Sintering of COMILOG Ore in Moanda

J.-J. Dailloux
ERAMET COMILOG Manganese S.A., Paris, France

M. Sibony, F. Wasser
CRT, Pyrometallurgy Section, Trappes, France

1. INTRODUCTION

COMILOG, a manganese ore and manganese alloys producer, is now part of the manganese branch of the ERAMET group. The other activities of ERAMET are nickel and high-speed steels. ERAMET Manganese uses electric furnaces as well as blast furnaces and is present in Gabon, USA, France, Norway, Italia and China.

COMILOG operates one of the biggest Manganese ore mines in the world in Moanda (Gabon). The annual production is roughly 2 Mt per year. The Moanda ore is of high grade: between 47.0 and 52.0% Mn. A large proportion of the production is used by the subsidiaries of the group ERAMET, particularly in the plant of Boulogne-sur-Mer, at COMILOG France. This plant operates 3 blast furnaces for the production of HCFeMn.
Today the fines generated by the extraction and processing of ore in Moanda are stored on a heap and the blast furnaces are fed with lumpy ore.

In order to valorize the fines in Moanda and to increase the productivity of Boulogne-sur-Mer, COMILOG has decided to produce sinter in Gabon. The sinter produced will be mainly fed to the blast furnaces of COMILOG France, but will also be partly used in the electric furnaces of ERAMET Manganese and also sold on the market outside of the group.

2. INDUSTRIAL PROJECT AND PROCESS

The project for a sinter plant in Moanda was launched in 1996. The sinter plant will be commissioned at the end of 2000.
In order to be able to feed the COMILOG France blast furnaces and other customers, the designed capacity for the sinter plant is 600 000 t/y. 70 to 80% of this production will be used by ERAMET Manganese and the remaining part will be sold on the market.
The plant consists of a fines beneficiation plant and the sinter plant itself.

2.1. Beneficiation of Ore Fines

The fines generated by the ore extraction and processing, completed with fines from the heap, are dispatched on a curvoduct and linear conveyors to the new implantation (on more than 8 km).
After separation of the ultra-fines, the fines are beneficiated in a new special unit producing a concentrate of 1-10 mm granulometry and 52.0% manganese content.
The process and the technology engineering have been developed within the ERAMET group.

2.2. Sinter Plant

The sinter plant is mainly composed of a sinter machine and an external cooler.

Several tests have been performed at lab scale and pilot scale to size the machine area and the cooler and after comparison with its competitors, Lurgi has been chosen to build the sintering unit.

The main characteristics of the sinter machine are given in the table below:

Sinter production	75 t/h
Sintering area	56 m²
Specific sintering capacity	32 t/m²/24 h
Anthracite or/and coke breeze consumption	9 t/h
Aspiration pressure drop	145 mbar
Re-circulating fines (<5 mm)	35 t/h

The hot agglomerate is broken down and cooled in a separate cooling unit with a cooling area of 70 m².
The obtained sinter is then crushed and screened.
The fines (<5 mm) are recycled in the burden.

3. SINTER ANALYSIS AND PROPERTIES

3.1. Sinter Characteristics

The main objectives that have to be achieved with the sintering of Moanda ore are the following:

- increase of Mn content and reduction of humidity enabling reduction of transport costs,
- increase of Mn / SiO2 enabling a better slag / metal ratio and Mn recovery,
- increase of Mn / P ratio, thanks the mineralogical beneficiation of ore fines,

- improvement of burden granulometry enabling a better permeability in the upper part of blast furnaces or in electric furnaces
- improvement of burden reducibility enabling a reduction of coke consumption

In order to be able to feed the Moanda sinter either in blast furnace (rich or poor slag) or electric furnace, it has been decided to produce a self-fluxing sinter without addition of any lime or dolomite.

Thus, the expected sinter analysis is given is the table below:

%Mn	%Fe	$\%SiO_2$	$\%Al_2O_3$	%CaO	%MgO	%P
59	3	3	6	0.1	0.1	0.1

3.2. *Grain Size and Physical Properties*

Under these conditions, the physical properties of the commercial sinter are expected to be:

➔ Granulometry: 5-50 mm

➔ Tumbler test (ISO 3271):

-strength > 6.3 mm = 75 % minimum

-abrasion < 0.5 mm = 5 to 7 %

3.3. *Permeability*

Permeability measurements were performed in a column (Ø 150 mm) on lumpy ore and sinter. Air is blown from the bottom of the column through the burden and the pressure drop is monitored.

