Tenova's approach to the future energy scenario

This paper reviews three of Tenova's energy saving technologies for electric arc furnaces and reheat furnaces arguing that improvements in existing technologies through its in-house R&D as well as strategic acquisitions of high performance technologies best serve its customers.

Energy efficiency, reduction of environmental impact and higher product quality will be the drivers of innovation in the steel industry over the next few years. The increasing demand for energy and its consequent increase in prices are pushing steel companies to develop new solutions. The efficient use of resources is an integral part of Tenova's mission and this paper presents three examples of how Tenova is approaching the expected new energy world scenario where oil prices are growing far beyond US$100 a barrel with improvements in melting processes in the electric arc furnace (EAF), environmental friendly combustion techniques and hot recovery.

EAF MELTING

The target for reducing electrical consumption with its resultant abatement of CO2 emissions requires a significant R&D effort by Tenova in EAF melting technology. The expansion of steel production using the EAF versus the integrated blast furnace – oxygen steelmaking (BOF) route has contributed to a decrease in overall energy consumption for steel production.

Some key figures are presented in Table 1 to illustrate this.

Process	Energy (GJ/t product)				
	Actual Energy Requirements	Absolute Minimum	% Difference	Practical Minimum	% Difference
Liquid Hot Metal (5°oC)	13 - 14	9.8	25 - 30	10.4	20 - 26
Liquid Steel (BOF)	10.5 - 11.5	7.9	25 - 31	8.2	22 - 29
Liquid Steel (EAF)	2.1 - 2.4	1.3	38 - 46	1.6	24 - 33
Hot Rolling Flat	2.0 - 2.4	0.03	98	0.9	55 - 63
Cold Rolling Flat	1.0 - 1.4	0.02	98 - 99	0.02	98 - 99
18-8 Stainless Melting	—	1.2	—	1.5	—

Notes: Actual includes yield losses and is the average of state-of-art and less-efficient operations for the United States, Japan, and Europe. [illegible] In all cases, full credit is taken for the energy in off gas.

Table 1 Theoretical and practical energy requirement of different steelmaking routes

Source: Fruehan, US DoE, March 2000

Options for further reductions in energy consumption in the EAF are possible with improved electrical energy transfer, better post combustion practices and by preheating the scrap charge.

To reach this result no revolutionary breakthrough process is required but rather the simultaneous contribution of suitable advanced technologies and an intelligent management of the melting process.

Within this scope Tenova offers a number of important key technologies:

- **Consteel®** :Continuous scrap preheating and charging.
- **Koester® (KT) lances** : Tenova's proprietary lances for injecting oxygen and carbon to optimise the chemical package.
- **EFSOP®** : A highly reliable and well proven real time off-gas measurement and control system.

One of the most important pillars of Tenova's EAF energy and environmental optimisation is the reliability of the EFSOP flue gas analysis system. Every improvement is based on accurate measurement of the relevant off gas chemical composition and other process trends. First developed in Canada by Goodfellow, over the many years that EFSOP has been in service at a wide number of sites the reliability for off-gas analysis now averages 97% and for the closed loop control system 94%.

Considering 10 installations, the economic advantages of installing EFSOP presently range from $5.25 to $1.00

per tonne good billet averaging US$2.43/tgb (Fig 1).

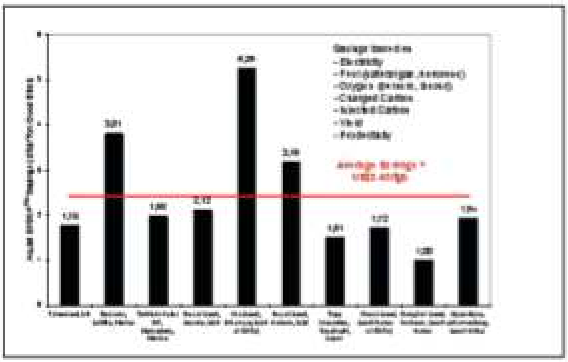


FIG : 1 The economic advantages of the EFSOP EAF melting control system

In October 2007 Tenova Goodfellow won the 2007 Award of Excellence of the Canadian Engineering community for the excellent results achieved with the EFSOP system installed at the Topy Industries Steelworks in Toyohashi, Japan.

