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Report No 479

The Production of Sponge Iron from Texada Island (B.C.) Iron Ore.

By

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Object of Investigation -

To produce sponge iron, on a semi commercial scale, from Texada Island iron ore and to determine the suitability of the sponge iron so produced for the manufacture of steel.

Shipment -

A shipment of 2496 lbs. of this ore was received on November 4, 1930, from Mr. John D. Galloway, Provincial Mineralogist, Province of British Columbia.

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Nature of the Ore & Chemical Analysis of Shipment -

The ore is a high grade magnetite. The shipment was crushed and carefully sampled. This sample, on chemical analysis, gave the following results:-

(Dried at 105° C.)

Fe_3O_4	85.59	(Fe = 62.06)
$CuFeS_2$	0.13	(S = 0.15)
FeS_2	0.20	(Mn = 0.10)
MnO_2	0.16	(P = 0.056)
SiO_2	8.41	(Cu = 0.045)
F_2O_5	0.13	
CaO	2.80	
MgO	1.17	
Al_2O_3	1.31	
	99.90	

Laboratory Concentration Tests & Conclusions drawn therefrom -

With the object of determining the extent to which the gangue content of the ore could be removed by concentration and thus provide a basis from which the suitability of the ore for the production of sponge iron might be judged, small scale magnetic concentration tests were carried out in the Davis Magnetic Tube. The results of these tests have been presented in our report entitled "The Laboratory Concentration of Texada Island Iron Ore". These tests, in brief, showed that the ore responds very well to magnetic concentration, and that by grinding to minus 40 mesh or finer the gangue, including the sulphur bearing constituents, is liberated to an extent sufficient to make it possible to produce from this concentrate a low sulphur-low phosphorus sponge iron containing over 90% iron.

Large Scale Tests -

In the light of the information obtained from the laboratory concentration tests, the following series of steps for the commercial production of sponge iron from Texada Island ore, was indicated as the most suitable.

1. The wet magnetic concentration of the ore ground to minus 100 mesh.

2. The sintering of this concentrate to produce a product more physically suitable for reduction and briquetting.

3. The low temperature reduction of this sintered material, crushed to minus 10 mesh.

4. The briquetting of the sponge iron so reduced to yield a product suitable for conversion into steel in electric or open hearth furnaces.

Concentration:

In this run, 1500 lbs. of ore were crushed to minus 6 mesh and fed to a rod mill at the rate of 100 lbs. per hour, the rod mill being operated in closed circuit with an Aikens classifier. A screen test on the classifier overflow gave the following results:

Plus	100 mesh (Tyler Screen)	2.00%
Minus	100 Plus 150 mesh	7.65%
Minus	150 Plus 200 mesh	11.45%
Minus	200 mesh	78.90%
		100.00%

From the screen test it will be seen that the material was ground much finer than necessary, since the small scale preliminary tests indicated that the desired results could be obtained with 100 mesh material.

The concentration was carried out in two Grondal Magnetic Separators, so arranged that the second of these machines served to clean the tailing from the first. The results obtained in this concentration are summarized in Table I. This table shows that the results obtained in the preliminary small scale tests, can be duplicated in large scale operations.

Table I

Wet Magnetic Concentration of Texada Island Ore.

Feed:			
	Weight	Percent	100.0
	Iron	"	62.06
	Copper	"	0.045
	Sulphur	"	0.150
	Phosphorus	"	0.056
	Insoluble	"	11.54
Concentrate:			
	Weight	Percent	85.2
	Iron	"	70.25
	Copper	"	Nil
	Sulphur	"	0.01
	Phosphorus	"	0.02
	Insoluble	"	3.39
Tailing:			
	Weight	Percent	14.8
	Iron	"	14.90
	Copper	"	0.30
	Sulphur	"	0.95
	Insoluble	"	58.40
	Iron Recovery		96.4%
	Sulphur Rejected		94.3%
	Phosphorus Rejected		69.6%
	Insoluble Rejected		74.9%

Ratio of Concentrate - 1:1.17

Sintering:

This operation was carried out for two reasons; first, low temperature reduction or metallization is very difficult to carry out on fine material that packs tightly and is impervious to the reducing gases; and second, a much better briquett is obtained from comparatively coarse material than from very fine sponge. The finely divided concentrate was, therefore, agglomerated by sintering.

The successful sintering of finely divided material is rather difficult due to imperviousness of the bed to the air blast and the tendency of the material to run through the grates. In commercial practice, however, there is generally, if not always, sufficient so-called "returns", that is, semi sintered material and comparatively fine particles of sintered material available to mix with the raw material, thus correcting these undesirable conditions to a large extent.

In these tests a total of 1000 lbs. of concentrate were sintered on a 12 x 48 inch Dwight and Lloyd continuous sintering machine. The mix yielding the most physically satisfactory sinter was as follows:

Concentrate	70%
"Returns"	17%
Coke Breeze	5%
Water	8%

In addition to the above "returns" a layer of coarse sinter (about 4 mesh) was placed directly on the grates to prevent the fine material from being drawn through.