The permeability of the sinter has been found to be about 10 times higher than that of the lumpy ore. This allows to increase the blast volume of the blast furnace and reduces the risk of bridging in the electric furnace.

3.4. *Mineralogical Composition*

The sintering pre-reduces the manganese oxide contained in the ore from "$MnO_{1.9}$" to "$MnO_{1.3}$". Microprobe observations show that the sinter consists mainly of grains of Mn_2O_3 enclosed in a silicate glass (Figure 1). Some molten MnO grains are also present (Figure 2).

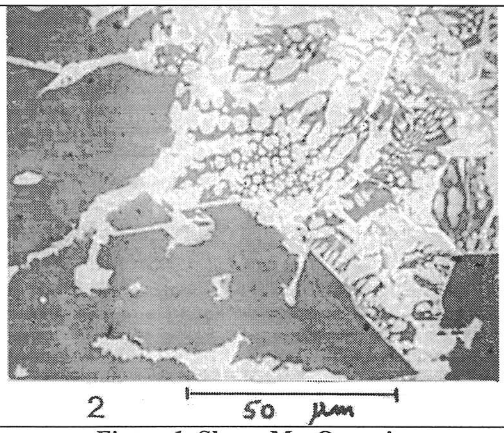

Figure 1: **Sharp Mn_2O_3 grains**

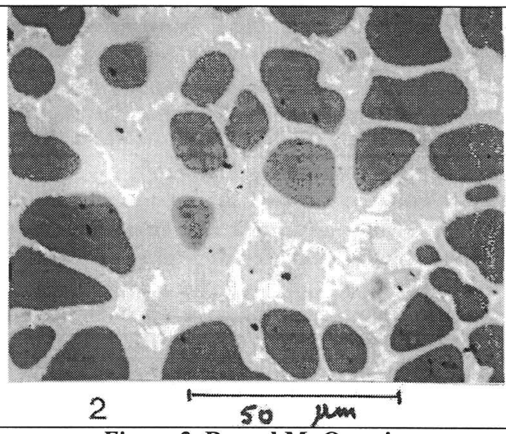

Figure 2: **Round MnO grains**

3.5. *Reducibility*

Several measurements of the reducibility of the sinter have been performed in the ERAMET Research Center.

These are lab tests (200 g of sinter) performed in a modified "Boris" furnace. This furnace is a vertical counter current solid-gas exchanger that reproduces the conditions met by the sinter in the pre-reduction zone of a blast or electric furnace (Figure 3).

The sinter sample is gradually heated to 1000 °C (2 °C/min) in a gas flow simulating the gas produced at blast furnace tuyeres (40% CO and 60% N_2) or in an electric furnace (60% CO and 40% CO_2). The input gas flow and analysis are regulated continuously and the off gas analysis are continuously recorded.

The sample is analyzed before and after the test in order to calculate the oxidation degree of Mn and Fe as the sinter enters the elaboration zone of a furnace.

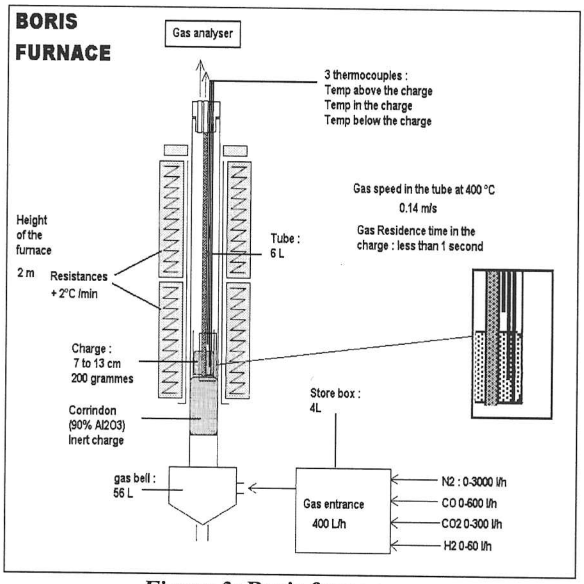

Figure 3: **Boris furnace**

Figure 4 gives an example of the evolution of temperature and gas analysis during a test.

