OPERATIONAL AND SAFETY RESULTS AT ARCELORMITTAL PIRACICABA EAF[1]

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Abstract

ArcelorMittal Piracicaba meltshop, located in the state of São Paulo–Brazil, currently operates a 130 ton AC EAF, the nominal diameter of the furnace is 6800 mm, with production capacity 1.1 Mtpy. Since EAF installation in 2004, the furnace is equipped with the MODULE Technology chemical energy package including: four combined burner / supersonic oxygen injectors, four combined burner / carbon injectors, oxygen and natural gas regulation valve trains, four carbon dispensers, electrical - automation system and an intelligent Human Machine Interface to manage and supervise the melting process. The MODULE Technology chemical package has been installed with the objective to increase the chemical energy input and to distribute the oxygen and carbon injection in a multi-point fashion. This document will outline and focus on the use of chemical energy system in operation in the EAF, operating benefits and improvements generated. In addition to the Module Technology, a CATFIS automatic temperature/sampling manipulator was installed in 2004 to provide maximum safety conditions during EAF operation by removing the operators from the front of the slag door; the system is capable of taking samples without having to power-down the furnace while maintaining the supersonic oxygen and carbon injection. As additional safety improvement, in July 2007 a MOTANK remote controlled truck equipped with a horizontal ram has been installed in the EAF. The MOTANK system is intended to eliminate the need for a man driven forklift to operate machinery in front of the slag door.

Key words: Chemical energy package; Oxygen injection; Carbon injection; EAF safety equipment; Automatic temperature/sampling manipulator; Remote controlled ram for slag door.

RESULTADOS OPERATIONAIS E DE SEGURANÇA NO FEA DA ARCELORMITTAL PIRACICABA[1]

Resumo

A aciaria da ArcelorMittal Piracicaba, localizada no estado de São Paulo – Brasil, atualmente opera um FEA AC de 130 t, diâmetro nominal de 6800 mm, com capacidade de produção de 1 Mtpa. Desde a instalação do FEA em 2004, o forno está equipado com a tecnologia MODULE (pacote de energia química) incluindo: quatro injetores combinados queimador / lança supersônica de oxigênio, quatro injetores combinados queimador / carbono, estande de regulação de oxigênio e gás natural, quatro tanques para fluidização e transporte pneumático do carbono, sistema de automação elétrica e IHM inteligentes para gerenciar e supervisionar o processo de fusão. O pacote químico, tecnologia MODULE, foi instalado com o objetivo de aumentar o aporte de energia química no FEA e distribuir a injeção de oxigênio e carbono em diferentes pontos do forno. Este trabalho irá focar o uso da energia química na operação de FEA, benefícios alcançados e ganhos obtidos. Além da tecnologia MODULE, um manipulador para tomada de temperatura e amostra automático, CATFIS, foi instalado em 2004 para proporcionar condições máximas de segurança durante operação do FEA removendo os operadores da porta de escória. O sistema tem a capacidade de retirar amostras sem necessidade de desligar o forno (*power-off*) e também mantendo as lanças de injeção de oxigênio supersônica e de carbono em operação. Como um item de melhoria de segurança operacional, em Julho 2007, um sistema MOTANK, carro equipado com uma lança horizontal para limpeza por controle remoto da porta de escória, foi também instalado no FEA. O sistema MOTANK é usado para eliminar a necessidade de ter um homem dirigindo e operando um carro motorizado (tipo empilhadeira) defronte a porta do forno.

Palavras-chave: Energia química; Injeção de oxigênio; Injeção de carbono; Segurança no FEA; Amostragem automática; Limpeza remota da porta de escória.

1 *Technical Contribution to the XXXIX[st] International Steelmaking Seminar of the ABM, May, 12-16[th] 2008, Curitiba – PR – Brazil.*

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MELTSHOP AND ELECTRIC ARC FURNACE DATA

The Piracicaba mini-mill is a plant specializing in the production of bars for building construction. The product is 6,35 to 32mm diameter reinforcing bars.
The steelmaking shop, supplied by Danieli, has an AC EAF 130 ton tapping capacity (table1 resume the EAF main technical data), 130 ton ladle furnace for secondary metallurgy, continuous casting machine (square billets 130mm & 150mm x 11000mm), Fe-alloy charging system, pulse-jet type fume treatment plant 1,600,000 m^3/h for primary and secondary fumes, fully integrated automation and process control systems (harmonic analyzer and Level2 included) plus new hot charging facilities for billets.