Thanks to EFSOP installation, the Japanese steelworks achieved significant reductions in its environmental impact making significant savings in energy consumption. The performance of EFSOP resulted in an 18% reduction in CO2 emissions and a reduced use of non-renewable energy resources including a 45% reduction in kerosene consumption and 13% reduction in coal use.

One of the most recent EFSOP installations is at the Dalmine furnace in Italy, where Tenova's KT oxygen lances and KT carbon injectors are also installed. Thanks to the EFSOP control and optimisation system Dalmine together with Tenova is now implementing a dynamic process control in order to reach the end of the melting/ refining process in a given time, predetermining consumption of energy and the desired composition of steel and slag and at the correct temperature.

In the frame of energy savings Tenova Meltshop Business Unit obtains important results worldwide.

Other sites using EFSOP of special mention are ORI Martin (Italy) which is the first application of EFSOP control to a Consteel scrap heater and Gerdau Ameristeel Sayrville (USA) which uses both Consteel and KT lances.

Arvedi will be the first Customer to use EFSOP, Consteel and KT lances all together on the EAF of their new ESP direct casting and rolling plant presently under construction at Cremona, Italy to reach the best melting performances.

REHEATING FURNACES

For the reheating of cast billet, bloom or slab prior to rolling environmentally friendly combustion techniques are being supplied by Tenova.

In steel reheating furnaces thermal efficiency can be represented by means of the Sankey diagram and it is expressed by the ratio between the useful heat (to the charge) and the fuel input (Fig 2).

The main short term opportunities to energy saving and consequently

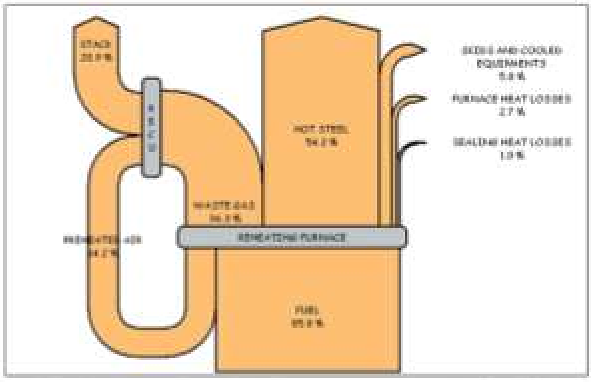


FIG : 2 A Sankey diagram for a reheat furnace expresses the ratio of useful heat to the charge to the fuel input

reduction of CO2 emission are from improving the combustion systems of large reheating furnaces.

Also in this case energy saving results not from breakthrough technologies but rather through the continuous development of existing combustion techniques.

Tenova LOI Italimpianti, with almost 50 years experience in furnace process improvements is answering customers' energy problems with a new generation of FlexyTech® furnaces equipped with its FlexyTech® burners.

The common approach to energy saving in the reheating furnaces has been to increase the air preheat temperature: a typical solution is the use of conventional regenerative burners. The drawback of this approach is increased NOx formation with its consequent environmental impact (Fig 3).

FIG : 3 NOx emissions and fuel consumption as a function of combustion air preheat

The Tenova LOI Italimpianti approach is to use 'flameless' combustion to minimise the environmental impact. The flameless combustion is achieved through designing the burner so that the mixing of fuel gas and combustion air is delayed with a high recirculation of the flue gases. The fading of the visible flame comes with the high temperature

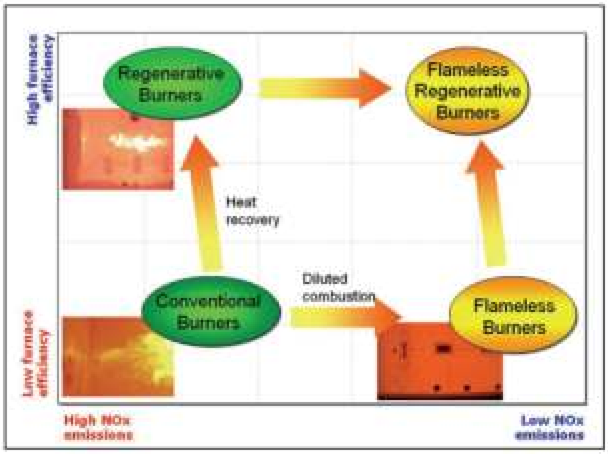


FIG : 4 Reducing NOx emissions by 'flameless' combustion

flame spots which are the main source of NOx formation Fig 4 illustrates the relationship between conventional burners and flameless.

