THE SÃO LUIZ PELLETIZING: A NEW SOURCE OF DIRECT REDUCTION AND BLAST FURNACE PELLETS [1]

Evanio Gariglio [2]

José Murilo Mourão [3]

Marcelo da Silva Klein [4]

Marcos Medeiros Goossens [5]

Marcus Eduardo Emrich Botelho [6]

Abstract:
This paper describes the new iron ore pelletizing plant of Companhia Vale do Rio Doce, which is currently being erected in São Luis (MA) and is scheduled to start operation in april 2002.
The plant will have a production capacity of 6.0 million tons/year of high grade blast furnace and direct reduction pellets. Among the interesting features of the new plant, it must be highlighted the largest travelling grate furnace ever built (192 m long and 768 m² of effective grate area) and the use of roller press for ore comminution.
The special properties of the Carajás ore enable the plant to have a simplified flow sheet and as optimized compact layout.
The São Luis pelletizing plant in ore of the important effects implemented by CVRD to strengthen its leading position in the iron ore business worldwide

Keywords: iron ore, pellets, Carajás, materials, products, marketing.

(1) This paper will be presented at **1st International Meeting on Ironmaking** September, 24 to 26, 2001 BELO HORIZONTE / MG / BRAZIL
(2) Manager of Product Development and Market at CVRD Pelletizing Plants
(3) Director Holding of Pelletizing CVRD
(4) Chemical Engineer at CVRD'S Pelletizing Product Development
(5) Mine Engineer at CVRD'S Carajás Mine
(6) Metallurgist Engineer at CVRD'S Pelletizing Product Development

INTRODUCTION

Since 1942, CVRD has been producing iron ore at the Itabira mines in Southern Brazil. From that time on, there has been an impressive growth in capacity to supply domestic and international markets. Keeping that pace, in the 1980s, CVRD established a second system to produce iron ore from the Carajás mines in Northern Brazil. Figure 1 illustrates the location of these two systems.

Figure 1 – Southern and Northern systems.

As a result, more and more ultra-fines were being generated, impacting costs and the environment. Pelletizing was the most effective and feasible technology to utilize these fines directly in blast furnaces (BF) and direct reduction (DR) reactors.

In 1969, CVRD started the construction of a pelletizing complex on the Tubarão peninsula in Vitória, Espírito Santo state, to treat Itabira fines, which has been operating at rapidly expanding outputs. The current seven lines in operation are able to produce up to 25.5 million metric tons[1](Mt) of pellets annually.

Two of the plants belong to CVRD outright, while the other five are joint ventures with foreign partners, as shown in Table I. Over the years, the Company has become the most important pellet exporter in the sea borne trade.

[1] All figures in this work in tons refer to metric tons.

Table I – Current CVRD Pelletizing Plants

Plant	Basic layout	Start up	Shareholders		Nominal capacity (Mt/y)	Actual capacity (Mt/y)	Expansion plan (Mt/y) [1]
CVRD I	Lurgi	Nov.1969	100% CVRD	-	2.00	2.20	2.60
CVRD II	Lurgi	Apr.1973	100% CVRD	-	3.00	3.30	3.90
ITABRASCO	Lurgi	Jan.1977	51% CVRD	49% ILVA [2]	3.00	3.40	4.00
HISPANOBRÁS	Lurgi	Jan.1979	51% CVRD	49% ACS [3]	3.50	4.00	4.00
NIBRASCO I	Lurgi	Jul.1978	51% CVRD	49% JSM [4]	3.50	4.30	4.85
NIBRASCO II	Lurgi	May.1978	51% CVRD	49% JSM	3.00	4.30	4.85
KOBRASCO	Lurgi	Oct.1998	50% CVRD	50% POSCO [5]	4.00	4.00	4.50
				TOTAL :	22.00	25.50	28.70

(1) To be completed in 2004 (2) ILVA SPA (Italy) (3) Aceralia Corporacion Siderurgica (Spain) (4) Japanese Steel Mills (Nippon Steel Corporation, Nippon Kokan KK, Sumitomo Metal Industries Ltd., Kawasaki Steel Corporation, Kobe Ltd., Nisshin Steel Co. Ltd., Nissho Iwai Corporation) (5) Pohang Iron and Steel Company (South Korea)

The eighth pelletizing plant, which is currently under construction at São Luis, Maranhão, will have the largest traveling grate ever built. It will feature unique technologies and will be the result of 30 years' experience in design and operation of pelletizing plants. This plant will use 100% Carajás pellet feed.

