CELSA NORDIC IN MO I RANA (NORWAY): RESULTS OF THE EAF CONSTEEL® START UP[1]

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Abstract

In 2007 Celsa Nordic, part of Celsa Group, one of the most diversified European private steelmaking groups, has decided to upgrade its Mo I Rana Norwegian plant installing a new Tenova EAF-Consteel®. The new EAF will keep either the same nominal capacity of the existing furnace (83 ton). Thanks to the installation of the Consteel® continuous scrap charging technology, the new EAF will increase its productivity by 30% passing from the actual 700.000 to 900.000 ton per year although, with the existing transformer and decreasing the consumption considerably. In spite of the increase of productivity the upgrade with the Consteel® will guarantee a tremendous reduction of the environmental impact. This paper summarizes the results achieved in 2009 and the practices used to manage the melting process.Moreover the paper describes the new innovative fume dedusting system designed by Tenova for Mo I Rana plant in order to further low the emissions.

Keywords: Consteel®; Electric arc furnace; Continuous scrap charge; Fume treatment plant; Heavy metal recovery unit.

Resumo

Em 2007 a Celsa Nordic, parte do Grupo Celsa, um dos mais diversificados grupos siderúrgicos privados europeus, decidiu atualizar sua planta norueguesa Mo I Rana instalando um novo FEA-Consteel® da Tenova. O novo FEA manterá a mesma capacidade nominal do forno existente (83 ton). Graças à instalação da tecnologia de carregamento contínuo de sucata Consteel®, o novo FEA aumentará sua produtividade em 30%, passando de 700.000 para 900.000 toneladas anuais, porém com o transformador existente e diminuindo o consumo consideravelmente. Apesar do aumento da produtividade, a atualização com o Consteel® garantirá uma enorme redução do impacto ambiental. Este trabalho resume os resultados alcançados em 2009 e as práticas utilizadas para gerenciar o processo de fusão. Este trabalho também descreve o novo sistema de despoeiramento inovativo projetado pela Tenova para a planta de Mo I Rana para reduzir as emissões.

Palavras-chave: Consteel®; Forno elétrico a arco; Carregamento contínuo de sucata; Planta de tratamento de gases; Unidade de recuperação de metais pesados.

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Introduction

The Celsa Armeringsstål plant located in Mo I Rana, Norway, is part of Celsa Group, one of the most diversified European private steelmaking groups, and their main products are rebar and low alloyed carbon steel grades. In 2007 they have decided to upgrade its plant installing a new Tenova EAF-Consteel®.
The previous furnace was an EAF conventional top charge of a nominal capacity of 83 ton. The injection system was composed by a door manipulator with two consumable oxygen pipes and one carbon pipe.
The main purpose of this installation is: reduce production costs, increase productivity and minimize the mercury emissions at the stack.
The scope of work has been to install the new EAF with the Consteel® continuous charging system, the KT injection system and a new primary fume treatment plant with activated carbon system.

Figure 1: Celsa Armeringsstål EAF before revamping with the door manipulator.

The new EAF will keep the same heat size of the existing furnace with a 130 tonn capacity including the hot heel.

Installation of the EAF Consteel®

The main equipment is a Consteel® system, coupled with a Tenova EAF shell complete of KT.
The new EAF maintains the same size of previous furnace. The total capacity is 130 tls, including the hot heel (35-40 tls) for the Consteel® process.