Table 1. EAF main technical data

EAF type	EBT, full platform
Charging	Two bucket charge
Heat size (tapping)	130 ton
Nominal shell diameter	6800 mm
Transformer rating	102 MVA + 20%
Transformer max secondary voltage	1350 V
Electrode regulation	HiReg® digital electrode regulation
Electrode diameter	610 mm
Electrodes circle diameter	1250 mm
Chemical Energy Package	Module technology: 4 OXYGENJET and 4 CARBONJET

Figure 1 - EAF general view

MODULE TECHNOLOGY - CHEMICAL ENERGY PACKAGE

Equipment Configuration

The Module Technology chemical energy package was started-up with the new EAF. The objective of the system was to maximize the use of chemical energy and optimize the overall melting process. The main benefits are:
- improved foaming slag conditioning
- improve homogenous liquid steel temperature and chemistry
- improved metallurgical process control
- improved overall operating efficiency
- reduced electrical energy usage
- reduced power on time
- reduced conversion cost.

According to the furnace geometrical characteristics, process requirements, scrap charge mix and transformer size, the following configuration has been selected:

- Four OXYGENJET for supersonic oxygen injection/burner mode (figure 2 and 3). This injector delivers a highly coherent supersonic stream of oxygen that penetrates into the steel bath for C oxidation and other oxidizing reactions in the steel/slag interface.
- Four CARBONJET for 'soft' carbon injection/burner mode The carbon injection into the slag promotes FeO and MnO reduction with consequent early slag foaming metallic yield better control.

The injectors have been distributed around the upper shell and on the EBT sump panel inside dedicated water cooled tile boxes in order to reach the optimum distribution of the oxygen and carbon injection in a multi-point fashion. The operating data is reported on Table 2.

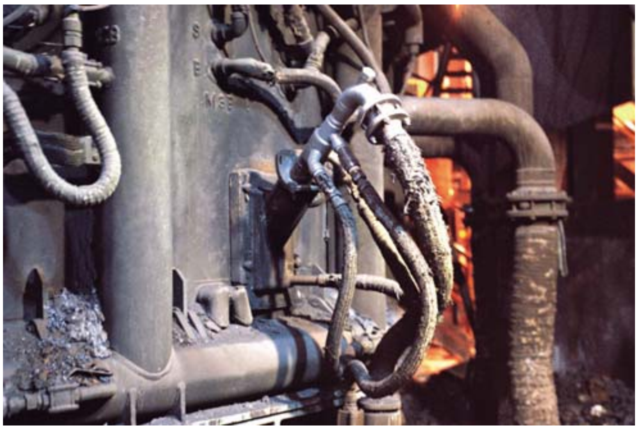

Figure 2 - Oxygenjet injector

Figure 3 - EAF with side wall injectors

Table 2

Injector Type	Mode	Features
OXYGENJET	Burner	• 4 x 3.5 MW
	Injection	• 4 x 2300 Nm^3/h supersonic oxygen • Deep injection of oxygen in the liquid steel for the generation of chemical energy. • Carbon-monoxide post-combustion in the slag interface. • Decarburization mode; • Oxygen and natural gas consumption savings due to the shut-off of the second oxygen and natural gas shrouding for coherency during injection mode.
CARBONJET	Burner	• 4 x 3.5 MW • oxygen/natural gas ratio control according to process requirements
	Injection	• 4 x 30 Kg/min carbon flow rate • Carbon injection for foaming slag conditioning and iron oxide reduction; • Oxygen and natural gas consumption savings due to the shut-off of the oxygen and natural gas during injection mode.

All the above mentioned tools work as high efficiency oxy-fuel burners (3.5 MW each) for heating and assisted melting of scrap after each scrap bucket charge. The burner mode is of primary importance in the EAF melting process; it must transfer heat

efficiency to the scrap pile that supports subsequent scrap melting. Each burner flame prepares the area in front of the injector by creating a cavity where oxygen and carbon will be injected.
From the melting process point of view, the use of a dedicated carbon injection tool with flow-rate precise control and dedicated dispensers, simultaneously create a great amount of exothermic chemical energy by the combustion of C to CO in the liquid bath and retain it in the slag/steel interface by the early and excellent foamed slag generation. Moreover, the foamed slag becomes the vehicle that transfers and distributes the chemical energy generated over the entire liquid steel surface.