The evolution of iron ore sales as well as the main expansion numbers of CVRD are shown in Figure 2.

The new São Luis plant, 100% owned by CVRD, will make available to the market 6.0 Mt/y of pellets for both BF and DR applications. The start-up is scheduled for March 2002. Companhia Vale do Rio Doce will enter the twenty-first century being able to offer 34.7 million tons/year of high quality pellets to steel mills.

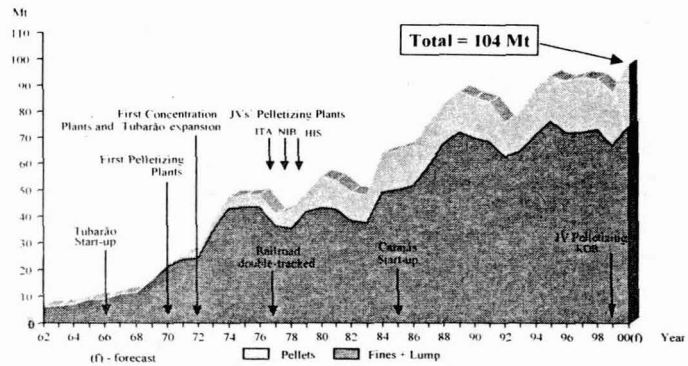


Figure 2 – Growth of CVRD's sales

CARAJÁS IRON ORE – GEOMETALLURGICAL PROPERTIES

Carajás is remarkable not only because of its late discovery in 1967 but also for the size of its reserve of high quality natural ore (66% Fe), on a scale far beyond any other known in the world.

The iron ore exploitation works have estimated the reserves at 17.2 billion tons of high grade ore, including 2.1 billion measured, 2.2 billion indicated and 12.9 billion inferred. These reserves are divided into two main groups situated 35 km apart, consisting of the North Ridge (6 billion tons) and the South Ridge (10 billion tons), as shown in Figure 3. The balance is located at the East Ridge and at the Sao Felix do Xingu Ridge. Total reserves are distributed in about 60 different deposits.

The first ore body chosen to be developed was the N4E, due to the ease of railroad access and because it would permit future mining of two other deposits (N4W and N5, with 3 billion tons of reserves) using the same dressing complex and train loading terminal.

The N4E is a J-shaped ore body at an elevation of 715 meters above sea level. It is 4,100 x 300 x 400 meters respectively in length, width and depth at the final pit. The original geological reserves represent 1.4 billion tons, yielding 1.2 minerable reserves with 66.3% Fe content.

Currently, there are three mines in operation: N4E, N4W and N5.

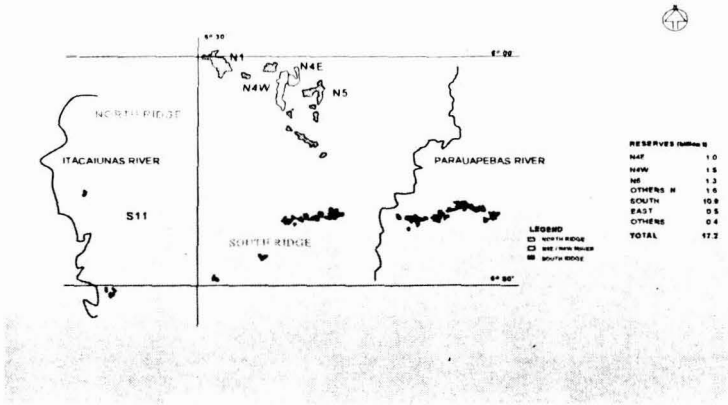


Figure 3 – Carajás iron ore reserves

Originally, the iron formation was jaspilite and not itabirite. According to the theory currently accepted, the several types of hematite forming the iron ore bodies were derived from tropical weathering of the jaspilite, which leached the silica, causing enrichment of hematite layers.