Table 1: main Tenova EAF data

EAF DATA	
HEAT SIZE	83 (90) tls
EAF CAPACITY	123 (130) tls
EAF DIAMETER	6300 mm
EAF TRANSFORMER POWER	75 MVA
ELECTRODE DIAMETER	600 mm
PITCH DIAMETER	1225 mm

The Tenova EAF is equipped with the KT injection System constituted by 3 KT oxygen lances and 2 KT carbon lances coupled with the oxygen lances, with a carbon flowrate of 60 kg/min for each injectors..
Oxygen injection into the EAF is done with 3 fixed water-cooled sidewall lances (KT lances). The lances are equipped with a converging / diverging type of nozzle to deliver an oxygen jet with supersonic speed. The nozzle design is specifically adjusted to the inlet pressure and the design flowrate. Additionally, the jet is shrouded by a gas / oxygen flame to tighten the jet and thereby increase the jet length. The KT control system is designed to automatically turn each of the oxygen injectors on and off based on a set of programmed recipes.
KT® Oxygen Lances work during all Power On time, producing a homogeneous distribution of oxygen and adding chemical energy with a high efficiency in the cold spots of the furnace.
During flat bath operation KT® Oxygen Lances continue the supersonic oxygen injection, to complete the decarburization of the bath. The peculiar installation in the slag line, with a fixed vertical and horizontal angle, favours the natural movement of the bath due to the arc electromagnetic field. In this stage of the melting process, carbon injection is used to foam the slag, stabilising the arc and maximising its energy transfer efficiency to the bath.
KT® Carbon Injectors are installed below the panels, in the slag line and above the level of the bath. The aim is to protect the hot spots, where the electrode radiation is higher. The carbon injection is thus realised to reduce refractory wear, to improve the formation of the foamy slag, which enhances the electric arc energy transfer and, finally, to reduce electrode oxidation.
Three oxygen lances are installed, one capable to inject 3000 Nm^3/h and the other two to inject each 2500 Nm^3/h of oxygen with a pressure of 13.5 bar.

Table 2: KT injection system data in May 2009

3 KT OXYGEN LANCES	
Main Oxygen flowrate:	2 x 2500 Nm3/h, 1 x 3000 Nm3/h
Propane max flowrate (burner mode):	300 Nm3/h
Oxygen inlet pressure:	approx 13.5 bar
installation:	43° from the horizontal
2 KT CARBON INJECTORS coupled with the oxygen lances	
Flowrate up to 60 kg/min per injector	

Consteel® Installation

The Consteel® process is well known and will only be briefly described here. Scrap is loaded on to the conveying system and travels toward the furnace. In the last conveyor section, the scrap enters the preheater tunnel, in which gases leaving the furnace flow over the metallic charge. Chemical and sensible heat in the gases is transferred to the charge in a manner similar to that of counter flow heat exchanger.
An important feature is that there is never any solid scrap present in the furnace. Melting takes place with the electrodes always working on a flat bath. The scrap is not heated by the arc but by the pool of liquid steel in the vessel. Thus the process is quite different from the operation of a batch-type, top-charged furnace.

