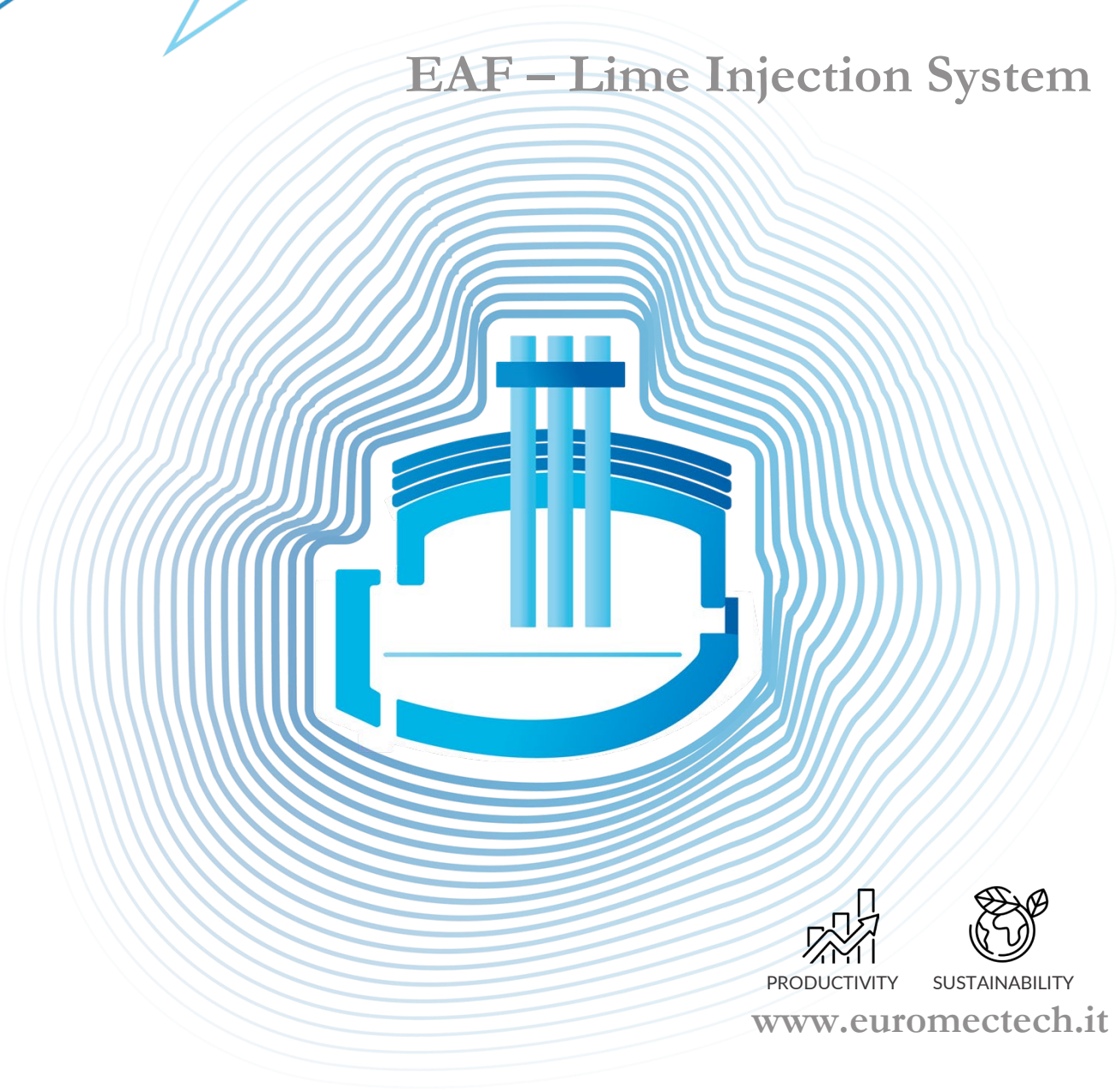
EUROMEC

ENGINEERING AND INDUSTRIAL SYSTEMS

EUROMEC

EAF – Lime Injection System



PRODUCTIVITY SUSTAINABILITY

www.euromectech.it

EUROMEC is a leading company in the field of Slag Conditioning and chemical packages for the steelmaking industry.

These packages are linked to EUROMEC's strategy to create value for its customers in terms of:

Improving the
PRODUCTIVITY

Improving the
SUSTAINABILITY

A solid and reliable design clearly linked to EUROMEC's reputation and tradition built over 30 years of history.

