OPERATIONAL RESULTS OF LIME AND DOLO-LIME PNEUMATIC INJECTION TECHNOLOGY AT TENARIS DALMINE EAF[1]

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Abstract

The pneumatic injection of lime and dolo-lime at Tenaris Dalmine (Italy) electric arc furnace is a valid and well proven improvement versus practice to charge the fluxes via conveyor belts transportation system and 5th hole roof opening. It improves refractory side bank protection, continuous slag foaming, viscosity control, distribution in the bath surface and overall process optimization. By the use of fluxes fine particles, the system allows a more reactive and faster solution; system has reduced dust generation from the conveyors transportation systems.In March 2008, Tenaris Dalmine (Italy) installed two dedicated dispensers and two combined burner/lime injectors in their 100 ton EAF, the applied technology allows management of lime and dolo-lime requirements via pneumatic injection. The paper describes the results, benefits and improvements obtained with the application of fluxes pneumatic injection technology in the EAF.
Keywords: Pneumatic lime-dololime injection; Foaming slag.

RESULTADOS OPERACIONAIS DA TECNOLOGIA DE INJEÇÃO DE CAL E CAL DOLOMÍTICA NO FORNO ELÉTRICO DA TENARIS DALMINE

Resumo

A injeção pneumática de cal e cal-dolomítica no Forno Elétrico da Tenaris Dalmine (Italia) é uma melhoria muito positive ao invés de inserção do material via sistema de correias transportadoras pelo quinto furo. Isto melhora a proteção nos refratários laterais , scoria espumante continua, controle de discosidade, distribuição na superfície do banho e otimização do processo global. Através da utilização de fluxos de partículas finas, o sistema permite uma solução mais reativa e rápida. O sistema reduz a produção de poeira das correias transportadoras. Em março de 2008, a Tenaris Dalmine (Italia) instalou dois dispensers dedicaods e dois injetores combinados (queimado/cal) no FEA de 100 t, a tecnologia aplicada permite o gerenciamento de cal e cal-dolomítica através de injecção pneumático. O Paper descreve os resultados, benefícios e melhorias obtidas na aplicação do fluxo pneumático na tecnologia de injeção no FEA.
Palavras-chave: Injeção de cal e cal dolomítica; Escoria espumante.

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1 INTRODUTION

Key to improved performance for electric arc furnace steel producers have been the optimization of foamy slag practices that provides benefits of saving electrical energy, improved arc stability, reduced noise, improved productivity, lower nitrogen levels and increased refractory life in the furnace. In addition optimized slag practices satisfying MgO solubility requirements and basicity control have improved clean steel practices and refractory consumption.

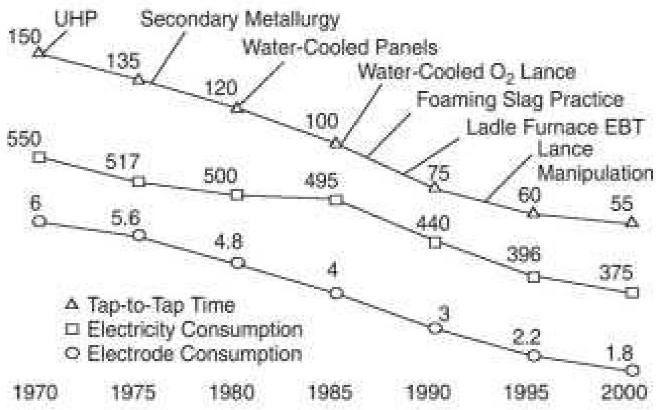

Figure 1: Historical overview of improvements in the EAF.[1]

Material handling systems have had an impact on the ability of steel plants to efficiently utilize the lime additions for a precise control of the slag chemistry.
The pneumatic injection of lime and dolo-lime at Tenaris Dalmine electric arc furnace is a valid and well proven improvement versus practice to charge the fluxes via conveyor belts transportation system and 5th hole roof opening. It improves refractory side bank protection, continuous slag foaming, viscosity control, distribution in the bath surface and overall process optimization. By the use of fluxes fine particles, the system allows a more reactive and faster solution; injection system has reduced dust generation from the conveyors transportation systems.

