmed arrangements for this Division to perform magnetizing roasting experiments on concentrates produced in the Mineral Processing Division from ore from the Snake River Area, Y.T. These concentrates were to be upgraded by magnetizing roasting and magnetic separation, the latter to be performed in the Mineral Processing Division. Natural gas was chosen as the reductant because of its availability in the Snake River area.

Subsequently, three additional samples, identified as samples A, B and C were received. These concentrates were combined jig concentrates from pilot-plant operations. For a fuller description of the manner of preparation of these concentrates, reference should be made to Mines Branch Investigation Report IR 63-103 entitled "Pilot Plant Jig Tests on Iron Ore from Snake River Area, Y.T., for Crest Exploration Limited" by P.D.R. Maltby.

EXPERIMENTAL WORK

The roasting experiments were performed in an Inconel bomb contained in an electrically heated, rotating retort. A schematic diagram of the equipment used is shown in Figure 1. In each experiment 500g of concentrate was placed in the Inconel bomb, which was then sealed and placed inside the retort. The latter was continuously rotated to improve the gas-solids contact and the temperature distribution. While the charge was being brought up to the desired temperature, the system was flushed with an inert gas, such as nitrogen, to prevent any premature reduction of the concentrate. When the desired temperature was attained the flow of nitrogen was discontinued and natural gas at 2.5 l/min was admitted, which constituted a large excess over the stoichiometric requirement for the reduction of Fe_2O_3 to Fe_3O_4. The exhaust gases were burned on exit from the bomb. At the end of the reaction period the bomb was withdrawn from the furnace and quenched in water for about one hour under a small positive pressure of nitrogen to prevent re-oxidation. When cool, samples of the product for chemical analysis and magnetic separation in a Davis tube were obtained by riffling. The material was ground to minus 200 mesh before magnetic separation. The concentrate and tailings from the Davis tube were analyzed for total iron and ferrous iron and the iron recovery in the concentrate was calculated.