EUROMEC, a better everyday life for industrial people.

Euromec EAF Slag Conditioning and Chemical Packages

The Electric Arc Furnace (EAF) is driven by a complex and dynamic process. The proper utilization and balance of electrical and chemical energy (mass and energy balance) are crucial milestones for achieving excellent results in terms of productivity, efficiency, quality and sustainability targets.

A wise use of chemical energy is linked to the optimization of several factors, including:

- Melting control of the metallic charge
- Combustion control
- Conditioning of slag chemistry, encompassing:
  - Control of iron oxyde
  - Control of dephosphorization
  - Oxidation of carbon, silicon, etc.
  - Control of slag basicity
- Practice of foaming slag
- Refractory lifespan

EUROMEC's EAF Slag Conditioning and Chemical Package is a state-of-the-art, reliable package that supports the furnace operators in achieving the best results in their operations..

Here in after a focus on the LIME INJECTION practice in EAF operations is made.


PRJ2
PRJ1

Euromec's pneumatic lime storage and injection system

The Euromec Lime Injection System is specifically designed to meet the demands of the steelmaking process for injecting lime powders. This system ensures a controlled flow rate of lime with high accuracy to EAF processes.
Compared to charging lime lumps through a scrap bucket or the EAF roof 5th hole, lime powder injection is considered the best practice. It offers several expected improvements, particularly in the control of slag conditions and the slag foaming process:

- **Reduction in lime consumption**
- **Decreased electrical energy consumption**
- **Lower on power on time**
- **Overall cost savings through extended refractory life and reduced consumption of O2, CH4 and C**
- **Improved steel quality, including lower N incorporation and optimal dephosphorization practice**
- **Environment benefits with reduced lime and/or fluxes dust in the Meltshop environment**

The accuracy of flow rate regulation and the system's reliability are crucial factors for effectively controlling the EAF process, enabling dynamic regulation of slag conditioning practices.

FEATURES

REDUCED LIME CONSUMPTION

REDUCED ELECTRICAL ENERGY CONSUMPTION

LOWER POWER ON TIME

LOWER NITROGEN INCORPORATION, DEPHOSPHORIZATION

SHORT-TERM RETURN ON INVESTMENT

TYPICAL EUROMEC ARRANGEMENT:

Lime Storage Bin

The Lime Storage Bin is designed with a suitable volume to be defined according to EAF process requirements. The bin is equipped with a lime continuous level monitoring system and further instrumentation to be able to assist the EAF process automation. The end cone is fluidized.
The lime moves from the Lime Storage Bin to a Lime Pressurized Dispenser.

Lime Pressurized Dispenser

The pressurized dispenser, with a suitable volume to be defined according to EAF process requirements, is a suitable technology to guarantee the proper lime flow rate (80÷200kg/min) to the EAF lime injectors. Design and technology of the Euromec pressurized dispenser are confidential.
The Pressurized Dispenser is equipped with a dedicated weighing system with proper accuracy.
The Pressurized Dispenser is equipped with:

- a special fluidizing bottom (an Euromec confidential design solution);
- valve and instrumentation rack.

Downstream the fluidized bottom a properly designed rotary valve complete the equipment according to Euromec design.

Weighing system, fluidized bottom, valves, rotary valve and instrumentation is a suitable architecture for the proper EAF process automation control.

RESEARCH ARTICLE - ABSTRACTS

Study on the Pneumatic Lime Injection in the Electric Arc Furnace Process: An Evaluation on the Performance Benefits

In order to provide a general overview of the main advantages related to the lime injection practice in EAF operations Euromec decided to show the main conclusions described in a research article pubblished in Steel Research international on 2021. Below the summary of the article.

The pneumatic lime injection during the electric arc furnace (EAF) process by insufflation lances mounted on the furnace walls has gained much interest in the latest years. The main advantages, in comparison to the traditional procedure of lime lumps addition within the scrap bucket, can be summarized in:

- raw materials consumption reduction
- foaming benefits
- operational cost benefits
- improvement in environmental aspects.

In the proposed work, the advantages of a new lime injection system installed on a 90 t EAF of Acciaierie di Calvisano (Italian Meltshop) are analyzed. Data from more than 1200 heats are acquired and compared with the traditional practice from an energetically and emissions point of view.

To evaluate the benefits on the slag foamability, several slag samples, taken at the beginning and at the end of refining stage, are analyzed through isothermal solubility diagrams (ISDs). The ISD analysis results are then compared and validated with the total harmonic distortion (THD) of the arc in the corresponding heat.