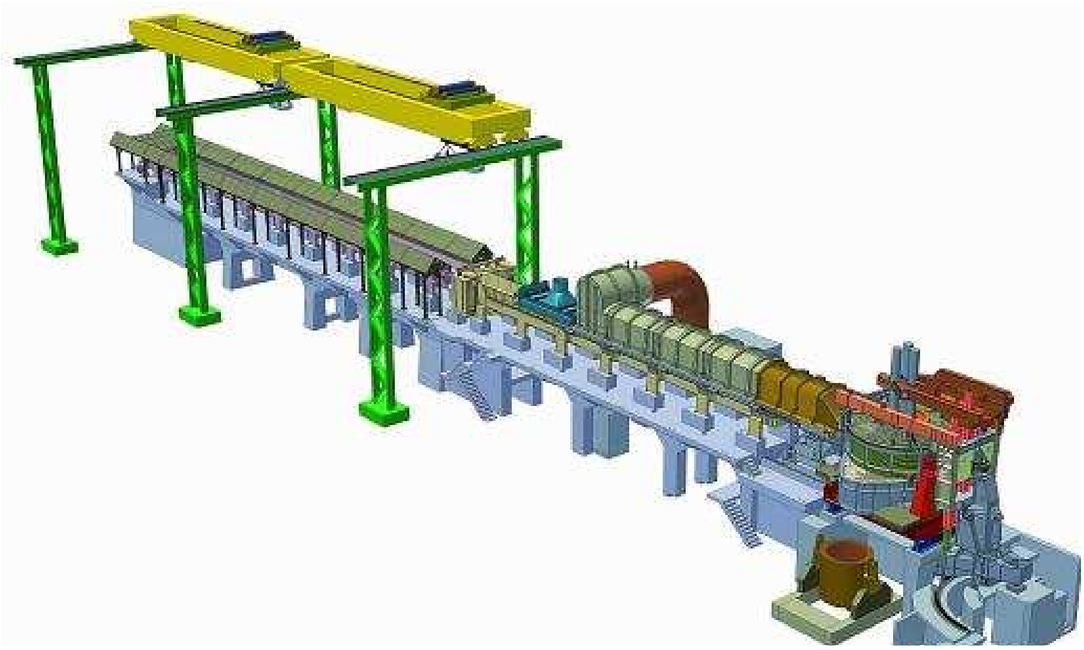

Figure 2: Scheme of Consteel® system.

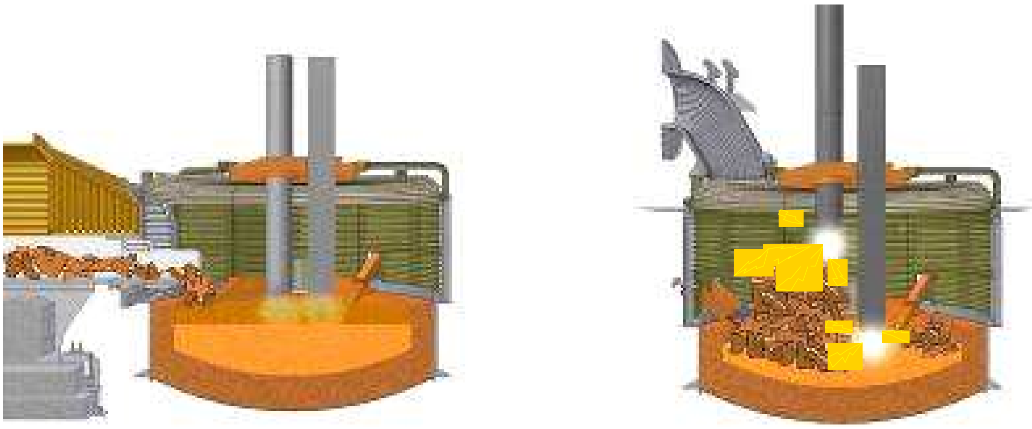

Figure 3: Comparison of batch, top-charge melting and CONSTEEL® melting.

The foamy slag covering the arc shields the furnace wall and roof from heat radiation. The arc is stabilised, thus dramatically increasing the efficiency of heat transfer from arc to steel bath. This minimises 'flicker' effects on the power supply network. With the arc covered by slag, the melting process is a much less noisy operation than in the case of an arc that is not covered.

The Consteel® installed in Celsa Armeringsstål is composed by a charging section and a preheating section moved by an end drive and a split drive.

Figure 4: The Consteel® in Celsa Armeringsstål.

This Consteel® has a total length of 75 m and is provided by a static seal for the draft air sealing. The system feed the EAF with 100% of solid scrap.
The scrap is charged on the Consteel® charging area with cranes disposed in longitudinal way respect to the Consteel®.

Table 3: main data of the Consteel® in Celsa Armeringsstål

CONSTEEL DATA	
CHARGING CONVEYOR LENGHT	approx 40 m
PREHEATING CONVEYOR LENGHT	approx 35 m
CONVEYOR WIDTH	2000 mm
CONVEYOR HEIGHT	800 mm
SCRAP MIX	100% solid scrap
SCRAP DENSITY	approx 0.7 t/m3
CONSTEEL DRAFT AIR SEALING	STATIC SEAL + RUBBER SEAL

EAF Consteel® performances

Thanks to the Consteel® installation and the new process, Celsa Armeringsstål has achieved excellent results.
The Consteel® continuous charging system allows to increase the productivity of the furnace without change the heat size.
Celsa Armeringsstål has increased his productivity from 134 tls/hP.on to 163 tls/hP.on, with an increasing of 20%.

