Energy saving and environmental improvement in the steel industry

The steel industry is strongly committed to both saving energy and improving the environmental performance of its plants and products through research and development activities. Techint Technologies proactively contributes to these activities. Examples are described.

AUTHOR: Carlo Raggio
Techint Technologies

Techint Technologies' R&D team, a network of specialists and engineers from various business units, are continuously carrying out extensive examinations of steel production practices; identifying which process factors and parameters affect the environmental performance and then developing technological solutions that can improve industrial production standards in terms of product quality, reducing waste and emissions, recycling waste and reducing energy consumption. This activity takes advantage of the network of the various production companies within the Techint group and with the Research Centre, Centro Sviluppo Materiali (CSM). Industrial testing and validation are performed through worldwide co-operation with the steelmakers. A selection of applications of developments in steelmaking, hot rolling and finishing operations are described below.

EAF STEELMAKING: KT AND EFSOP SYSTEMS

Energy and environmental issues draw us to the EAF route, mainly for producing long products. *Figure 1* illustrates total steel production and % via EAF for a selection of countries, although the trend is also towards high value-added products. EAF steelmaking requires less energy than the integrated route due to the use of scrap metal, while at the same time assuring higher operational flexibility and reduced environmental impact.

Nowadays, the tendency in high productivity EAFs is to increase the amount of chemical energy used (oxygen, carbon, natural gas) in order to reduce electrical energy consumption and consequently to reduce overall conversion costs. *Figure 2* shows data for oxygen consumption in EAFs.

Techint Technologies contributed to this trend with intensive R&D activity which brought about the development of the KT injection system, which has increased the efficiency of thermal and chemical input into the EAF. The patented KT oxygen lances, carbon injectors and multifunction burners are the most effective multi-point lances for EAF applications, with over 250 lances successfully installed in more than 20 countries.

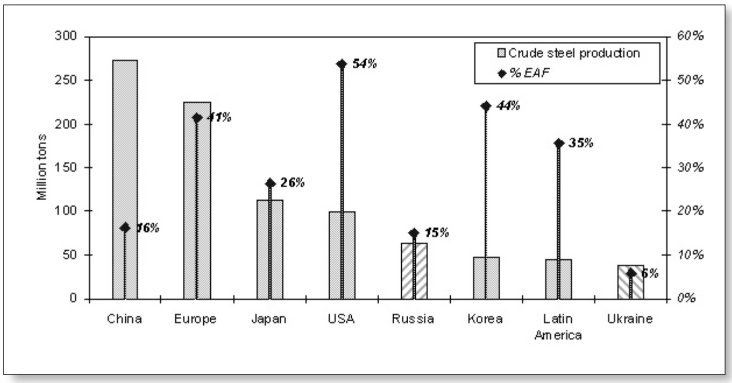

Fig.1 Total steel production and % via EAF for a selection of countries

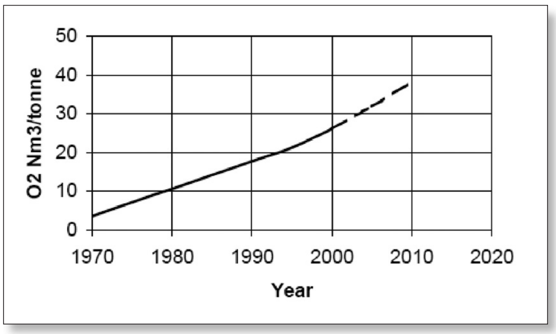

Fig.2 Oxygen consumption in EAFs

KT oxygen lances are installed at the slag line above the steel bath and work as a burner during the melting step and as a supersonic oxygen injector at a velocity of Mach 2.5 during refining. KT carbon injectors are also installed at the slag line, and the carbon injected into the slag reduces refractory wear, improves foaming of the slag and enhances arc energy transfer. In this way the FeO content in the slag is reduced with a positive impact on yield. The KT multifunction burner can be used during the initial step of scrap melting and later for post combustion.

The successful results of this system depend on the development of advanced mathematical models for simulation of oxygen penetration and decarburisation. Validation of the models has been performed by comparison with the experimental data of the industrial plants such as Tenaris Dalmine EAF.