TENARIS DALMINE MELTSHOP

Meltshop scrap yard has a total area of 13.300 m^2 and a capacity of 38.000 tons. The uncovered scrap yard is equipped with six 15-ton bridge cranes which load 2 bucket charges per heat. Two drying and soft pre-heating stages warm the scrap to 200℃ before charging to the furnace. The EAF is equipped with side-wall burner, three fixed-wall oxygen lances and three fixed-wall carbon injectors as well as a supersonic water cooled door lance. Productivity of more than 130 t/h is achieved with tap-to-tap times of about 40 minutes to produce 850.000 tons/year. Secondary metallurgy facilities include 2 LMFs (25 MVA each) and one vacuum degasser. Ferroalloys are added automatically. Steel is kept stirred by 2 porous plugs in the ladle bottom. Two continuous casting machines (1 vertical and 1 curved) cast round bars in the range 148-395 mm.
EAF data:

Furnace type	Tagliaferri EAF, 1991
Furnace diameter	6,100 mm
Volume	90 m3
Tapping system	EBT – swiveling flap
Charge mix	85 % scrap, 15% pig iron, two buckets
Transformer:	100 MVA (500/1000 V)
Oxygen Injectors:	3 KT Oxygen Lances
Carbon Injectors:	3 KT Carbon Injectors
Other chemical devices:	5 side-wall burners and 1 water cooled door lance

The EAF is performing at its best in terms of cost and productivity. Tenaris Dalmine's EAF has always been characterized by a very short tap-to-tap of 40 minutes and power-on time of 31 minutes; with a refining period that has always been less than ten minutes. The tap temperature is typically 1660^{o}C in order to achieve the desired steel grades and to accommodate, on average, 3 to 3.5 tons of Ferro Alloys (mainly FeSiMn, FeSi, FeMn, FeCr, Al, FeMo, etc.). Consistent average EAF parameters of the main steel grades production are as follows:

Metallic Charge	99.5 metric ton
Tapped Steel	93 metric ton
Yield scrap to liquid	93.4%
Liquid in ladle, with Fe-	95.5 metric ton
Tapping Temperature	1661 °C
Average Tapping	0.05 %

The following table details EAF average consumptions on a liquid-steel basis (as of January 2007):

Consumptions (based on liquid steel):

Electrical Energy	380 kWh/metric ton
Electrode consumption	1.38 kg/metric ton
Oxygen	35.7 Nm3/metric ton
Natural Gas	7.5 Nm3/metric ton
Injected Carbon	4.9 kg/metric ton
Charged Carbon	4.2 kg/metric ton

PNEUMATIC LIME INJECTION EQUIPMENT

In March 2008, Tenaris Dalmine installed the lime/dolo-lime injection system, supplied by MORE srl, in their EAF (Figure 2). The equipment is composed by two dedicated MOLI dispensers installed under two 125 m^3 storage silos (Figures 3 and 4). The silos are installed inside the storage building and are loaded pneumatically by truck. From each MOLI exit, the material is pneumatically conveyed to the LIMEJET injectors on the furnace into two separate 3" dia. pipelines approx. 60 meters long.