Table 4: main performances data reached in Celsa Armeringsstål

	2007	*Consteel performance tests*
PRODUCTIVITY:	134 tls/h P on	163 tls/h Pon
POWER ON TIME:	36 min	32.6 min
POWER OFF TIME:	9.9	8.1
HEAT SIZE:	80.4 tls	89 tls
ELECTRICAL CONSUMPTION:	474.6 kWh/tls	383.7 kWh/tls
OXYGEN CONSUMPTION:	21.6 Nm3/tls	26.2 Nm3/tls
PROPANE CONSUMPTION:	-	approx 0.7 Nm3/tls
CARBON CONSUMPTION:	5.5 kg/tls	6.1 kg/tls

There are two main characteristics that make the Consteel® system different from most of the other technologies available for melting scrap in the EAF: the preheating and the continuous charging. Preheating the charge is very helpful to reduce the energy consumption of the EAF.
The continuous charging has shown even more benefits resulting in a fast payback and beneficial environment conditions in light of:

- Low production costs
- High productivity
- Flexibility
- Reduced environmental impact
- Personnel safety

Charging continuously means to distribute the scrap charge along the whole power-on period. The buckets are not used, and the conveyor feeds the scrap from the yard directly into the EAF. The EAF roof is always closed and the gas suction is constantly performed from the primary circuit, not by the canopies of the secondary circuit. In the furnace the scrap melts by immersion and the electric arc is working on flat bath covered by the foamy slag.
The EAF control system adjusts automatically the conveying speed to maintain the steel bath at the target temperature and controls the oxygen and carbon injection to maintain the proper foamy slag.

Fume treatment plant installation

Cause to the strict environmental legislation and the high Mercury emission, Celsa Armeringsstål decided to revamp his primary fume treatment plant.
After a detailed study of the existing system, due also to the need of installing a new device for the filtering of heavy metals from the fumes on the primary circuit, the revamping of the system will be performed as follows:
1. Primary flow: a complete new system from the outlet of Consteel® system
2. Secondary flow from canopy and LF suction line is not modified.
The fumes flow sucked by the Consteel® is lower than a traditional top-charge furnace, the same is for the secondary fumes flow rate; as a matter of fact the considerable quantity of fumes generated during the bucket charging operation will be avoided.
A small sucking flow from a new canopy hood during melting operation is kept to capture the residual fumes coming from the furnace.
In the new layout concept:

- The existing secondary suction system (canopy, piping…) is not changed.

- A new system (complete with new bag house) is installed to treat fumes coming from the primary side (Consteel® fumes exit). It replaces completely the existing primary old suction filter.
- The primary system is connected to a device based on active carbons technology to absorb the content of heavy metals and dioxins in the fumes
- The primary circuit is designed in a way to allow the future installation of a boiler for the production of hot water or steam

The fumes coming out of the Consteel®, are carried into the post-combustion chamber and then, after about 50 m of ducts, are conveyed to a natural cooler.

The natural air cooler, with a total surface of 2700 m², reduces the inlet temperature from 500 ℃ to about 200 ℃ .

Then the gases will be mixed with fresh air, in order to reduce again the temperature to 120 ℃.

The temperatures of entry to the filter don't exceed the 120 ℃ and the dust emission, with temperatures among the 120-110 ℃, are less to 3 mg/Nm³ at baghouse outlet.

Figure 5: the new primary fume treatment plant.

Heavy metals adsorption equipment

In order to reach the required parameters regarding heavy metals concentration in off gases, new equipment working with activated carbon is installed in series to primary line after fans and before the chimney.

The fumes flow downstream from the top of the system to the bottom.