Oxygen and natural gas valve stands

Dedicated valve stands have been supplied to measure and control all the media, which feed the four OXYGENJET and the four CARBONJET injectors installed on the EAF upper shell.
In the valves trains, each line is flow controlled by segment valves, measured by 'Vortex' meters and could be purged with compressed air to have maximum operating flexibility and control according to process requirements.

MOCA carbon dispensers

Carbon injection flow rate and quantity requirements are provided by four dedicated carbon dispensers (one for each CARBONJET injector). Each dispenser has 2500 liters pressurized vessel capacity. The dispensers are located under two day-bins. Each carbon dispenser automatically controls the carbon flow rate from 10 to 30 Kg/min according to a set-point imposed by recipes loaded into the HMI. The pneumatic transportation of the carbon fines is also optimized by compressed air pressure and flow control.

Automation & HMI system

The Module technology package includes an electrical/automation system for a fully automatic operation of the melting process.
The automation requirements for the entire system is managed by a Siemens S7-400 PLC, the valve stands and the carbon dispensers are equipped with remote I/O. A dedicated Human Machine Interface desk has been provided for a 'user friendly' and fully automated operation of the process.

Figure 4 HMI desk

Figure 5 HMI screen

FUTURE UPGRADING

In 2008, the EAF will be upgraded with the installation of a Hi_Jet injector in place of one CARBONJET . While a normal carbon injector is basically a simple pipe, the Hi-Jet unit specially designed shape of the supersonic oxygen nozzle allows a simultaneous, coaxial injection of the carbon, where the supersonic oxygen jet acts to accelerate the carbon particles velocity thus assuring injected carbon higher efficiency and recovery.
Moreover, the original installation of the injectors in the water cooled tile boxes have been replaced with copper cast 'bulged panels' (Figure 6). The 'bulged block' is designed with an internal water cooling circuit, very well protected from heat and risk of damages, the manufacturing is made by copper foundry sturdy structure to guarantee stiffness and protection, both in terms of heat and mechanical stresses.

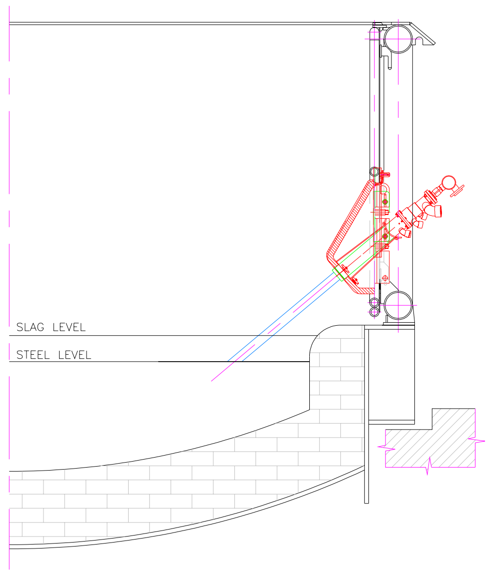

Figure 6 Hi_Jet section view

SAFETY DEVICES

During the meltshop design concept, the safety issues have been taken in particular attention in order to eliminate the presence of the operators in front of the slag door and in the EAF platform, areas with high risks of slag or steel splashing coming out of the door due to reactions in the furnace. The installation of dedicated equipment allows to eliminate the need to have an operator in front of the furnace door to take the measurement and to carry out the slag door cleaning. The following safety equipment has been installed in different steps to eliminate these risky operations :

- CATFIS, automatic temperature and sampling manipulator operating through the slagging door.
- MOTANK, remote controlled ram for slag door.