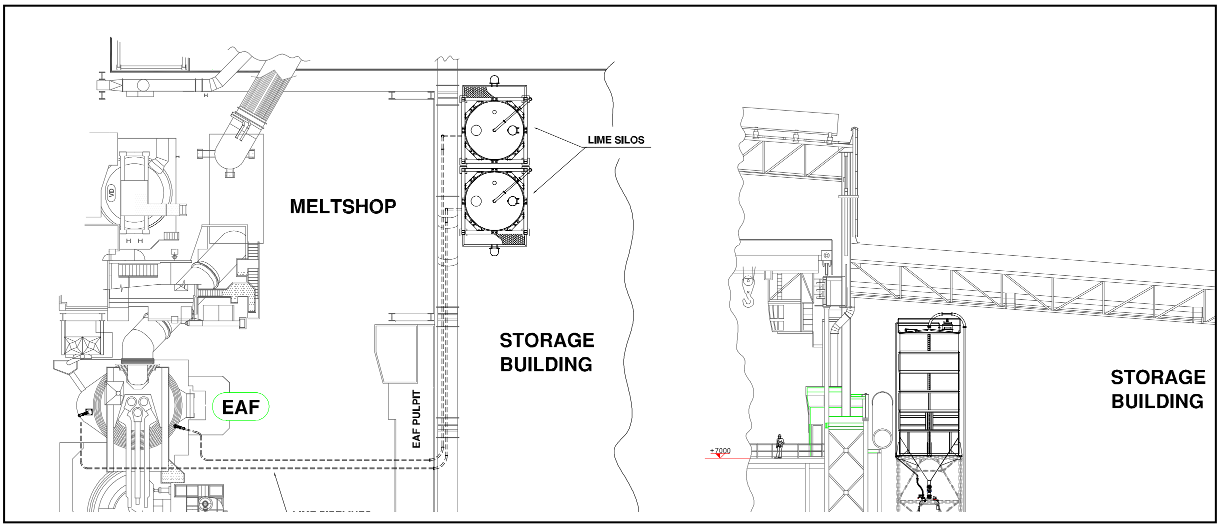

Figure 2: Lime/dolo-lime injection system.

Figure 3

Figure 4

Figure 3 and 4: Two dedicated MOLI dispensers installed under two 125 m^3 storage silos

The furnace is equipped with two LIMEJET injectors, combined burner/lime injector (Figure 5). The LIMEJET injectors' burner capability is of extreme importance for a reliable injection of lime/dololime material. The flame is needed both to clean the area from scrap prior to start the injection and to keep the area hot during the injection so to avoid lime build-up on the furnace wall.

Each LIMEJET injector generates a MSF-Mixed Swirled Flame of oxygen /natural gas up to 4 MW capacity. The MSF-Mixed Swirled Flame technology has been performed to improve combustion and heat transfer efficiency to the scrap surface. The MSF burner tip design dramatically improves the mixing of reactants and avoids the generation of a cold flame and develops a very hot flame close to the injector, improves flame stability and its heat transfer ability, especially to the scrap located in the injector area. The MSF significantly helps to minimize the risk that unburned natural gas flows through the scrap pile producing endothermic reactions by cracking. The MSF burner concept provides nozzle self cleaning capability and to operate with the best ratio between oxygen/natural gas, correct duration of burner usage.