The equipment is dimensioned for a flow of 215.000 Nm3/h of gases at 120 ℃. It is composed by a set of 6 absorbers 3200 x 12000 mm made in stainless steel. These absorbers are filled by 60.000 kg of activated carbon.

Figure 6: the heavy metal recovery unit

In Figure 7 are shown the mercury emissions in the atmosphere, in one month, before (in blue) and after the new fume treatment plant installation (in purple)[1].
It is noticeable how there is a strong reduction in mercury emissions after the installation of the new plant.

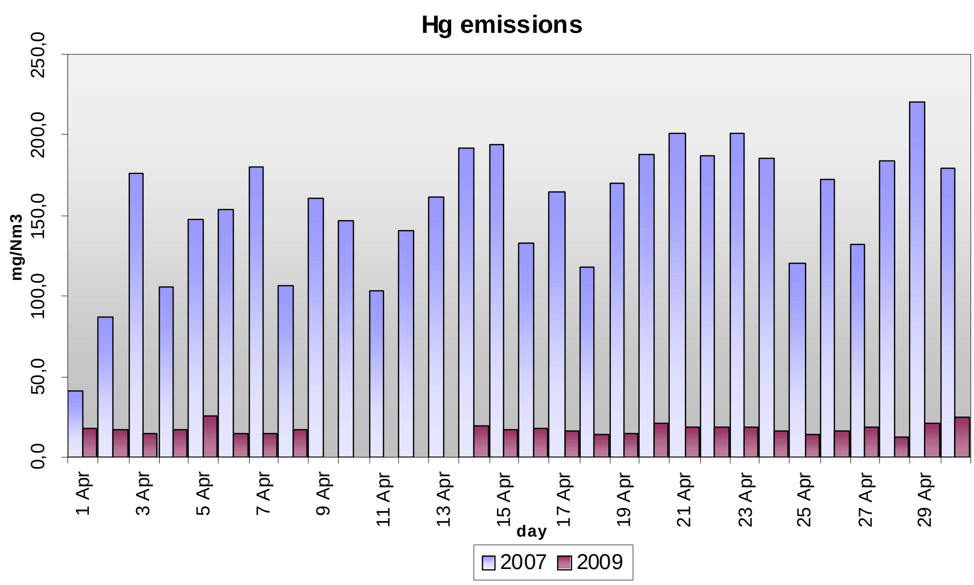

Figure 7: Hg Comparison before anf after the installation of the new plant.

The Figure 8 shows the mercury emission in 2009 in a month base. In purple are indicated the quantity of emissions in each month, while in blue is indicated the cumulated quantity.
The dotted line represents the cumulated limit in one year for the mercury emission based on the local legislation.

[1] The graph doesn't show the data from 9th April 2009 to 13th April 2009 because in that week the steelplant was close.