Another step towards EAF process optimisation is the use of Goodfellow EFSOP technology which is designed to improve chemical energy efficiency, lower conversion costs and improve safety through process control based on continuous analysis of EAF conditions during refining. The EFSOP system consists of a water-cooled sample probe, gas analysis system, supervisory control and data acquisition system, a proprietary EAF process model, and a real time, on line post-combustion control system. CO, CO_2, H and O in the off-gases is continuously measured and analysed.

The Tamsa steel plant is the first installation where EFSOP is in operation together with a KT chemical package. The combination of these two technologies gives important results in terms of energy savings and production costs as in *Table 1*.

ROLLING MILL : FLEXYTECH FURNACES

In the field of hot rolling furnaces the request of customers is to fulfill the needs of a wide range of product dimensions (length, width, thickness) and steel qualities, often with varying charging and discharging temperatures. Another important issue is to be able to carry out rolling campaigns where, in some cases, product quality is paramount, and in others, where the lowest possible specific energy consumption is the main aim. The aim of Techint Technologies' R&D team was to design a very flexible furnace in order to assure top performance in any condition, with a special focus on low environmental impact.

The result is FlexyTech Furnace and the relevant fields of innovation are:

- Innovative combustion system with new hardware (FlexyTech burners plus new air and gas line architecture) and a patented control logic called Sequential Firing
- Computerised FlexyTech model for off-line simulation of different design solutions and best online furnace regulation (level 2)
- Optimised profile and improved dedicated equipment such as design of new skids and riders

An extremely valuable technological result was the development of the burners which generate very low NOx emissions, much lower than the limits established by the German Institute TA Luft, and about one-fifth of the emissions produced by the best performing industrial furnaces. These burners are able to control the flame profile (length and volume) over a wide range of power inputs.

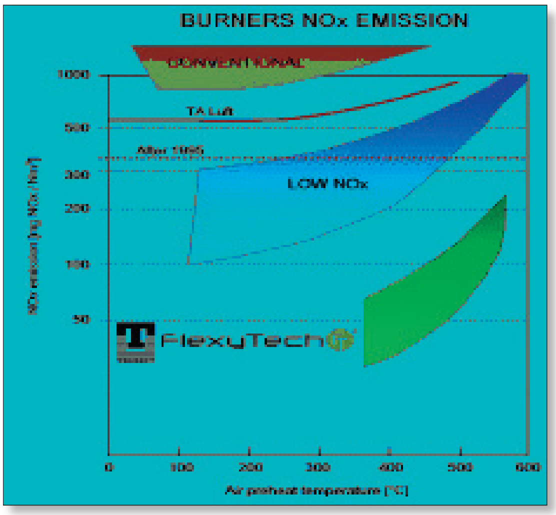

Fig.3 NO_x generation from burners

The flameless operation given by new baffle geometry assures lower spot flame temperatures and delays fuel-air mixing in order to entrain waste gases in the combustion.

Figure 3 shows the general performances in terms of NO_x, which are obtained firing natural gas.

FINISHING LINES: INSOLUBLE ANODE TINNING TECHNOLOGY

One of the most important results of Techint Technologies' R&D activity is the development of a new electrochemical insoluble anode for use in tin-plating. The close association with Techint's three tinning operations at Siderar and Sidor gave the necessary operating and process experience, whereas the CSM and Techint's Processing Line Business Unit researched potential improvements and studied a new tin dissolution process. *Figure 4* shows the CSM test facility. This is able to minimise the amount of sludge and loss of Sn(IV) and has been successfully proven through extensive tests on the Siderar tinning line.

The disadvantages of conventional tinning lines are the fumes exiting the plating tanks, the labour requirements for handling the tin anodes and its low productivity. Additionally, market demand is towards tinplate with thinner coatings; indeed some products require tin

Parameter	Without KT	With KT and EFSOP	Change, %
Electricity, kWh/tls	444.2	389.6	-12.3
Natural gas, m^3/tls	13	8.7	-33
Total C injected, kg/tls	9.2	10.3	+12
Oxygen, m^3/tls	33.5	38.4	+14.6

Table 1 **Results of EFSOP and KT application at Tamsa, Mexico**

coatings down to 0.2–0.4g/m^2, causing production problems. With conventional electroplating technology, the homogeneity of tin coating thickness decreases when the coating weight, due to the particular geometry of the tin anodes, which does not present a continuous surface. Another cause of irregular tin coating derives from non-uniform consumption of tin bars, which in turn gives rise to preferential current distribution.