This supergenic process of enrichment with fairly low degree of metamorphism gave special characteristics to the ore, such as:

- *very small grain size of hematite, ranging from 0 to 20 microns;*
- *high degree of voids between the mineral grains;*
- *consequent high surface area and permeability to gases.*

These are the reasons why Carajás ore has superior metallurgical properties and in particular the pellets made out of that ore will represent a new world benchmark in terms of *metallization and reducibility*. The photos in Figure 4 illustrate this fact and compare between hematite ores of small, medium and large crystals. The use of São Luis pellets by steel mills in BF or DR reactors will lead to better performance and productivity.

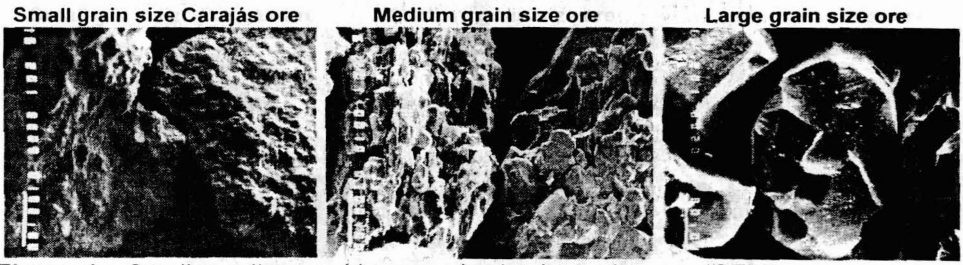


Figure 4 – Small, medium and large grain size hematite ores (SEM)

PROCESS CONCEPT OF THE SÃO LUÍS PELLETIZING PLANT

The unique features of Carajás ore allowed the design of a simplified flowsheet for São Luis pelletizing plant, as shown in Figure 5. The major simplification comes from the fact that one single comminution stage in a roller press (Figure 6) is enough to increase the specific surface of the feeding ore from 1,200 to 2,200 cm²/g, achieving the fineness required for the subsequent balling step.

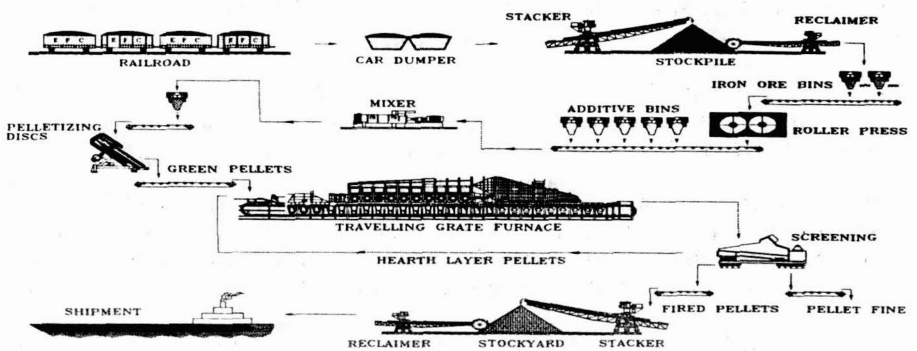
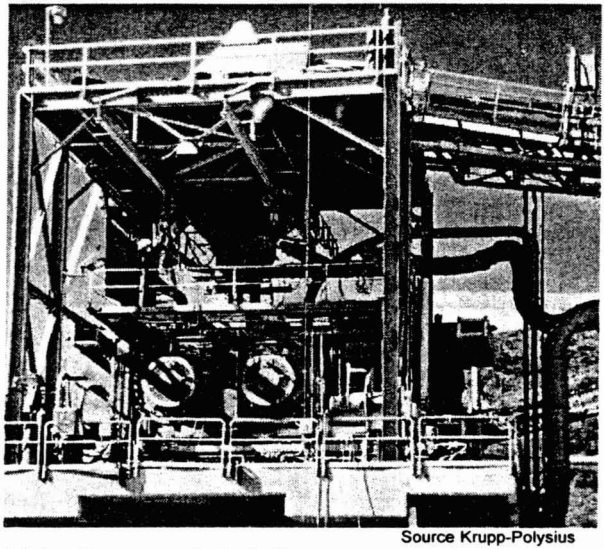