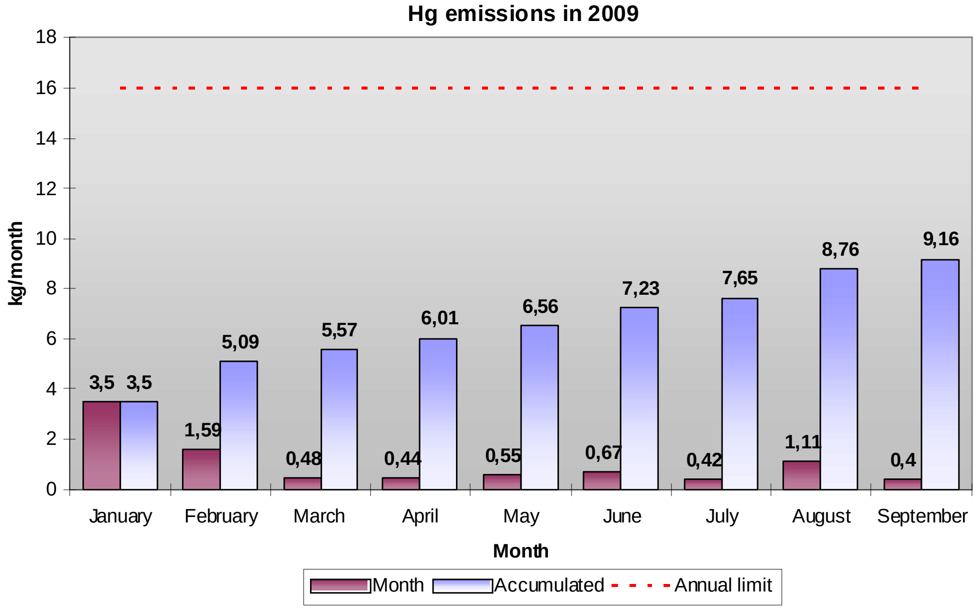

Figure 9: Hg emissions in 2009.

The actual limit is 16 kg/year of mercury emissions.
Before the installation of the new primary fume treatment plant the mercury emissions were approximately 80-113 kg/year.
Another important benefit coming from the Consteel and the fume treatment plant is the effect on dust emissions from both primary and secondary chimney.
As shown in the Figure 10 there is a strong reduction of dust emission from the primary chimney (in blue) after the Consteel installation. The effect of Consteel process is added to effect of new primary fume treatment plant.
In fact in a study of the Centre for Material Production and the Steel Manufacturer's Association about the methods to reduce the volume of dust generated during steelmaking, the Consteel® process, as one of the best preheating technologies, was proven to reduce dust discharged from the furnace by eliminating back charge.
In fact, as far as the Consteel® EAF does not require the basket charge, it permits the Dedusting system to minimize its size, reducing the associated cost of the off-gasses equipment in case of Greenfield plants or avoiding additional expenses in case of increase of productivity.
Then, if one considers that the preheating tunnel has a larger section than a normal off-gas duct, the fumes speed in the Consteel® tunnel section is much lower than in a fourth hole elbow. The big particles of dust are falling on the scrap laid on the bottom of the tunnel, and then taken by the scrap back into the furnace. This means that there is a recycling of part of the dust, the biggest particles, which can be estimated between 20 and 30 percent of the total EAF dust production, meaning a considerable reduction of this big environmental cost.
In the graph are shown also the data of dust emissions from the secondary chimney. In this case the improvement is due only to the Consteel® process. In fact the secondary fume treatment plant has not been changed. The reduction of dust emissions is due to the fact that with the Consteel® process is avoided the big dust generation during the buck charging.
Another important thing to notice is that after the Consteel® installation the productivity is increased, and this didn't have effect on the positive dust reduction.