CATFIS automatic temperature & sampling manipulator

With the installation of the chemical package a CATFIS automatic temperature & sampling manipulator has been supplied. The system is designed to automatically measure temperature, bath carbon and oxygen, as well as take dip samples for chemical analysis. The main safety benefit of the equipment is removing the operators

from the front of the furnace slag door; this unit provides maximum operator safety during sampling operation.
The system is capable of taking samples without having to power down the furnace, oxygen and carbon injection can keep on as the work of the CATFIS does not interfere with them, the reliability of the measures/samples is very high due to the fact that the sensors enter into the steel bath at a constant predetermined angle. As the carrier is water cooled, the sensors cardboard can be used at their standard shortest length and no special cardboard's are necessary, combined cardboard's (i.e. temperature + carbon) can be used and allow substantial savings. All sampling takes place automatically via operator input from the automation system located in the EAF control pulpit or from local box. Operator intervention is only required to change sampling tips after each machine cycle.
The CATFIS system consists of a supporting & revolving turret installed on the platform in the right side of the slag door (Figure 8), it is equipped with an electric drive, speed controlled, an upper rotating turret and a junction box for the electrical connections. The rotation on the horizontal plane moves the horizontal arm to loading position and to work position where the unit enters the furnace to take a measure/sample of molten steel. One rotating horizontal arm supporting at its front end the electric activated mechanism that allows the simultaneous forward and downward movements of the independent water cooled carrier used to drive the probes into steel bath.

Figure 7 CATFIS in front of slag door

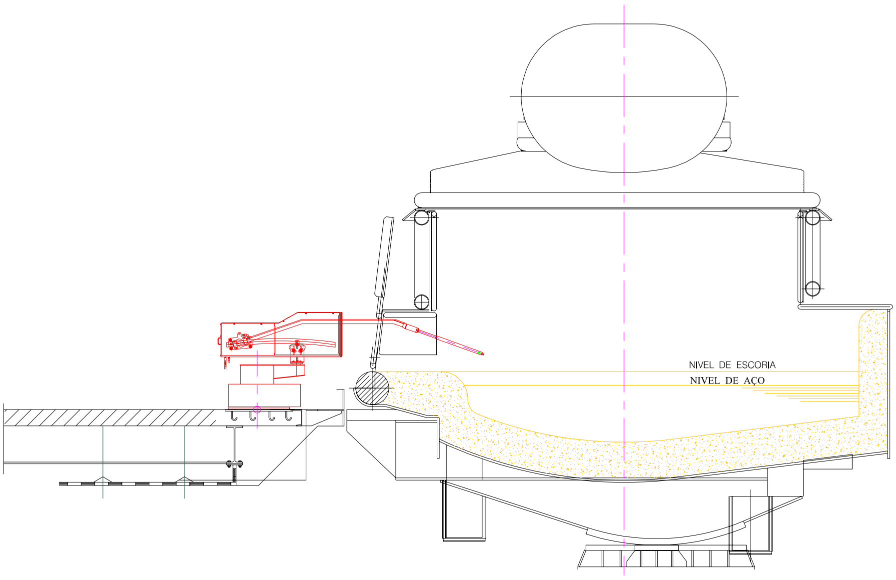

Figure 8 CATFIS section view

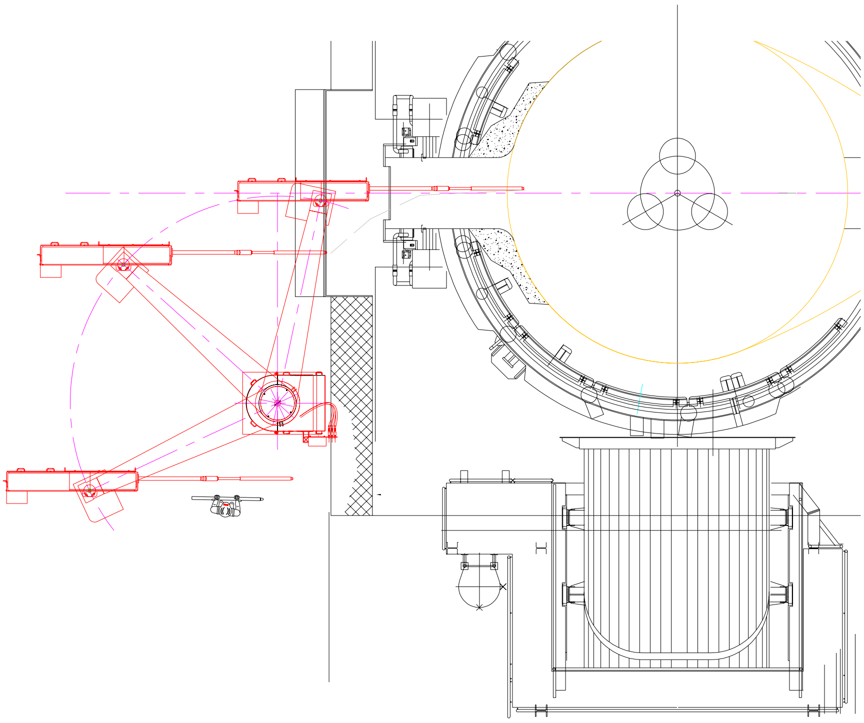

Figure 9 CATFIS plant view

MOTANK - remote controlled ram for slag door.