The sinter obtained was well fused and was fairly hard. It seems probable that if possible the mix should be changed to yield a sinter with cells that are smaller and more numerous since such a sinter would be mechanically stronger and more suitable for reduction in stack furnaces. For our purpose, however, the sinter obtained was quite satisfactory since our plans included crushing the sinter to 10 mesh and reducing it in an externally heated rotary retort.

Low Temperature Reduction (Metallization):

The only equipment available for this operation consisted of an electrically heated rotary retort that has been used in all our work on the low temperature reduction of ores. This alloy retort, which forms the heating chamber of a 60K.W. furnace has an inside diameter of 14¾" and an effective loading length of 48 inches.

In carrying out this work, batches of approximately 100 lbs. of the sintered concentrate, crushed to pass a 10 mesh tyler screen, were charged into the retort. The retort and its contents were heated to 1800°F and held at this temperature for periods of time varying from 6 to 7½ hours with different charges. During the entire heating and holding period a stream of city gas was passed through the retort. At the end of the heating operation, the material was discharged into a special container provided with a tightly fitting cover.

In all, nine batches, totalling 1000 lbs. of sintered concentrate, were metallized in this manner. The results obtained with each batch and the general average result of the total amount metallized are summarized in Table II.

Table II

- Results of Metallization Tests on Sintered Concentrate -

Batch No.	Total Iron	Metallic Iron	Metallization	Sulphur
1	87.35 %	82.63 %	94.6 %	0.02 %
2	88.26	87.07	98.6	
3	91.16	90.96	99.7	
4	90.81	90.23	99.3	
5	91.62	90.03	99.3	
6	91.01	90.42	99.3	
7	83.92	74.76	89.1	
8	84.90	80.08	94.3	
9	89.63	88.85	99.1	
General Average of Mixture of 9 Batches -	89.17	86.79	97.5	0.02 %

This material was given one pass on the drum type dry magnetic separator and a concentrate of the following composition was obtained:-

Total Iron	90.03 %
Metallic Iron	88.26
Sulphur	0.020
Phosphorus	0.025

It will be noted in Table II that the metallization in two of the runs was considerably below that of the others and that this has resulted in the metallic iron content of the mixture of all 9 batches being somewhat lower than it would otherwise have been.

Briquetting:

Sponge iron in the loose powdery form is most unsuitable for charging into steel melting furnaces for two reasons: first, its density is so low that in order to get any considerable weight into the furnace, repeated rechargings involving great expense would be necessary, and second, such finely divided material is subject to excessive oxidation loss in melting. By means of briquetting the material may be formed into compact briquettes the density of which will be about 50 to 60 percent of that of solid steel and these bruiquettes due to their greatly reduced surface area do not oxidize during melting.

In this work some 660 lbs. of minus 10 mesh sponge iron were briquetted in a 70-ton Southwark briquetting machine. The material briquetted very satisfactorily. The briquettes were 2 inches in diameter and averaged about 1 1/8 inches long. One of these briquettes weighed about 55 percent of the weight of a solid steel slug of the same dimensions.

- Sponge Iron Briquettes from Texada Island Ore -

Melting Tests:

To demonstrate that these briquettes are quite suitable for conversion into commercial steel by melting and alloying with carbon and manganese, melting tests were carried out. Melting was done in a 50-lb. Ajax-Northrup high frequency induction furnace and the steel produced was cast into $3\frac{1}{2}$" ingots.

The results of these tests are summarized in Table III which gives for each ingot made, the materials used, the weight and chemical analysis of the ingot produced, and the approximate recovery of the metallic constituents of the charge.

Summary and Conclusions:

This work has confirmed the conclusion drawn from small scale laboratory concentration tests that Texada Island magnetite is eminently suitable for the manufacture of sponge iron. Approximately seven hundred pounds of sponge iron of excellent quality were produced from this ore and the suitability of this sponge iron for the manufacture of low sulphur, low phosphorus steel was demonstrated by actual melting tests.

Table III

\- Summarized Results of Melting Tests -

Ingot No.	Charge (lbs.)				Ingot						Recovery
	Briquettes	Coke	Ferro Mn	Ferro Si	Wt. (Lbs.)	C	Mn	P	S	Si	
1	45.0	.09	0.40	0.40	37.5	.11	.55	.028	.017	.16	92.3
2	45.0	.13	0.40	0.40	37.0	.09	.49	.028	.015	.15	91.0
3	45.0	.10	0.40	0.40	36.5	.22	.66	.032	.017	.25	90.0
4	45.0	.26	0.40	0.40	37.0	.29	.67	.026	.028	.25	91.0
5	45.0	.19	0.40	0.40	36.5	.43	.73	.028	.022	.31	90.0
6	45.0	.39	0.40	0.40	36.6	.99	.75	.029	.024	.30	90.0