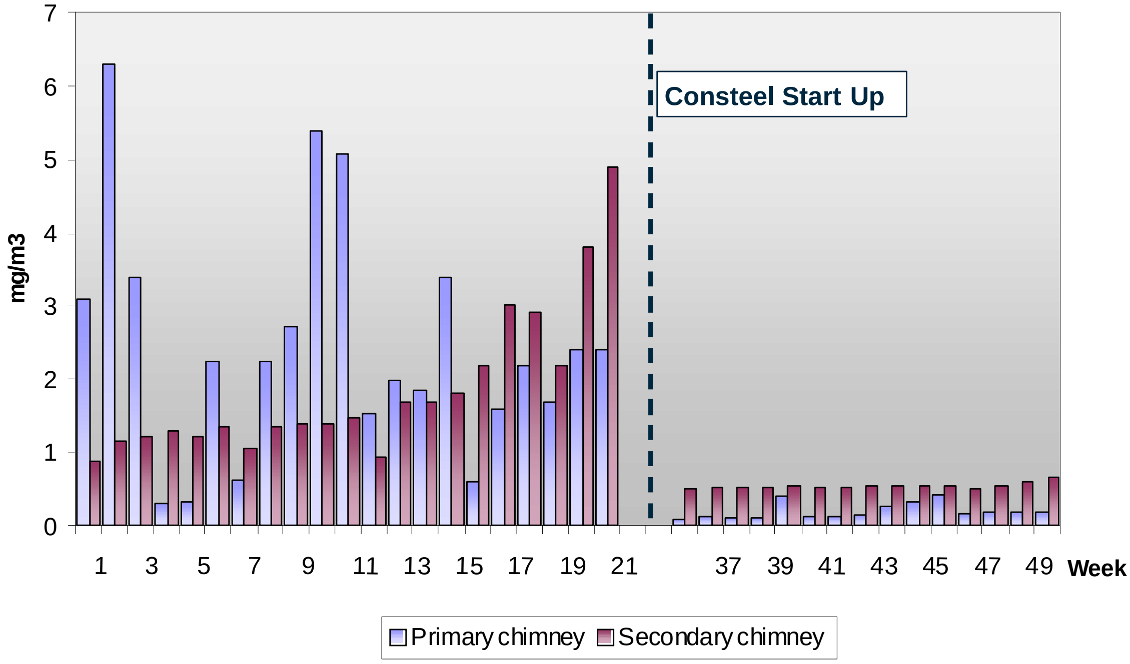

Figure 10: Dust emissions before and after the Consteel® start up.

Conclusion

The installation of the Tenova Consteel® system has enabled Celsa Armenigsstal to increase the productivity, passing from 700.000 to 900.000 t, to meet high standards of environmental protection, and to minimise disturbance to the power supply network.
Celsa Armeringsstål revamps also the furnace with the Tenova EAF, that maintains the same heat size of previous furnace. The new EAF is equipped with 3 KT oxygen lances and 2 KT carbon injectors.
Another development is the installation by Tenova of a new primary fume treatment plant equipped with a heavy metal recovery unit. This plant allows to achieve a big reduction of emission of mercury in accordance with the environmental-friendly policy.

BIBLIOGRAPHY

1 BIRAT, J.P. A futures study analysis of the technological evolution of the EAF by 2010, Irsid-Usinor Recherche, **La Revue de Métallurgie**-CIT, p. 1355, Nov. 2000.
2 WORRELL, E., MARTIN, N., PRICE, L. Energy Efficiency and Carbon Dioxide Emissions Reduction Opportunities in the U.S. Iron and Steel Sector, LBNL-41724, **Energy Analysis Department**, Environmental Energy Technologies Division, Ernest Orlando Lawrence Berkeley National Laboratory, University of California, Berkeley, pp. 9-11, pp. 20-29, July 1999.
3 DE MIRANDA, U., DI DONATO, A., VOLPONI, V., ZANUSSO, U., ARGENTA, P., POZZI, M Scrap continuous charging to EAF, ISSN 1018-5593, no20883 European Commission, Luxembourg, pp. 1-41, 2003.
4 CONSIDINE, T., JABLONOWSKY, C., CONSIDINE, D.M.M., RAO, P.G. The Industrial Ecology of Steel, Final Report to Office of Biological and Environmental Research, US Department of Energy, Award No.DE-FGO2-97ER62496, Pp 15-16, March 26, 2001.
5 VALLOMY, J.A., FALLON, C. Continuous Melting in EAF – A Way to Minimize Flicker and Harmonics, **MPT Metallurgical Plant and Technology International** (Germany), Vol. 20, No. 4, pp. 94-101, Aug. 1997.

6 SANWU, W., SHOUJUN, Z., RISHENG, T. Application of Hot Metal Charging for 90t Consteel- EAF at SGIS, Consteel® International Symposium Proceedings, Metallurgical Industry Press, Beijing, pp.39-41, 2004.

7 BRADLEY; J.G., PAGE, H.L., KEATIN, D.E., BROWN,T., GUZY,S.D., Wheeling-Pittsburgh Steel, Mingo Junction plant : Revitalized with a new continuous steelmaking process, **Iron & Steel Technology**, vol. 2, no6, pp. 29-45, 2005.