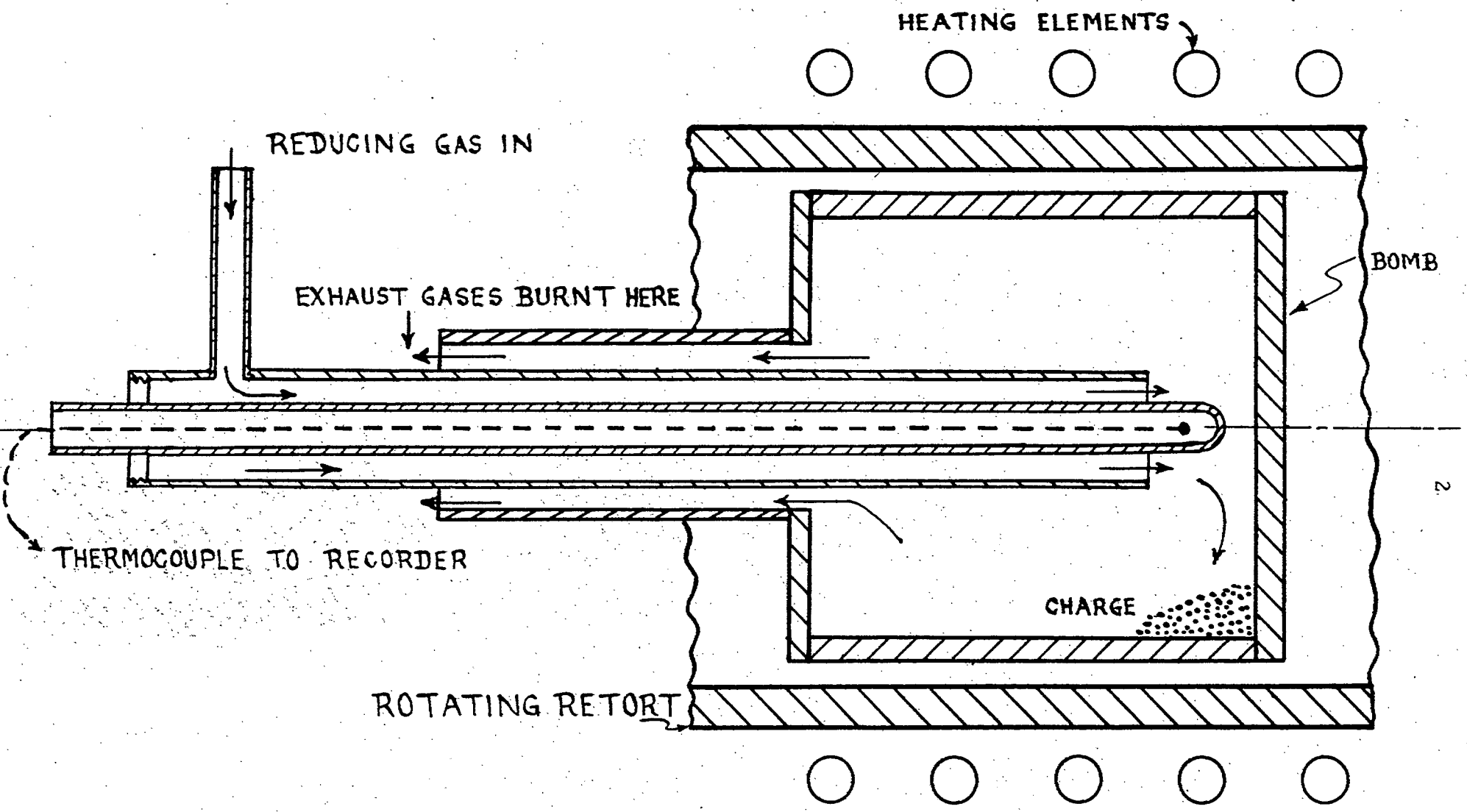

FIGURE 1 - Schematic diagram of equipment used in roasting Crest concentrates

RESULTS

The screen analysis of sample No. 1 and chemical analysis of samples No. 1, A, B and C are given in Tables 1 and 2 respectively.

TABLE 1

Screen Analysis of Sample No. 1

Screen Size (m)	Weight (%)
+ 10	44.8
-10 + 20	34.5
-20 + 35	15.3
-35 + 48	4.6
-48	0.8
	100.0

TABLE 2

Chemical Analysis of Crest Ore Concentrates

Sample	Constituent (%)			
	Total Fe	Fe^{++}	SiO_2	P
No. 1	57.2	3.97	14.1	0.29
A	56.6	2.90	10.7	0.24
-6m fraction from A	62.5	2.51	N.D.	N.D.
-6m fraction from B	60.4	3.12	N.D.	0.13*
-6m fraction from C	62.7	3.82	N.D.	0.09*

* Information obtained from Mineral Processing Division.
N.D. Not determined.

The experiments performed in this investigation may be divided into three categories:

(i) Experiments in which concentrate No. 1 was roasted as received,

(ii) Experiments in which concentrate No. 1 was pulverized to finer sizes, and then roasted,

(iii) Experiments in which selected size fractions from concentrates A, B and C were roasted.

The conditions of roasting, pre-treatment (if any), grade of magnetic concentrate produced, and percentage iron recovered in the concentrate have been summarized in Tables 3, 4 and 5 for the three categories (i), (ii) and (iii) respectively.

Due to the limited nature of the investigation it was not possible to establish any definite relationship between the Fe^{++}/ total iron ratio and either the recovery of iron in the concentrate or the grade of the concentrate. However, in the experiments performed, it was found that up to a Fe^{++}/ total iron ratio of about 0.45, the recovery of iron increased as the Fe^{++}/ total iron ratio increased. No correlation between the grade of concentrate and Fe^{++}/ total iron was observable.

It was noticed that grinding concentrate No. 1 to -48 mesh or even to -100 mesh did not improve the grade of the magnetic concentrate: in fact, it was consistently lower. On the other hand, percentage of iron reporting in the concentrate was higher in almost all cases when the roasted concentrate (i.e., feed to the Davis tube) was ground finer.

There was very little change in the grade of the magnetic concentrate when the temperature was varied between 750° and 850° C. Increasing the roasting time from 1/ 2 hour to 1 hour resulted in a little more iron being recovered in the Davis tube concentrate, except in Test No. 6. In this test, where the concentrate was roasted at 850° C for 1 hour, the Fe^{++}/ total Fe ratio was 0.615, indicating that the reduction had proceeded to the FeO stage instead of Fe_3O_4. Because FeO is nonmagnetic, most of the iron in this case was lost in the tailings.

The results obtained in the first series of experiments indicated that a half-hour roasting time at 850° C would be suitable. In at least one case (Test No. 7) the grade of the final concentrate improved, but the recovery of iron was slightly lower when the roasted material was ground to -325m before magnetic separation.