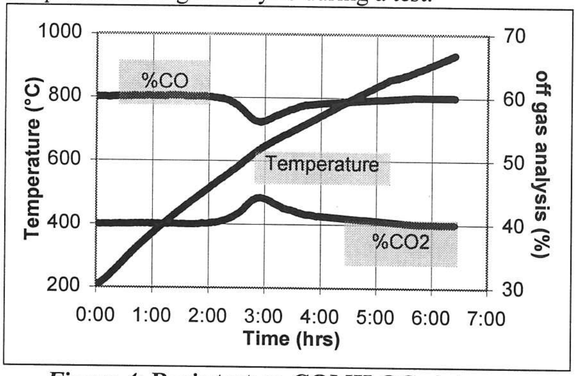

Figure 4: **Boris test on COMILOG sinter**

These reducibility measurements show that the pre-reduction reactions occuring with the sinter are of lower magnitude than with lumpy ore, because of the lower oxidation state of the manganese and iron contained in the sinter. This results in a lower CO2 release in a sinter burden than with a lumpy ore burden.

Chemical analysis of the final product after pre-reduction test allow to calculate the oxidation degree of the manganese entering the elaboration zone. It shows that the particle size has a major effect of the reducibility of lumpy ore: the bigger the particle, the lower the reducibility.

Because of its high porosity, the reducibility of the sinter is not dependant on the particle size, which means that COMILOG sinter has the same reducibility as COMILOG lumpy ore with a particle size of 5-10 mm, whatever the size of the sinter.

This means that COMILOG sinter with a granulometry above 10 mm entering elaboration zone of the furnace is more pre-reduced than other sinters or ores.

Therefore, this is a great advantage of using Moanda sinter compared to other sources of manganese because it makes it able to use a burden of higher granulometry with an high reducibility (which can be obtained only with lumpy ore of low granulometry).

3.6. New operating possibilities

This new combination of high permeability and high reducibility specific to the COMILOG sinter will allow to reach more efficient operating points, where specific coke consumption is lowered and process risks (such as bridgings ...) are avoided.

It will allow to dramatically reduce the coke consumption in the furnace compared to the operating conditions met by the use of lumpy ore while ensuring the safety of the operations.

3.7. Energy gains

Important energy gains are expected from the use of COMILOG sinter, both in blast and electric furnaces. As explained above, the specific carbon consumption will drop when switching from a lumpy ore to a sinter operation. Also the high manganese content of the sinter (59 %) will allow operation with a low slag / alloy ratio and decrease the amount of energy necessary to melt the slag.

Example of improved blast furnace operation:

The high permeability of the sinter allows an increased blast volume and thus an increased productivity of the blast furnaces, leading to lower specific thermal losses. The high reducibility reduces the fixed carbon consumption. Both effects have been taken into account in a blast furnace model developed by ERAMET Research Center. This model shows that the specific coke consumption from a ferromanganese blast furnace can be expected to decrease by **15%** by switching from a raw ore burden to a 80% COMILOG sinter burden.

FeMn	Blast furnace	Electric Furnace
Slag/alloy	- 30 %	- 20 %
Energy consumption	- 15% coke consumption	- 10% electrical consumption

4. Conclusion

In order to improve significantly the performances of the COMILOG France blast furnace and to improve the manganese recovery by valorization of fines at Moanda mine, COMILOG started the first feasibility studies of ore preparation in 1996. In September 1998 the board decided to invest in a new sintering plant, with a production capacity of 600 000 t/y of self-fluxing manganese sinter. In June 1999 the contracts for the agglomeration unit were signed. The start-up is scheduled for mid-December 2000.

The chemical and physical characteristics of the new sinter have been studied by ERAMET Research Center, located at Trappes (France). COMILOG sinter has a high manganese content (about 59%), a high permeability and a very high reducibility, compared to other sources of manganese.

These properties lead to an increased productivity and a decreased coke consumption when producing FeMn and SiMn with COMILOG sinter, in the blast furnace as well as in the electric furnace.