In July 2007 the MOTANK equipment has been installed in the EAF platform (Figures 10 and 11) to operate in conjunction with the CATFIS sampling and measuring lance. The unit is intended to clear the non-melted scrap and excess slag deposits from the EAF slag tunnel prior to temperature or sample taken by CATFIS manipulator.
The MOTANK system consists of a remote controlled cart equipped with an horizontal ram. The cart has four wheels, powered by hydraulic motors, that move it forth and back from park to work position and vice-versa. On its upper part are the supports for the piston that allows the ram vertical displacement and the piston that allows the ram horizontal displacement.

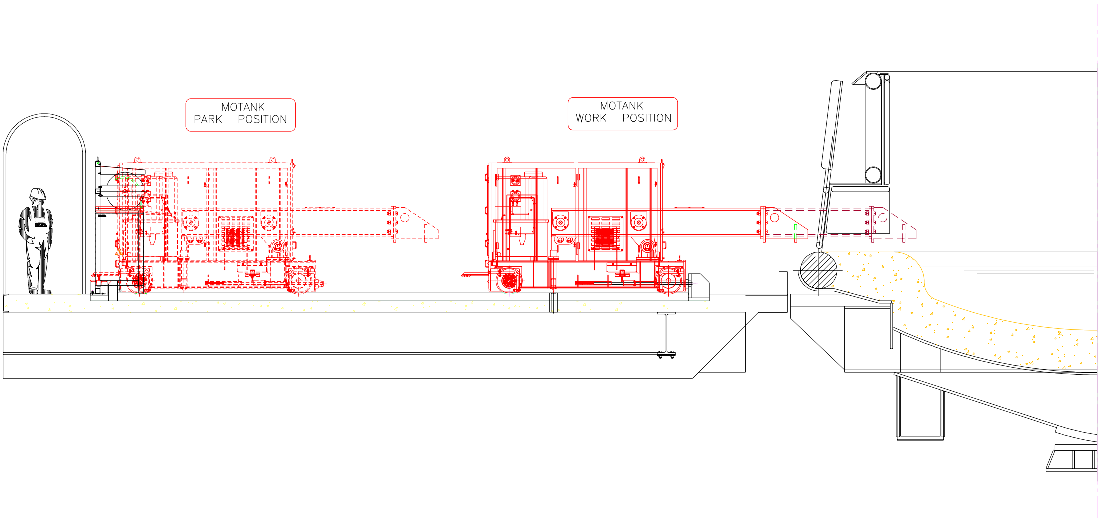

Figure 10 MOTANK section view

Figure 11 MOTANK

The installation of the MOTANK has demonstrated the following benefits:

- it is totally safe being remote controlled; the manned fork lift ram is therefore abandoned;
- it operates with the EAF powered on;
- it operates with the oxygen/carbon injection;
- it allows a safe and reliable temperature and sample being taken with sampling and measuring lance manipulator;

CONCLUSIONS

The fix injection Module Technology and the safety equipment installation in the EAF have showed the following benefits and improvements:

- Traditional injection equipment (water cooled or consumable oxygen and carbon lances, side wall burners) is entirely substituted by an effective fix injection technology. This enormously reduces maintenance requirements and down time associated with traditional lance manipulators.
- System automation design allows the entire process to be constant, repeatable and predictable.
- The start/stop of the injectors and set points are managed automatically via Level2
- Multiple injection profiles have been programmed to adjust the oxygen / carbon input ratio to compensate for different scrap mix carbon levels.
- Furnace personnel manual workload is reduced considerably as the entire process is automated (the operators have more time to focus on monitoring and regulation system).
- Removing all the operator from the EAF slag door area, providing maximum operator safety during sampling and slag door cleaning operation.
- Slag door remains closed at all times eliminating cold air intake into the furnace.