TABLE 3

Results of Roasting and Magnetic Separation Tests

Test No.	Conditions of Roasting		Analysis of Roasted Conc:		$\frac{Fe^{++}}{\text{Total Fe}}$ Ratio		Davis Tube Results			
	Temp (°C)	Duration (hr)	Total Fe (%)	Fe^{++} (%)			Wt (%)	Fe (%)	Recovery* of Iron (%)	P (%)
4	750	1/2	59.0	19.4	0.329	Conc	76.3	65.3	83.9	N.D.**
						Tails	23.7	40.4		
5	800	1/2	59.9	21.7	0.362	Conc	79.0	65.9	85.1	
						Tails	21.0	43.2		
3	850	1/2	59.9	27.9	0.466	Conc	83.0	65.3	88.5	0.21
						Tails	17.0	41.5		
1	750	1	59.5	19.4	0.326	Conc	79.6	64.8	86.8	N.D.
						Tails	20.4	39.6		
2	800	1	59.7	26.6	0.445	Conc	82.2	65.5	88.4	N.D.
						Tails	17.8	40.1		
6	850	1	60.2	37.0	0.615	Conc	10.3	69.1	11.8	N.D.
						Tails	89.7	59.8		

* Recovery = $\frac{\text{Wt of Fe in Conc}}{\text{Wt of Fe in Conc + Wt of Fe in Tails}}$

** Not determined

TABLE 4

Results of Roasting and Magnetic Separation Tests on Pulverized Sample No. 1

Test No.	Size of the Concentrate Prior to Roasting (m)	Conditions of Roasting		Analysis of Roasted Conc		$\frac{Fe^{++}}{Total\ Fe}$ Ratio	Davis Tube Results					Remarks
		Temp (°C)	Duration (hr)	Total Fe (%)	Fe^{++} (%)			Wt (%)	Fe (%)	Recovery of Iron (%)	P in Conc (%)	
10	-20	700	1/4	56.3	18.9	0.336	Conc Tails	78.0 22.0	63.4 39.2	85.2	N.D.	
7	-48	750	1/2	58.1	25.0	0.430	(A) Conc Tails	85.7 14.3	61.4 46.8	88.7	N.D.	Mag. separation done without further size reduction
							(B) Conc Tails	82.1 17.9	64.0 46.4	86.3	N.D.	Roasted conc ground to -325 m before magnetic separation
8	-100	700	1/2	59.7	22.6	0.379	Conc Tails	91.4 8.6	63.5 30.1	95.7	0.19	Mag. separation done without further size reduction
9	-100	750	1/4	60.4	21.0	0.348	Conc Tails	90.9 9.1	63.5 29.6	95.6	0.21	"

N.D. = Not determined

TABLE 5

Results of Roasting and Magnetic Separation Tests on Jig Concentrates (Sample Nos. A, B and C)

Test No.	Description of Charge	Conditions of Roasting		Analysis of Roasted Conc		$\frac{Fe^{++}}{Total\ Fe}$ Ratio	Davis Tube Results					Remarks
		Temp (°C)	Duration (hr)	Total Fe (%)	Fe^{++} (%)			Wt (%)	Fe (%)	Recovery of Iron (%)	P in Conc (%)	
11	Crest A conc	850	1/2	61.6	14.9	0.242	Conc Midd Tails	56.9 7.7 35.4	65.04 63.19 52.39	69.0	N.D.	Separation done on Jeffrey magnetic separator
12	-65 mesh fraction from A conc	850	1/2	62.0	37.6	0.606	Conc Tails	87.3 12.7	65.4 29.0	87.3	0.29	Ground to 100%-325 mesh before magnetic separation
13	-6 mesh fraction from A conc	850	1/2	N.D.	N.D.	-	Conc Tails	68.1 31.9	64.15 56.74	70.3	N.D.	
14	-6 mesh fraction from B conc	850	1/2	62.3	13.3	0.214	Conc Tails	69.9 30.1	63.04 58.11	71.6	N.D.	
15	-6 mesh fraction from C conc	850	1/2	66.3	16.2	0.244	Conc Tails	78.5 21.5	66.1 59.0	80.5	N.D.	

N.D. = Not determined

CONCLUSIONS

On the basis of the experiments performed in this investigation, it was concluded that:

(1) concentrates prepared in the Mines Branch from iron ore submitted by Crest Explorations, Ltd., could be upgraded from 57% to 65% iron by roasting in an atmosphere of natural gas followed by magnetic separation,

(2) an iron recovery of 88% could be obtained when the roasting took place at 850° C for 30 minutes,

(3) although there was no apparent advantage in grinding the concentrate prior to roasting, the grade of the magnetic concentrate did improve somewhat by grinding the roasted concentrate to -325 mesh before magnetic separation,

(4) the phosphorus content of the final concentrate did not drop below about 0.2%, which was too high.

RLS/GVS/dm