For thicker coatings such situations are alleviated since more cells are employed in the sequence of electroplating steps, allowing the tin coating to grow with more uniformity.

Techint has developed an innovative process for dissolving the tin that minimises the amount of sludge and losses of tin are below 4%.

The process is based on the oxidation of tin tinning electrolyte saturated with pure oxygen.

The main chemical reactions involved in metallic tin dissolution are:

1) $2Sn + O_2 + 4H^+ = 2Sn^{2+} + 2H_2O$
2) $Sn + O_2 + 4H^+ = Sn^{4+} + 2H_2O$
3) $2Sn^{2+} + O_2 + 4H^+ = 2Sn^{4+} + 2H_2O$
4) $2Sn^{2+} + 2PSA = Sn(PSA)_2$
(PSA – phenol sulphonic acid)
5) $Sn + Sn^{4+} = 2Sn^{2+}$

Oxygen is necessary to enhance the reaction rate of the oxidation of tin by the acidity of the bath formed at the insoluble anode. The electrochemical reactions occurring at the electroplating site with insoluble anodes are:

6) $2Sn^{2+} + 4e^- = 2Sn$ (cathode)
7) $H_2O = O_2 + 4e^- + 4H^+$ (anode)

The acidity formed at the anode in the dissolution reactor restores the two moles of tin deposited on the strip, thus the mass balance is assured. The iridium mixed metal oxide covered titanium anodes are connected to the necessary rectifiers to give a total capacity of 22kVA. The replenishing rate of the plant is controlled by flow rate of the oxygen.

The plant can work in three modes:

- At constant oxygen flow rate (manual)
- At constant tin dissolution rate (auto 1 mode)
- At rate proportional to the current given by the rectifiers (auto 2 mode)

This last mode permits working at constant tin concentration in the solution because the replenishing rate is calculated taking into consideration the tin plates at any given moment.

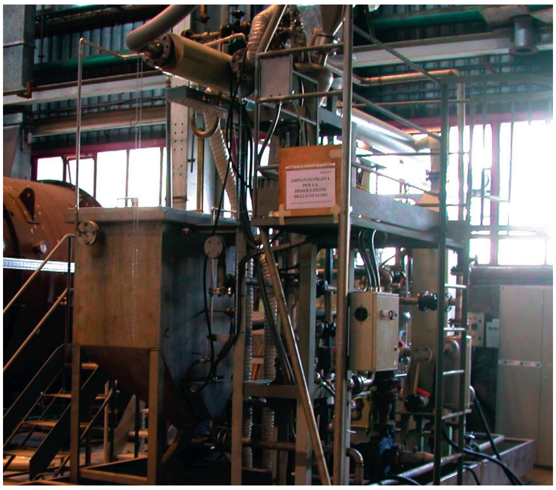

Fig.4 CSM tinning technology test facility

Parameter	Benefit
Constant tin covering on strip	Less tin consumed
Better edges	Better strip quality, particularly important for tin coating
No anode handling	Reduced labour costs, higher productivity and flexibility safer and better working environment
Covering on tanks	Reduced labour
Electrolyte always under control	Less fumes
Anodes closer to strip	Reduced electricity consumption

Table 2 The main advantages of tin plating with insoluble anodes

CONCLUSIONS

Thanks to these new processes and technologies, Techint Research and Development activity has successfully met the most significant environment targets in dust and pollutant emission control and energy saving in the frame of a sustainable development. Looking ahead, Techint Technologies will continue to be strongly engaged in looking for the most economically and environmental friendly solutions for the steel industry.

KT, EFSOP, FlexyTech, insoluble anodes tinning represent an important result of this R&D approach. MS

Carlo Raggio is Director, Research and Development, at Techint Technologies, Genova, Italy

CONTACT: carlo.raggio@techint.it