Figure 5 - Flowsheet of São Luís pelletizing plant

This simplifies the plant layout of the preparation steps, since a pair of roller presses replace the huge set of ball mills, hydrocyclones, thickeners, homogenization tanks, pumps and disk filters found in a conventional wet-circuit-pelletizing-plant.

No additives will be added to the piles, since the plant will be provided with an independent additives grinding system, capable of supplying five different types of ground, partially pre-mixed and ready-to-use additives to five bins at the mixing station. The additives comprise fluxes, binders and solid fuels.



Source Krupp-Polysius

Figure 6 – Industrial roller press installation

The pressed ore will be transported by conveyor belts, passing under the additive bins, where the several pre-ground additives will be ready for dosing. The grinding and dosing of each additive apart from the ore will allow fine process and quality adjustments.

The mixing of pressed ore and additives will be accomplished by two drum-type plow mixers, each one having an effective volume of 20 m^3. These mixers will be the largest ever installed in the iron ore industry.

From the mixers, the material will be stored in silos at the balling section, from which it will be fed into ten pelletizing disks, with 7.5 m diameter each. Oversize and undersize green pellet screening will be done by roller screens downstream of the pelletizing disks, ensuring that only adequate sized material will enter the furnace.

The green pellet induration will take place in a traveling grate furnace designed by Lurgi. With a total length of 192 m and an effective width of 4 m, giving a grate area of 768 m^2, the São Luís plant's traveling grate will be the largest of its kind in the world.

Designed taking into account the particularities of Carajás ore and assuming the regular use of solid fuel, the furnace will have some interesting features, such as a pre-heating zone (45 m) longer than the firing zone (30 m).

After being discharged from the furnace, the fired pellets will go through a single-deck-roller-screen, which will ensure final undersize screening. Hood and windbox exhaust gases will be piped to three electrostatic precipitators (EP) for dust removal. Figure 7 shows a sketch of the traveling grate with the electrostatic precipitators.

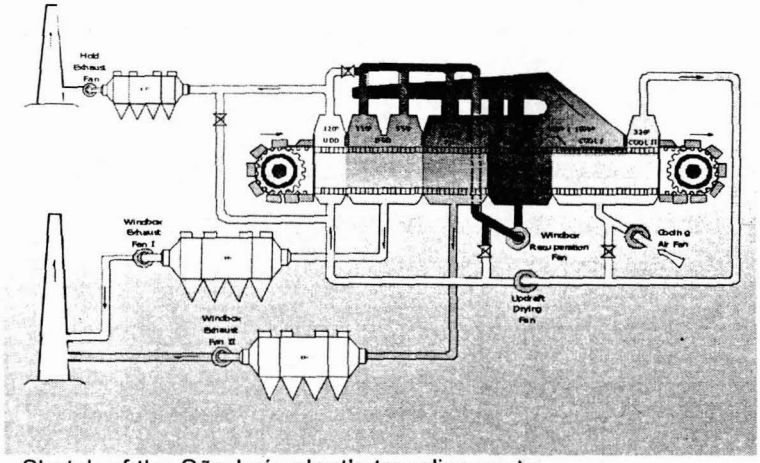


Figure 7 – Sketch of the São Luís plant's traveling grate

After screening, the fired pellets will be conveyed to and stacked at the final product stockyard, from which they will be reclaimed to load vessels berthed at the Ponta da Madeira Maritime Terminal.

To especially enhance the quality of direct reduction pellets, prior to their shipment, these pellets will be treated in a pellet coating station.

Table II shows some characteristics of the main equipment.