The upgrade to lime injection drives to considerable savings in electrical consumptions, oxygen, methane, and lime, with an overall save of more than 4,000 t year of equivalent CO2 .

INTRODUCTION:

The electric furnace process has evolved becoming a highly efficient scrap smelter, which integrate a technology able to improve energy using oxygen, gas, carbon, and lime injection. Generally, the lime charging procedure into the EAF is based on lime addition, in the form of lumps, directly within the scrap bucket through conveyor systems. This practice, however, has several issues related with lime emissions during the scrap bucket charging and an inadequate distribution of lime in the furnace, made possible instead by lime injection. **In recent years, the usage of pneumatic injection of lime in EAFs, due to its surprising results in terms of reduction of the specific raw material consumption, foaming benefits, operational cost benefits, and improvement in environmental aspects, has acquired interest as a viable technology for the steelmaking industry.**

Acciaierie di Calvisano steelmaking plant decided to upgrade its EAF, implementing a new system of lime delivering, in place of the traditional procedure. Combining carbon and lime powder injectors, the lances are able to create a homogeneous layer of foamy slag over the whole metal bath surface. The addition of lime is essential for the proper bath chemistry and the slag foaming practice, which offers an increased energy efficiency of the furnace, since the heat from the arc is captured by the slag; a protection of the water panels and the roof from radiation and a decreased noise pollution and low nitrogen incorporation in the steel are achieved.
The lime presence is also essential for carrying out the dephosphorization during the refining of the bath. If not removed, phosphorus has detrimental effects on the mechanical properties of the steel. Therefore, highly available CaO in the slag allows to decrease the phosphorus content of the bath trough the generation of tricalcium phosphate compounds ($3CaO{\cdot}P_2O_5$) which are captured by the slag. The thermodynamic of the process is ruled by the content of lime in the slag, the higher the content the better the dephosphorization, whereas the kinetic is controlled by the dissolution rate of lime into the slag, the finer the lime the fastest the dephosphorization.

The aim of this work is to evaluate and validate the potential benefits of injecting lime in fine particles, compared to the standard technique.

Tests were conducted in a **90 t top-charge EAF** equipped with a wallmounted, multipoint injecting system (carbon, lime, oxygen, and burners) on two different steel grades: special steels and structural steels, representing most of the steel production of the partner plant. Four injection points are available, three in the cold spots and one over the eccentric bottom tap-hole (EBT) (Figure 1).

However, carbon and lime are only introduced at #1 and EBT positions. The reason lies in the fact that the exhaust gases evacuation system is placed over the position #3 and this can suck the carbon and lime powders. In addition, position #2 has been abolished due to an excessive refractory wear in the surrounding areas

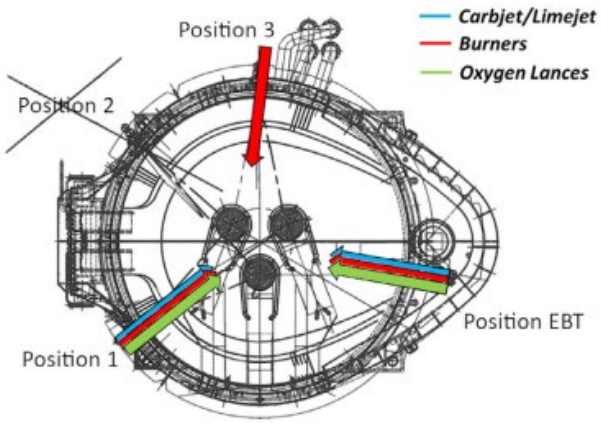


Figura 1 – Schematic position of multipoint injection system [1]

Three different lime addition procedures were considered:

- STD (the traditional procedure)
- INJ1 (lime injection procedure), and INJ2 (lime injection procedure with a different amount of injected lime).

Steel grade	Procedure	N° of heats
Special steel (three buckets)	STD	231
	INJ1	160
	INJ2	163
Structural steel (four buckets)	STD	429
	INJ1	150
	INJ2	71

Table 1 – Experimental plan design. [1]

Electrical, oxygen, methane, lime consumptions, carbon, and slag production were evaluated and correlated with the slag foamability through isothermal solubility diagram (ISD) and total harmonic distortion (THD) values.

MAIN RESULTS:

a. LIME CONSUMPTION

Switching from lump lime procedure to injected lime system led to a considerable CaO reduction in term of lime usage.

STD Route

4,0

tons of used Lime.