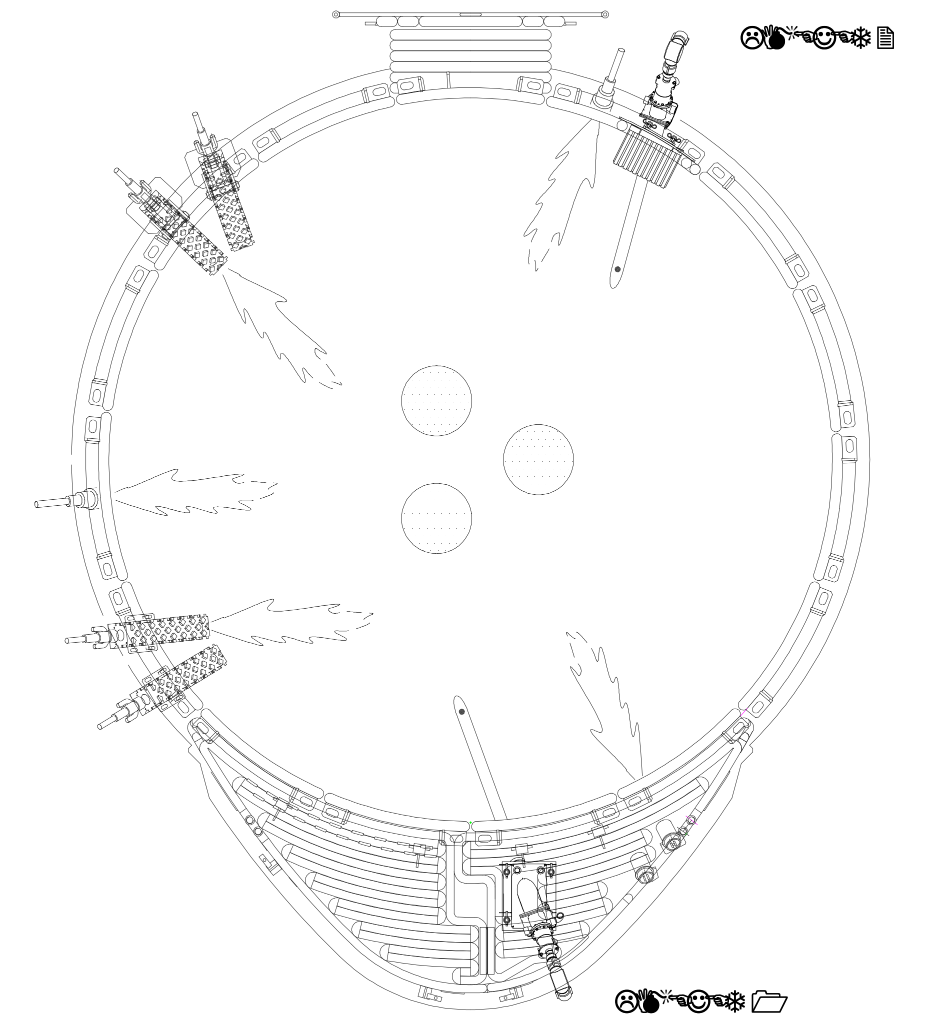

Fig. 5

Figure 5: The furnace is equipped with two LIMEJET injectors, combined burner/lime

The two MOLI dispensers are equipped with dedicated pneumatic cabinets for a precise control of the transport air flow and pressure which is need to optimize the pneumatic transport conditions to reduce the risk of pipeline clogging and to reduce the introduction of ‘cold air’ in the melting process. The LIMEJET injectors on the EAF shell are housed into water cooled copper boxes to hold them in the proper position, Limejet 1 is installed on the EBT horizontal panel and Limejet 2 is installed on the left side of the slag door.

TECHNOLOGY CONFIGURATION

Two were the available products to be injected: blended HiCal Lime + 10% MgO with a very fine sizing (1mm and down) and Limestone ($CaCO_3$) with a sizing of 3-5 mm.

The LIMEJET 2 has been used to inject the HiCal, while the $CaCO_3$ has been injected trough the LIMEJET 1, bulk DoloLime was charged trough the roof.
$CaCO_3$ was injected in small quantities (200-300 kg) during refining, in order to obtain a cooling effect on the slag to maintain it in the best conditions to foam. By pneumatic lime injection, a better control of the slag has been noticed from the very beginning, but some limitations of the total amount of injected lime were noticed, mainly due to two main problems:

- The use of $CaCO_3$ which has limited the lime injection on one injector only.
- Very fine lime lost in the fumes and splashed on the electrodes if injected in a flat bath condition (end of melting and refining). The lime injection was limited to the melting phase, in order to use the scrap as "shield" to prevent loss of material in the off-gas system.

