Steel Millennium

THE LEADING REVIEW OF ADVANCED PROCESS TECHNOLOGY WORLD - WIDE

The KT injection system for high-performance electric-arc furnaces

The KT injection system injects oxygen and carbon into the EAF via special atomized water-cooled, multiple injection lances in order to achieve a more homogeneous temperature, a better foamy slag with reduced FeO, faster scrap melting and reduced energy consumption.

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Multipoint Köster Technology, the KT injection system, is a product of Techint Technologies which improves the efficiency and reduces the operating costs of the electric-arc furnace.

The basic concept is to inject oxygen and carbon into the furnace at the slag line, just above the metal bath, via multiple lances, strategically positioned for each furnace (see *Figures 1* and *2*).

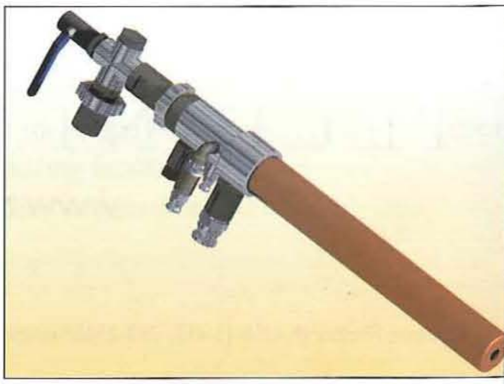
The copper lances do not project beyond the refractory and the short distance between the nozzle and the bath increases the overall efficiency of oxygen and powdered carbon consumption, compared with a conventional lance projecting through a furnace door. This short distance is made possible by the unique design of the copper lance, which uses atomized water to increase the heat transfer between the fluid and the copper. See *Figures 3* and *4* and *Table 1* for further technical details.

The oxygen lances point downwards at an angle of 45° or more to avoid steel splashing on the electrodes and walls, whereas the carbon injectors are angled about 30° in order to promote carbon injection into the slag (see *Figures 5* and *6*).

The oxygen lances inject oxygen 2 m into the furnace at supersonic speed (see *Figure 7*). The oxygen stream is surrounded by methane to maintain a reducing atmosphere around the nozzle and to protect the brickwork from oxidation.

● **Figure 1** ***KT injection system***

● **Figure 2** ***Inside view of EAF showing lance position***



● **Figure 3** ***Carbon injector***

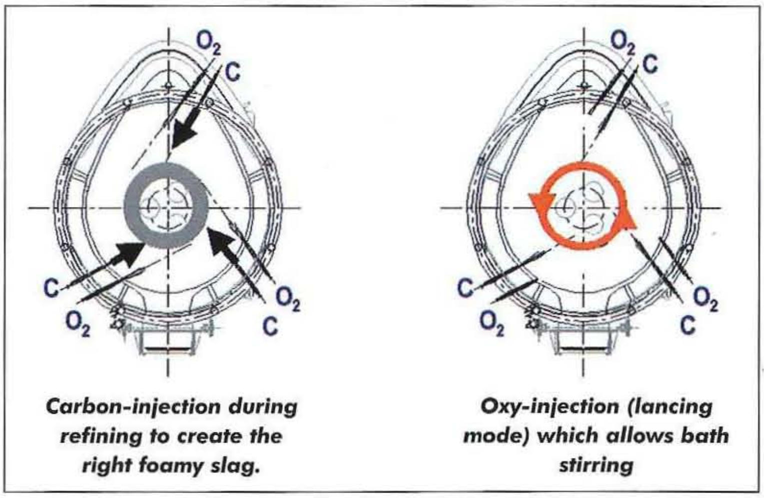
● **Figure 4** ***Cut-away view of cooled KT body (same for oxygen and carbon lances)***

● **Figure 5** ***External view of EAF showing both types of lance***

During melting they work as very powerful burners (5 MW), while during refining they become supersonic oxygen injectors, hence these lances are working during the whole power-on period, producing a more uniform distribution of chemical energy in the furnace. Further technical details are given in *Table 2*.