FlexyTech TSX flameless burners offer the following performances:

- NOx emissions below 40ppm at 3%O2 in dry fuel gases;
- ultra-low CO emissions (below 5 ppm);
- no valves in hot air for staging;
- minimum excess air operations for maximum fuel efficiency;
- NOx emissions not dependent on turn-down;
- air preheating up to 550°C.

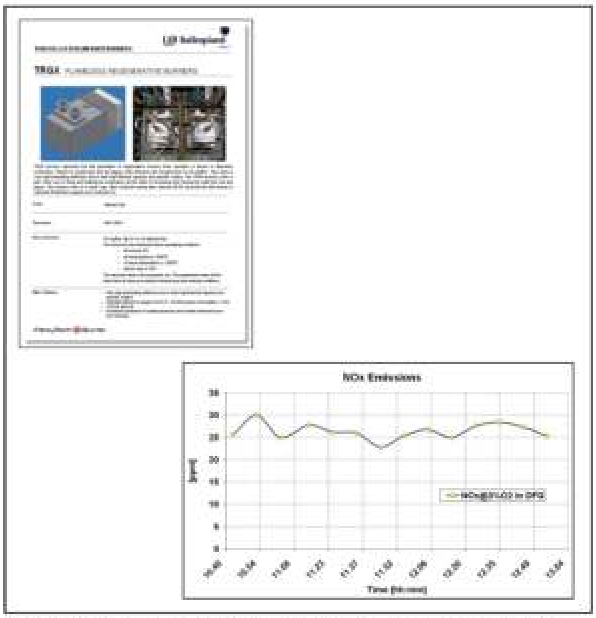


FIG : 5 NOx emissions at Georgsmarienhutte billet reheating furnace using 'flameless' combustion

These important successful results are confirmed from more than 1000 flameless burners installed in new furnaces or as replacements in existing furnaces.

Fig 5 plots NOx emissions measured at Georgsmarienhütte on their walking beam billet reheating furnace fitted with TSX flameless burners.

A step forward is achieved with TRGX regenerative flameless burners. This updated regenerative burner ensures maximum energy saving with minimum environmental impact: with reduction of NOx with respect to conventional commercial flame burners in which typical values are NOx <100ppm@3%O2 compared with <40ppm for TSX plus an energy saving of about 20% compared to conventional reheating furnaces equipped with a central recuperator.

Tenova regenerative flameless burners are available with thermal capacities from 1.5MW up to 5MW using natural gas or COG fuels.

HEAT RECOVERY

Both EAF and reheating furnaces loose a large amount of energy in cooling the furnace structures. In the EAF normally the fume ducts are water-cooled to cope with the very high temperatures (about 1700°C) and in many cases the energy transferred to the cooling water is simply lost into the environment.

The energy losses from the flue gases represent about 25% of the total input of energy considering the energy balance of a 150t EAF furnace (Fig 6).