Moreover, some problems have been experienced with the LIMEJET 2 copper block. The block in the position was exposed to the flame of the adjacent side-wall burner, causing the copper to suffer for the high energy load.
In order to improve the two mentioned critical aspects, some modifications has been made to the original configuration:

- LIMEJET-2 copper block has been substituted with a regular copper tile-box positioned flat with the inner face of the side-wall panel. With this solution was not possible to keep the LIMEJET injector at the proper vertical angle and distance to the steel level. Thus, the LIMEJET-2 has been substituted with a side-wall burner, and the lime was injected through a water cooled pipe just under it (Fig.6).
- Discontinued the use of the $CaCO_3$. Although the benefit of injecting this material during refining was evident, it is non-sense to keep a silo occupied for a material to be used in so small quantities.
- Lime sizing changed to 5-13 mm for the LIMEJET 1 and 1-5 mm for the LIMEJET 2.

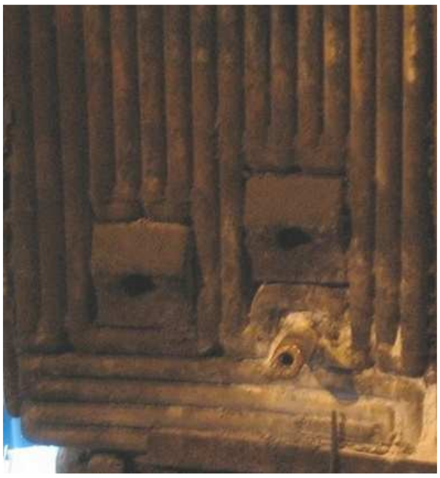
Fig. 6

Figure 6: LIMEJET-2 copper block.

A good equilibrium was found by pneumatic injecting a total of 1200 kg of HiCal during melting. 1700 kg of DoloLime were added through the roof. Pneumatic injection during flat bath was not possible because the lime pipe was almost

horizontal causing the lime to bounce on the electrodes and being sucked into the fumes.
Thanks to the increased efficiency of the DoloLime, a 10% reduction of the total fluxes consumption has been consolidated with this configuration in addition to a better foamy slag control.
On March 2009, in order to have the LIMEJET 2 installed in the proper position (with regards to the vertical angle and distance to the steel), the installation has been changed by adopting two adjacent copper blocks to protrude inside the furnace shell both the LIMEJET 2 and the side-wall oxy-fuel burner (Figure 7).