The carbon injectors are also installed in the refractory, above the steel level, so that the carbon is injected directly into the slag. Their function is to create a foamy slag, which improves the arc heat transfer to the bath and gives protection from the external atmosphere. This reduces electrode consumption by oxidation and refractory consumption caused by arc radiation (see also *Table 3*).

An indirect advantage of the improvement of the foamy slag is the reduction of FeO content.



● **Figure 6** ***Plan view of EAF showing injection***

The process

The KT injection system is completely automatic, but is supervised by a furnace control room operator. The automation is independent from the furnace system but linked with it for data transfer.

The KT process for traditional furnace charging has three modes: burner, melting/cut and refining. With a continuous charging mode such as with the Consteel process or direct reduced iron (DRI) feeding, there is just the refining phase. (See pages 161–165 for more details on the Consteel process.)

Burner mode This occurs during the first phase of bucket melting. As the lances are placed close to the slag level, much lower than a normal panel burner, the heat transfer to the scrap is significantly increased.

The combustion ratio between oxygen and gas is between 2.1 and 2.2, close to the stoichiometric ratio, in order to burn fully all the injected gas, but not to create unnecessary FeO. During this phase the carbon injectors are in stand-by mode with a purging flame, but the burners are creating the space within the furnace to permit the carbon injectors to start in the next phase. Meanwhile, electrodes have gone to the bottom of the furnace and they are starting to

● **Table 1** ***Cold copper lance body technical details***

Length	About 1000 mm, depending on refractory wall thickness
External diameter	90–100 mm
Type of cooling	Atomized water and air
Type of cooling water	Same as for the furnace panels
Type of water filter	Tangential, self-cleaner
Cooling water capacity	Not higher than 2 m³/h
Cooling water pressure	3 bar minimum
Compressed air	Oil-free
Cooling air capacity	About 50 Nm³/h
Cooling air pressure	3 bar minimum
Useful life	More than a year without any kind of repair. (The first repair made at Sidenor took place after 11 months)

● **Table 2** ***Oxygen lance technical data***

Oxygen flow	800 to1000 Nm^3/h (burner phase), up to more than 2000 Nm^3/h (supersonic phase).
Oxygen pressure required	Higher than 10 bar, optimum pressure around 13 to15 bar
Natural gas consumption	Between 200 and 500 Nm^3/h
Natural gas capacity	Less than 10% of the oxygen value during the supersonic phase
Natural gas pressure required	Higher than 3 bar
Nozzle useful life	Higher than 2000 heats

● **Table 3** ***Carbon injector technical data***

Carbon powder injection rate	Up to 60 kg/min
Capacity of the carbon transport gas	More than eight times the volume of the carbon transported
Transport gas pressure	Typically between 1.8 and 2.8 bar, according to the length of the injection line
Capacity of the jet shrouding gas	Between 2 and 20 Nm^3/h (for different running conditions)
Natural gas pressure	Higher than 3 bar
Nozzle useful life	Higher than 2000 heats depending on the type of carbon used. (Nozzles already installed last about one year)

work on the liquid heel and radiate heat to the rest of the scrap.

Melting/cut mode The change to this phase is automatic and based on a total energy consumption set point. The burner changes into a supersonic lance (Mach 2.2), with a higher combustion rate and with flame protection (see Figure 7). Energy is directed to the lowest part of the charge, with all the advantages of the injection from the bottom, but without the problems that can occur with a tuyere.

The effect on the charge is a cut in the scrap in the bottom area, so that it is forced to fall vertically into the liquid heel. The carbon injector then commences to foam the slag (see Figure 8).

This new concept of scrap melting helps to reduce power-on time as it is a very efficient process, but it also helps to reduce the delays related to a non-homogeneous energy input, such as scrap levelling and clogging in eccentric bottom tapping furnaces.