Table II – Main equipment of São Luís pelletizing plant

Capacity : 6,000,000 t/y Start up : March 2002 Main Equipment		
Quantity	**Specification**	**Dimensions**
02	Roller Presses	approx. 1,400x1,700mm roller dimensions
02	Drum Type Mixers	20 m³ total volume, each
10	Pelletizing Discs	7.5m diameter, each
01	Travelling Grate	192 m length 4 m width 768 m² reaction area 32 windboxes (4x6 m each)
03	Electrostatic Precipitators	to clean hood and windbox exhaust gases

CHARACTERISTICS OF SÃO LUÍS PELLETS

The São Luís pelletizing plant will be capable of producing both DR and BF pellets. The main expected characteristics of these products are shown in Table III.

Table III – Main characteristics of São Luís pellets

Item (ISO Standard)	Direct Reduction Pellet (DRP)	Blast Furnace Pellets (BFP)	
		Fluxed	Self-fluxed
• FeT	67.20	66.00	62.25
• FeO	0.25	0.25	0.25
• SiO_2	1.30	2.00	4.00
• Al_2O_3	1.00	1.00	1.00
• CaO	0.70	2.00	4.00
• MgO	0.30	0.05	1.00
• P	0.030	0.030	0.030
• Mn	0.30	0.30	0.30
• S	0.005	0.005	0.005
• CaO/SiO_2	0.54	1.00	1.00
• Tumbler (% + 6.3 mm)	94.0	94.0	94.0
• Abrasion (% - 0.5 mm)	5.0	4.5	5.0
• Compression strength (daN/p)	300	330	280
• Swelling (%)	-	15.0	15.0
• Disintegration + 10.0 mm (%)	85.0	-	-
+ 6.30 mm (%)	-	93.3	95.0
- 3.15 mm (%)	2.0	-	-
- 2.80 mm (%)	-	4.7	3.5
• Metallization (%)	96.0	-	-
• Reduction under load $(\Delta P)_{80}$ (mmWC)	-	1.3	1.8
$(dR/dt)_{40}$ (%/min)	-	1.44	1.48

São Luís DR pellets will be ready to feed the most important DR processes around the world (HyL and Midrex plants). The BF pellets (Fluxed and Self-fluxed) will be suitable for blast furnace operation with higher or lower slag volumes.

A research plan is currently being developed in order to optimize the chemical characteristics of DR pellets. The focus is to increase the iron content mainly by a decrease in $SiO_2 + Al_2O_3$ content. The goal is to get a final Fe content around 67.5%, which will contribute to a better performance of DR reactors and subsequent EAF steel making.

The superior reducibility of the pellets prepared with Carajás iron ores must be pointed out. Reducibility is one of the most important ore characteristics allowing higher performance in DR and BF processes and assuring better productivity. It is also important to mention the excellent high temperature properties of the BF fluxed pellets.

PELLET MARKET OVERVIEW

CVRD is present worldwide in terms of pellet sales, as can be seen in Figure 8.