INJ 1 Route

2,9

tons of used Lime.

-28%

LIME Consumption

INJ 2 Route

3,1

tons of used Lime.

-23%

LIME Consumption

b. ELECTRICAL CONSUMPTION

Electrical consumption for the production of structural steel is significantly different from STD to INJ procedures. The difference, from STD to INJ1 and STD to INJ2, turn out to be 30 kWh/t and kWh 22 kWh/t, respectively.

STD Route

0,0

Saving in electrical consumption kWh/t.

INJ 1 Route

-30 kWh/t

Saving in electrical consumption kWh/t.

INJ 2 Route

-22 kWh/t

Saving in electrical consumption kWh/t.

c. POWER-ON TIME

Power On reduction for the production of structural steel is different from STD to INJ procedures. The difference, from STD to INJ1 and STD to INJ2, turn out to be 1,6 min and 1.1 min, respectively.

STD Route

0,0

Saving in power On time [min]

INJ 1 Route

-1,6 min

Saving in power On time [min]

INJ 2 Route

-1,1 min

Saving in power On time [min]

d. OTHER SAVINGS

Other savings in term of Oxygen, Natual Gas and Carbon consumption were observed in favour of INJ practices vs. STD practice.

e. OTHER ADAVANTAGES

Other advantages in favour of INJ pratices vs. STD practice are related to the better, faster and more flexible possibilities to affect the slag chemical composition and foamability.
Basically having the possibility to get, during the heat, a properly thick, homogeneous and constant layer of slag provides the following advantages also observed during this study:

- Steel Quality:
  Liquid steel bath protected from athmosphere: this imply lower nitrogen (N) incorporation into the steel.
  Better dephosphoration of the liquid steel bath due to the possibility to affect the slag chemical composition faster.

- EAF Maintenance:
  Longer life of EAF shell and roof water cooled panel
  Longer life of EAF roof refractory delta
  Due to a better slag covering of the electrodes arc.

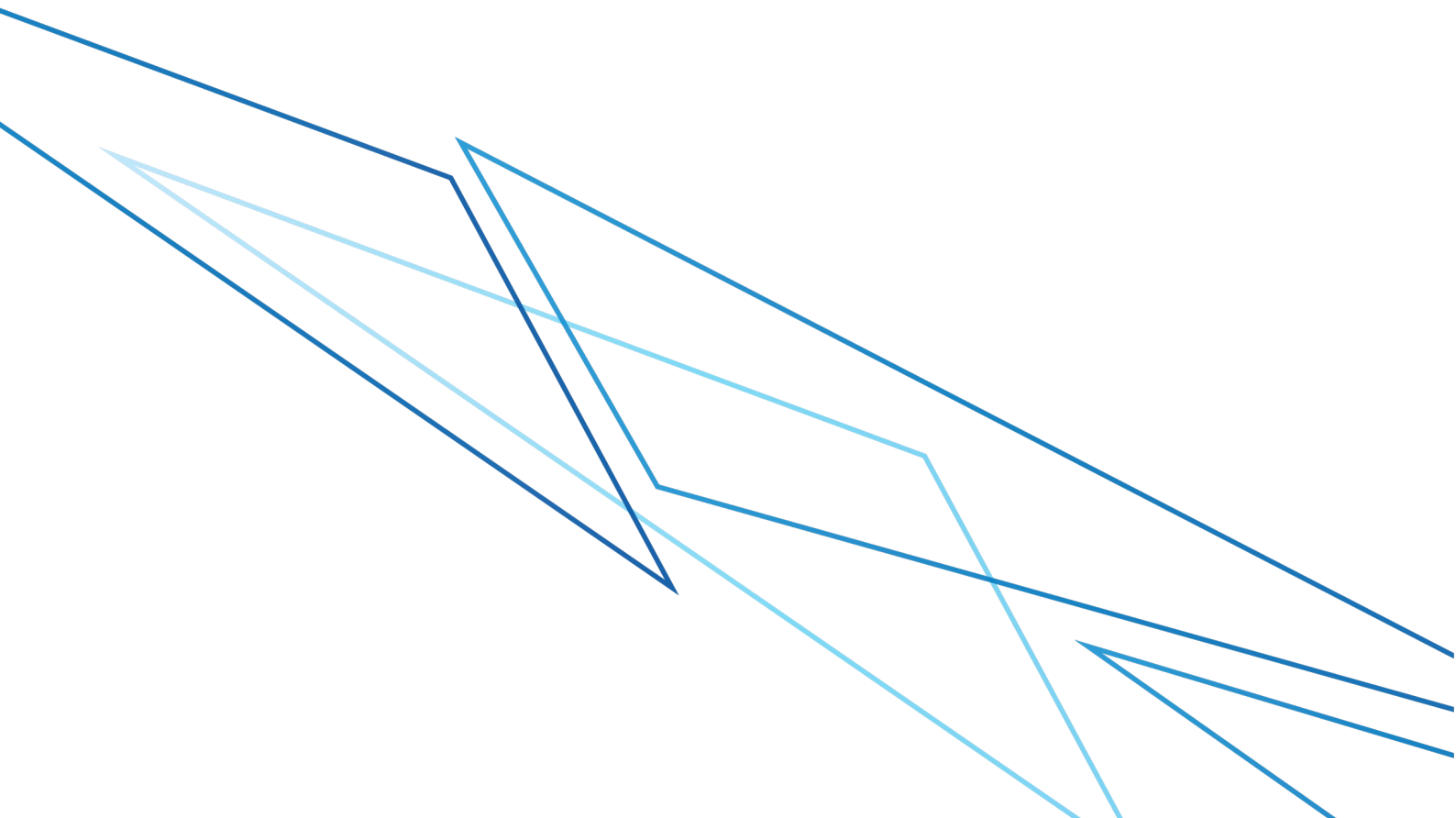
CONCLUSIONS:

In this work, a new method to feed fine particles lime within the EAF of the Acciaierie di Calvisano steelmaking plant by the use of injectors was investigated. The aim of this work was to analyze and validate the benefits of lime injection compared to the traditional "lump charging" technique, which involves the use of lime in lump. To assess the potential advantages and the effectiveness of this new system, a comparison between the two practices have been performed. The study was done analyzing 1204 heats and sampling slag for 23 heats, both at the beginning and in the end of refining, for a total of 46 samples. In particular, the consumption of electricity, oxygen, methane, carbon, lime, and slag foaming capacity was investigated. The results of the new lime injection technique and the analysis made on the samples are summarized as follows:

1. Lime consumption decreased
2. Electrical consumption decreased
3. Power-on time decreased
4. General savings in O2, CH4 and C consumptions were observed
5. Other operational general advantages in term of steel quality and EAF maintenance were observed.

As indirect effect a clear equivalent reduction in CO2 emission were observed.

REMARK:
What it is reported in this RESEARCH ARTICLE – ABSTRACTS is a summary of the article Study on the Pneumatic Lime Injection in the Electric Arc Furnace Process: An Evaluation on the Performance Benefits pubblished in 2021 on "Steel Research International". This is an open access article.



Main references:

Spain - Siviglia	24/0705	Lime injection system	2004
Italy - Padova	25/0216	Lime injection system	2005
Italy - Verona	26/1214	Lime injection system	2006
Iran - Mobarakeh	28/0504	Lime injection system	2008
Iran- Mobarakeh	28/0511	Lime injection system	2008
Iran - Ghaenat	29/1005	Lime injection system	2009
Mexico - Tamsa	11/0106	Lime injection system	2011
Italy - Vicenza	29/1014	Lime injection system	2012
Iran - Chadormalu	12/0911	Lime injection systems	2013
Italy - Lonato	13/0931	Lime injection system	2014
Iran - Korasan	13/0703	Lime injection systems	2014
Italy - Osoppo	14/0715	Lime injection system	2015
India - Raigarh	15/0301	Lime injection system	2015
South Korea - Inkehon	14/0819	Lime injection systems	2015
Italy – Calvisano	**15/0804**	**Lime injection system**	**2016 (*)**
Italy - Brescia	13/0815	Lime injection system	2018
Italy - Odolo	15/1206	Lime injection system	2018
Mexico	16/1022	Lime Injection system	2018
China - Donghai 1	20/157	Lime injection system	2020
China - Donghai 2	20/157	Lime injection system	2020
Germany – Henningsdorf	20/061	Lime injection system	2021
Italy - Caronno	17/0217	Lime injection system	2022
Italy - Lesegno	20/041	Lime injection system	2022

(*) The Lime injection system of Calvisano is the one described in the above mentioned RESEARCH ARTICLE.

ITALY
Euromec S.r.l.
Via de Ö, 19 - 24020 Colere (BG) – Italy
www.euromectech.it - euromectech@euromectech.it

CHINA
Euromec Technologies (Tianjin) Co., Ltd.
www.euromectech.it – yan.hongkai@euromectech.it