Refining mode Flat bath running takes place during the refining phase for traditionally charged furnaces and during the continuous charging phase for Consteel and DRI furnaces. During the flat bath period, according to the metallurgical requirements of the bath, the oxygen/carbon injection system automatically follows the necessary steps for the maintenance of the foamy slag. The oxygen injection power also increases bath circulation and hence improves the metallurgical reactions and bath temperature homogeneity. Furthermore, the carbon is

● **Figure 7** ***Oxygen injection***

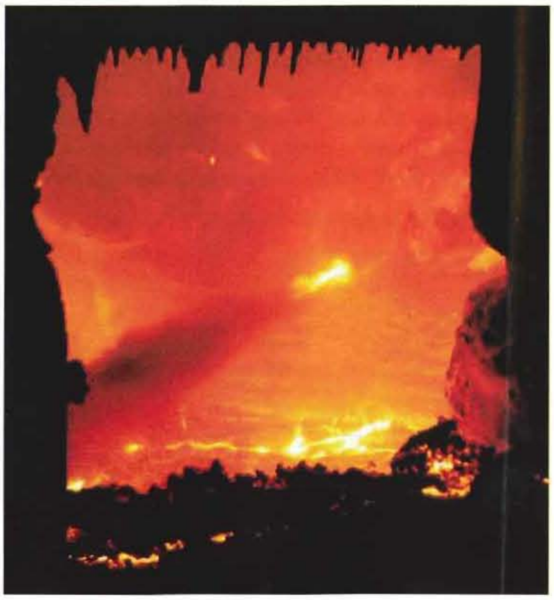
added to the slag in a continuous way, so avoiding undesired and unexpected swelling of the slag that can affect the process. Control of carbon injection is automatic which achieves consistent foamy slag conditions during the whole process.

Advantages

The KT system is an advanced chemical package which combines all the experiences and best aspects of other well-known systems (consumable lances, cooled supersonic lances, post-combustion injectors and panel oxygen injectors) in a compact, simple and cheap installation. This kind of installation can be retrofitted to improve productivity without additional electric power and with limited capital investment.

The main benefits of the KT injection system are as follows:

- High efficiency both in melting and in refining resulting from very efficient energy transfer to the bath and slag, and no opening of furnace doors required.
- Excellent flexibility of oxygen injection through control over the injection speed.
- Refractory protection from the arc radiation because of the foamy slag practice.
- Maximum safety in all operations thanks to the new cooling system with atomized water with very low consumption.



● **Figure 8** ***Carbon injection***

● **Table 4** ***Installed systems***

Plant	Year	Furnace size, tonnes	Transformer rating, MVA	Injection type carbon or oxygen
Dalmine (Dalmine-Italy)	2001	95	100	C, 0
Makstil (Macedonia)	2001	120	30	C, 0
K.S.C. (Ahwaz-Iran)	2001	150	100	C, 0
TPCO (Tianjin-China) under construction	2001	150	100	C, 0
Siderurgica Sevillana (Spain)	2001	75	70	C
Siderca SAIC (Argentina)	2001	80	90	C
IRO (Brescia-Italy) under construction	2001	70	55	C, 0
Cape Gate (South Africa)	2001	70	60	C, 0
George Fischer (Germany)	2000	Foundry 70 t/h		Cooling
Profilatinave (Brescia-Italy)	2000	70	50	C, 0
ORI Martin (Brescia-Italy)	2000	75	60	C
Sidenor (Greece)	1999	75	65	C
MMZ (Moldavia)	1998	120	80	C
BHP (Australia)	1998	70	60	C

- Automatic control of all chemical processes, but giving the operators the control functions and system direction.
- The KT carbon injection system can also be used for the injection of other solid material into the bath, such as lime powder or DRI fines and dust.

Consumption results

- The creation of the correct foamy slag enables a longer arc length to be used with a constant current power value. In this way the power transferred to the bath is increased by about 1–2%, with a more stable arc.
- The more efficient carbon injection (keeping the specific consumption unchanged) reduces FeO in the slag by 5–15%.
- The presence of carbon to protect the hot spots reduces the refractory consumption by 3–6%.
- The oxygen efficiency is higher than a conventional supersonic lance, cooled from the door. Observations show a value equal to 3.8–4.2 kWh/Nm^3 of oxygen.

Installations

There are currently 12 operating plants, with two more under construction (see *Table 4*).

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