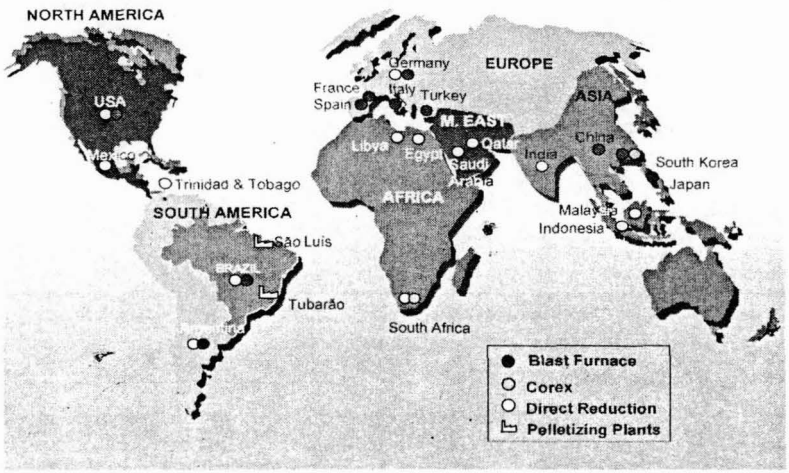


Figure 8 - Worldwide CVRD clients

At the beginning of pelletizing activities in 1969, only one type of pellet was produced. Basically, the material was sold as feedstock for blast furnace operation. With the advance of DR technology and the studies developed by Japanese steel mills concerning the cohesive zone of blast furnaces, pellets with different qualities were demanded. These facts were responsible for the diversification of pellet production, in order to comply with customer needs, taking into account their different operational practices and iron-making philosophies.

Adopting a policy of tailor-made supply, over the years CVRD geographically expanded its sales of pellets. Most of the countries involved in the seaborne iron ore trade currently import pellets from CVRD.

The new São Luis pelletizing plant will be located conveniently to supply most of the market. At first glance, Caribbean and North American clients have more favorable position, since they are located closer to the Ponta da Madeira loading port. However, even the most distant areas can be served by São Luis pellets, under very competitive conditions, considering the bigger ore ships which are traveling such routes.

Based on CVRD's internal studies, future demand for DR and BF pellets will be increasing mainly due to the following facts:

Blast Furnace	Direct Reduction
➢ Increase in world iron and steel production ➢ Installation of new BFs without sintering machines ➢ Revamping of idled BFs without sintering capacity ➢ Improvement of BF productivity ➢ Increase in PCI rate ➢ Decrease in pellet production in USA ➢ Decrease in sinter production in Europe ➢ Scarceness of lump ore	➢ Increase in world iron and steel production ➢ Use of coating technology in DR ➢ Improvement of DR productivity (oxygen injection) ➢ Installation of new DR reactors ➢ Scarceness of lump ore

Figure 9 shows the forecast for the seaborne iron ore trade between 2000 and 2005, broken down by the total volume of fines, lump ores and pellets. The demand for iron ore will increase by 31 Mt, with 18 Mt being for BF and 13 Mt for DR feed. This estimation was prepared in September 2000. As a reference, world steel production at that time was considered as 840 Mt in 2000 and 870 Mt in 2005, forecasting an increase of 30 Mt.

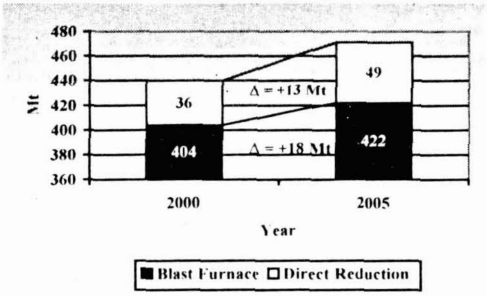


Figure 9 – Forecast for seaborne iron ore trade (Pellets + Fines + Lump Ores)

Dividing volumes and considering the different types of products, one can see that the demand for pellets will increase faster than that for both lump ores and fines, as shown in Figure 10. Based on this scenario, it is possible to conclude that the new pelletizing plant will start up at a very opportune moment, when world steel production will be expanding.

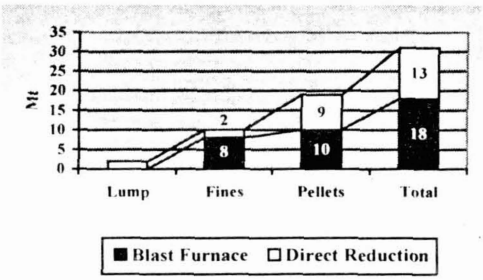


Figure 10 – Increase in demand for pellets, fines and lump ores between 2000 and 2005

CONCLUSION

By constructing a 6.0 Mt/y pelletizing plant in São Luís, CVRD consolidates its expansion plans in the iron ore business and will provide a new source of high quality pellets to the market. The adoption of the most advanced technology in plant design together with over 30-years' experience in pelletizing plant operation, R&D and the outstanding quality of Carajás ores are key points that will ensure the excellence of the new São Luís pelletizing plant.

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