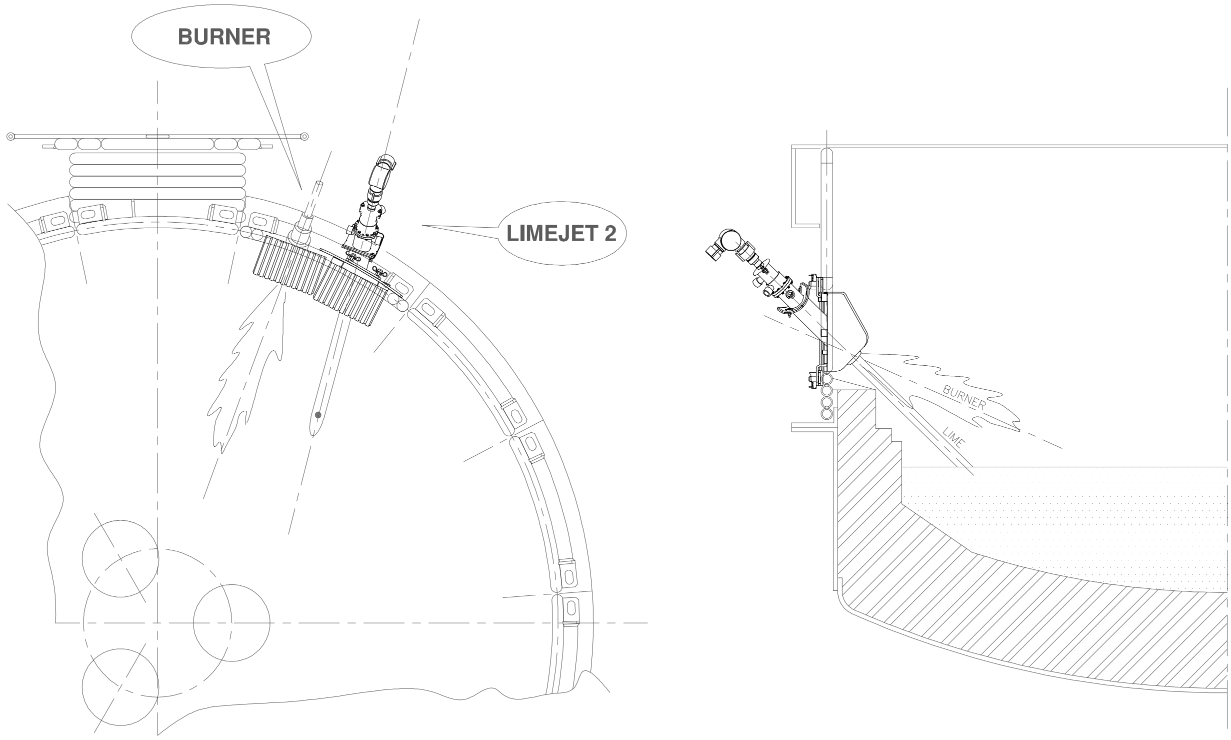

Figure 7: LIMEJET 2 positions.

The last configuration was reached when the LIMEJET 2 injector has been replaced with a HI_JET injector provided by More srl. The peculiarity of this patented tool is the injection of the fluxes fines embedded into an annular supersonic oxygen stream. Due to the high velocity oxygen stream, the lime particles exchange momentum with the oxygen and increase their speed up to 400 m/s, about ten times higher than the exit speed of the regular LIMEJET injector.
The high speed lime pierces through the slag reaching the steel and consequently improving the interaction with it and minimizing the loss in the fumes. The ability to inject lime in steel at the proper temperature range (at the beginning of the refining phase) improved the phosphorous removal capability.
Consolidated results have demonstrated the ability to maintain the same phosphorous content in the steel at tapping by reducing the total amount if Lime by 300 kg per heat with a saving of 3 kg/ton.
By the ability of the HI_JET to inject the material in the liquid steel, with consequent limited loss in the fumes, furthers trails are on-going to inject powdered recycled

materials (i.e. dust previously collected by the vacuum trucks during cleaning operation, crushed slag, etc.) into the liquid steel.
The Binary Basicity Index of the resulting EAF slag by pneumatic injection is always above 2.0, Quaternary Basicity Index about 2.0 and for the Ternary basicity Index 1,5. An average slag analysis with pneumatic injection technology is as below:

CaO	25 %	• FeO	35 % •
Al_2O_3	5 %	• MnO	7 %
SiO_2	13 %	• P_2O_5	0.4 %
MgO	10 %	• Other	5 %

OPERATING RESULTS AND CONCLUSIONS

The adoption of the lime injection practice at Tenaris Dalmine have demonstrated improvements in terms of :

- Ability to introduce lime and dolo-lime in the furnace during all the time of the heat. The capability to inject the fluxes during the refining allows for a better control of the foamy slag, thank to the cooling effect generated.
- The increased efficiency due to lime injection allowed the reduction of 10% of the total consumption. The use of HI-JET can reduce a 10% more the quantity of lime added to each heat..
- Ability to control precisely the total amount, and at the right moment, of fluxes material used with a full automated process.
- Ability to inject lime in steel with consequent metallurgical benefit.
- Possibility to place the injectors close to the hot-spots of the furnace with consequent extended refractory life.
- Very low maintenance on the system because of the very few moving parts involved.
- Increased lime overall yield, with consequent consumption savings.

REFERENCE

1 MANNING, C.P.; FRUEHAN, R.J. JOM, v. 53, p. 10, 2001.