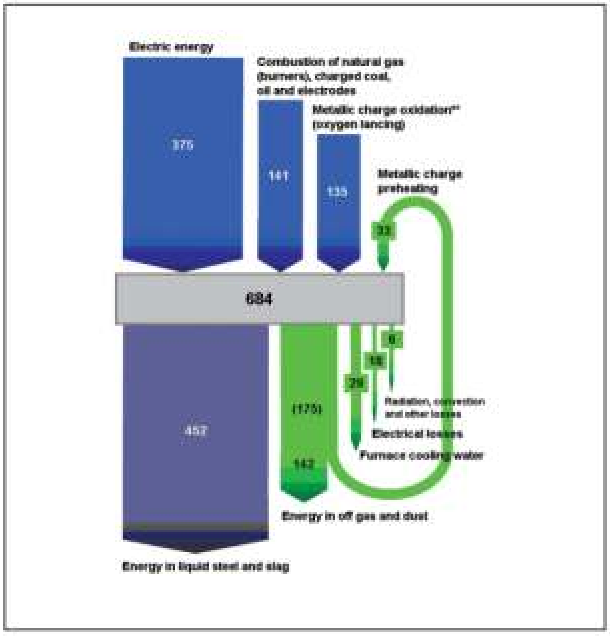
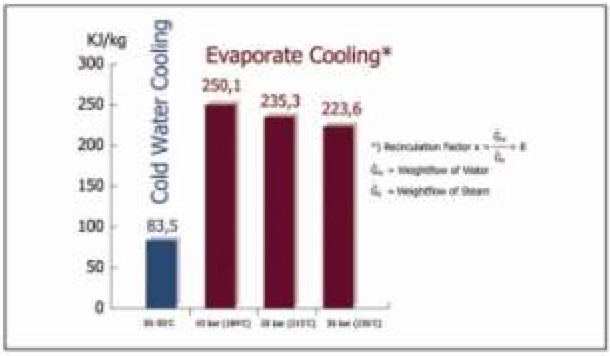
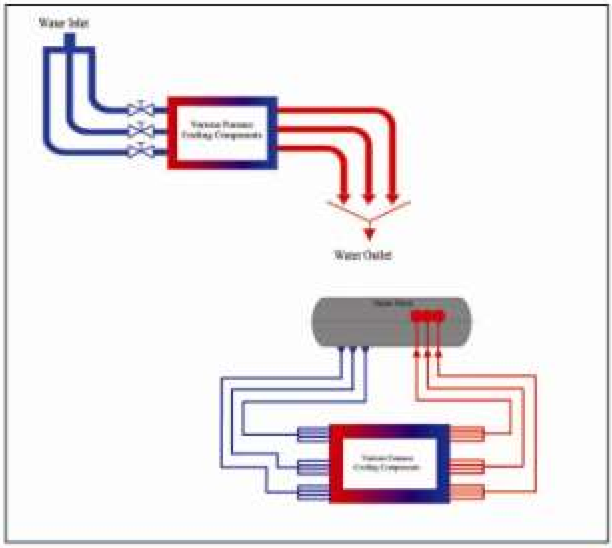


FIG : 6 Energy balance in an EAF (kWh/t)

In reheating furnaces the energy lost through cooling the skids is about 5% which, in an average walking beam furnace (150t/h) ranges from 3-6MW. Too many furnaces use cold water skid cooling without heat recovery. Some furnaces are equipped with a warm water cooling system in closed circuit with a heat exchanger to recover heat. A growing percentage of newly built furnaces cool the skids with evaporation and use the produced steam.





Plant type	EAF 140 t/h with cooled waste gas duct
[redacted]	
Duration of project	15 months
[redacted]	
Steam parameters (pressure/temperature)	13-20,5 bar saturated stem
[redacted]	

The principle of hot recovery is based on the production of steam that can be used as process heat, district heating or for hot water generation.

The investment costs of hot cooling are about 20% more than cold water cooling and will recover about 25% of the available energy. The investment costs of hot cooling are about 20% more

Furnace type	Tagliaferri EAF (1991)
[redacted]	
Tapping system	EBT – swiveling flap
[redacted]	
Roof swinging system	Rail and pivot on independent foundation
[redacted]	
Transformer	100 MVA (500/1000 V)
[redacted]	
Regulation system	TDRH with harmonics control
[redacted]	
Carbon injectors	Three KT carbon injectors
[redacted]	
Automation	Level 1 and level 2 by Tenaris Dalmine

than cold water cooling and will recover up to 90% off the energy otherwise lost in the waste gas duct. This leads to an amortisation period of currently 2-3 years.

Tenova, through its sister company Techint Italimpianti Deutschland Gmbh in Düsseldorf, recently received some important orders for hot cooling: one for a 250t/h walking beam furnace at Thyssen Krupp Steel Bochum, and the other for a 140t/h EAF at Georgesmarienhütte.

The steam produced at ThyssenKrupp is used in the internal network. In Georgsmarienhütte at least 12t/h of steam will be fed into the plant's steam network or led directly to the vacuum degassing process. Table 2 summarises the recovery system to be employed on the Georgensmarienhütte EAF flue gas ducting.

Table 2 Steam generated from evaporative cooling EAF ducting at Georgensmarienhütte

Plant Type	140t/h EAF with cooled flue gas duct
Year of completion	2008
Duration of project	15 months
Steam collected	12t/h
Steam pressure	13 – 20.5 bar saturated

Tenova is truly committed to find solutions for its customers that meet energy recovery and environmental constrains. This is obtained through continuous improvement using in-house R&D as well as the integration of some important acquisitions of technologies.

CONTACT :
Tenova, R&D , Via De Marini, 53 16149 Genova, Italy Tel +39 010 6054871
Fax +39 010 6054926, e-mail: carlo.raggio@it.tenovagroup.com