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The Rate of Reduction to Sponge Iron of a Typical Lake Superior Ore Under Certain Conditions in an Externally Heated Rotarting Retort.

T. W. Hardy

Ottawa, January 26, 1931.

REPORT

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The Rate of Reduction to Sponge Iron of a Typical Lake Superior Ore Under Certain Conditions in an Externally heated rotarting retort.

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Object of Investigation: In the Musso process for the semi direct production of steel from iron ore, the production of sponge iron from a mixture of iron ore and bituminous coal in an externally heated rotating metallic retort is the first and most important step. Since the commercial success of such a process depends to a large extent upon the productive capacity of the retort, it seems advisable to determine the rate of reduction when conditions are kept as closely as possible to those proposed by the inventor of the Musso process.

General Considerations: Among the more important factors governing the rate of reduction of iron ore particles are (1) size of particle (2) physical structure of the oxide (3) temperature of reduction (4) type and amount of reducing agent and (5) heat input. In addition to these, it is the

claim of the inventor of the Musso process that the rate of reduction is materially accelerated by exhausting the reaction gases from the retort as fast as they are formed, and maintaining a pressure somewhat below atmospheric within the retort. The type of ore, reducing agent, particle size and reduction temperature have been specified by the inventor and are easily duplicated. The rate and quantity of heat input for the proposed pilot plant, is, however, not definitely known, and in any case, cannot readily be duplicated in a laboratory test. The evacuation of the reaction gases from the retort was also found difficult to carry out, on account of the clogging of the pump with dust and tar.

It was however thought that the determination of the percentage metallization of a definite weight of ore-coal mixture heated to a definite temperature in an externally heated retort for various periods of time under otherwise comparable conditions would be of value in enabling us to form some idea of the rate of reduction and that by keeping such variables as the proportions of ore and coal in the mixture, the particle size and the reduction temperature in agreement with the values specified by Musso, it should be possible to form at least an approximate idea of the time required for reduction in the Musso pilot plant.

Experimental Method: In these experiments, reductions were carried out in an externally heated rotating retort which forms the heating chamber of a 60 KW electric furnace. The alloy retort, which has an inside diameter of 14½ inches and an effective loading length of 48 inches, extends 9 inches out of the charging end of the furnace and is supported on rollers provided for this purpose on the outside of the furnace shell. At the opposite end of the furnace an alloy sleeve or hub extension of the alloy retort extends about one

foot beyond the furnace shell and provides means of rotating the retort and for supporting this end of the retort outside of the furnace on two bearings of the roller type. The retort is equipped at the charging end with a cast plug, heavily insulated, and provision is made for tight closing by means of clamps. An alloy exhaust tube is provided in this plug to relieve any pressure to vent any gases generated within the retort.

The furnace is equipped with nickel chromium heating elements located on the side walls on the furnace roof and also under the retort. The thermocouple, which in conjunction with a Leeds & Northrup indicating controller serves to automatically control the temperature of the furnace, enters through the roof, and is so placed that the hot junction is almost touching the rotating retort. The furnace is supported on trunnions so that it may be tilted forward or backward as desired.

In each of the experiments herein recorded, the following procedure was observed. The furnace was first brought to a temperature of 1700°F. A charge consisting of an intimate mixture of 73 pounds of Bell ore and 27 pounds of Fairmont coal, both ground to 20 mesh, was then quickly introduced into the retort. This charge was kept in the retort, which was rotating at a rate of 1 R.P.M., for a definite period of time. The weight charged, 100 pounds, was chosen because it gave a maximum thickness of bed of four inches, which thickness is the same proportion of the retort diameter, as the proposed bed thickness in the Musso retort is of its diameter. After being kept in the rotating retort for the predetermined period of time, the sponge was discharged into a container provided with a self sealing cover. When cold, the sponge iron was carefully sampled and analyzed for total iron and metallic iron. The percentage metallization was calculated from these two results. It should be noted that these analyses are of

the crude sponge before magnetic concentration.

The introduction of the cold charge into the hot retort always caused a drop in temperature of about 20°F. The indicating temperature controller, however, showed that the outside of the retort reached the operating temperature again in about 15 minutes. In the results given herein, the time given for each run includes this fifteen minutes during which the retort was below the operating temperature of 1700°F.

Analyses of Materials Charged.

Bell Iron Ore
(Mesaba Range, Lake Superior)
Dried at 212°F.

Iron	- 56.50 %
Silica	- 11.90
Phosphorus	- .062
Sulphur	- .04
Alumina	- .69
Lime	- .38
Magnesia	- .21
Manganese	- .51
Loss on ingition	- 5.47

Fairmont Coal
(Fairmont, Pa)
As Charged.

Moisture	- 2.00 %
Volatile Matter	- 35.20
Fixed Carbon	- 54.60
Ash	- 8.20
Sulphur	- 1.40

Results Obtained:

Metallization obtained in Various Periods of Time.

Time	Wt. Charged	Depth: Bed	Temp.	Analyses: Total Iron	Metallic Iron	Metallization
50 min.	100#	4"	1700°F	51.17%	8.00%	15.6%
1 hr 5 min	100#	4"	1700°F	52.64	13.78	26.2
1 hr45 min	100#	4"	1700°F	57.56	32.10	55.8
2 hr15 min	100#	4"	1700°F	57.59	45.06	78.2
2 hr45 min	100#	4"	1700°F	60.65	58.12	95.8
3 hr15 min	100#	4"	1700°F	63.60	61.70	97.0
4 hr15 min	100#	4"	1700°F	64.86	62.12	95.7

Conclusions: The tabulated results of these tests show that in order to obtain a metallization of 90 per cent or better, under the conditions obtained in these experiments a total time of about 2¾ hours is required.

If conditions in this batch type laboratory retort were strictly analagous to conditions in the Musso retort, we would be justified in stating that an ore particle would require 2½ to 2¾ hours in the Musso retort for a 90 per cent reduction to metallic iron. As has been pointed out, however, conditions with respect to rate and quantity of heat input are probably not analagous and this together with the absence in these tests of the evacuation of the reaction gases, which operation is claimed by the inventor to materially speed up the rate of reduction, makes it unwise to draw this conclusion.

The tests are of value however in that they indicate that the time for heating and reduction to a 90 per cent metallized sponge in the Musso retort need not exceed two and three quarter hours.