RECORD IN PERFORMANCES WITH EAF CONSTEEL® TECHNOLOGY – THEP VIET (VIETNAM) MELT SHOP CASE[1]

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Abstract

In 2005 Thep Viet Steel Group started a new project for a greenfield melt-shop based on the energy saving Consteel® system, in the Phu My area, 60 Km away from Ho Chi Minh City, Vietnam. The project consisted of a complete melt-shop with a 60ton EAF-Consteel®, with Ladle Furnace, Continuous Casting Machine and auxiliaries; the target yearly production was 360,000 ton of rebar and low alloyed carbon steel. Despite the personnel with almost no experience in steel-making the development of the project has shown a remarkably short learning curve: the design hourly productivity of 70.6 tgb/hour of Power on time was reached in a steady state condition during the first half year, and in the first eight months of 2009 the production was more than 30% higher if compared with the same period in 2008, mainly thanks to the installation of 2 additional KT lances to increase the process efficiency and melting capacity. Starting from the description of the adopted solutions and the practices used to manage the melting process, this paper summarizes the results achieved during the commissioning phase in 2009. Total energy cost, increased yield, easy operation, better efficiency, low disturbances on the electrical network and flexibility with scrap have been all key-factors for record in performances achievement; the productivity of 2.54 tgb/h/MW on a monthly base is absolutely outstanding. Thanks to the excellent results achieved in this first melt-shop, Pomina and Thep Viet Steel Group had no doubts in pursuing with the Consteel® technology even for the new melt-shop project to be installed within 2011, with a foreseen tapping size of 120 ton and a yearly production of 1,000,000 tons of liquid steel. This installation, which will become the largest steel melt shop in Vietnam, strengthens a leading trend in this country with four of the latest steel projects adopting Consteel® technology.

Keywords: Consteel®; Electric arc furnace; Continuous scrap charge; Energy savings; Productivity increase.

Resumo

Em 2005 o Grupo Thep Viet Steel iniciou um novo projeto para uma aciaria totalmente nova baseada no sistema economizador de energia Consteel®, na área de Phu My, distante 60 km da cidade de Ho Chi Minh, Vietnã. O projeto consistiu em uma aciaria completa com um FEA-Consteel® de 60 t, um Forno Panela, uma Máquina de Lingotamento Contínuo e auxiliares, objetivando uma produção anual de 360.000 t de vergalhões e aço carbono baixa liga. Apesar da equipe com quase nenhuma experiência em fabricação de aço, o desenvolvimento do projeto mostrou uma curva de aprendizado notavelmente rápida: a produtividade horária projetada de 70,6 t de bons tarugos/hora de tempo de Power on foi alcançada sob condições estáveis no primeiro meio ano, e nos primeiros oito meses de 2009 a produção foi mais de 30% superior ao mesmo período de 2008, principalmente devido à instalação de 2 lanças KT adicionais para aumentar a eficiência do processo e a capacidade de fusão. Iniciando com a descrição das soluções adotadas e das práticas utilizadas para gerenciar o processo de fusão, este trabalho resume os resultados alcançados durante a fase de comissionamento em 2009. O custo total de energia, o maior rendimento, a operação mais fácil, a melhor eficiência, baixas perturbações na rede elétrica e a flexibilidade com a sucata têm sido todos fatores chave para recordes em desempenho; a produtividade de 2,54 t de bons tarugos/h/MW em uma base mensal é absolutamente marcante. Graças aos excelentes resultados obtidos nesta primeira aciaria, o Grupo Pomina e Thep Viet Steel não tiveram dúvidas em seguir com a tecnologia Consteel® mesmo no projeto da nova aciaria a ser instalada em 2011, com um peso vazado previsto de 120 t e uma produção anual de 1.000.000 t de aço líquido. Essa instalação, que será a maior aciaria do Vietnã, reforça a tendência líder neste país com quatro dos últimos projetos de siderurgia com a tecnologia Consteel®.

Palavras-chave: Consteel®, Forno elétrico a arco; Carregamento contínuo de sucata; Economia de energia; Aumento de produtividade.

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1 Introduction

Despite the international crisis, Vietnam is going on increasing the investments in a lot of industrial affairs, included steel making plant projects.
This country is keeping the same model already covered by China, developing as much as possible the internal market and economy.
This strategy has been a winning bet, being the only countries with an economic growth (China up to 9% and Vietnam up to 6% in 2009) in a general worldwide crisis scenario.
As in China, in Vietnam there are both cases of investors attracted by the “advanced western design/product”, to assure the best performances and a competitive cost in the tough steel market, and "China oriented" investors with very low prices and poor performances due to the cheap and old fashion design.
The growing Vietnamese market is open to both the solutions.
Tenova is working following both these two alternatives: sometimes supplying a full melting equipment package guaranteeing high performances, some other times supplying only key components (TDR Digital Regulation or Consteel® System) so as to “qualify” the rest of the cheap equipment – usually coming from China – and reach the high performances value required by new “western design” equipment.

2 Thep Viet Steel project

In the last years the increase of environment-related problems has generated the need of a more conscious approach to the exploitation of natural resources and the release of pollutant in to the environment.
Following the worldwide trend, even in Vietnam the legislators are now enforcing new laws aiming at the reduction of the impact of the present activities keeping in mind the concept of sustainable development as a development meeting present generations’ needs without hampering future generations’ possibility to satisfy their needs.
For this reason the whole Thep Viet Steel melt shop project had to comply with the Vietnamese government plan for the optimization of Ho Chi Minh industrial area.
Basically this project has been managed with an environmental friendly overview, focusing on:

- achieve a clean working environment,
- keep low noise emissions,
- control emissions,
- reduce dust generation,
- minimize disturbances on electrical network.

On the other side competition and global markets are increasing the economical challenges for the steelmakers and force them to look for reduction of their production costs.
The Consteel® system with continuous scrap charge operation is the best solution considering the local scrap density as low as 250 kg per cubic meter. With these values the only alternative would be a charge with five buckets and consequently long tap to tap times, besides high electrical consumptions.
Following this policy, the main goals of this project have been:

- minimize the production costs,
- maximize productivity at the lowest contracted electrical power.

3 The Consteel® system – General overview

The Consteel® system performs the continuous charging of scrap in the EAF by means of a conveying system that connects the scrap yard to the EAF. With the Consteel® system, scrap is loaded onto conveyors by the scrap yard cranes (Figure 1). Then the conveyors move the scrap, and the conveying surface oscillates forward slowly and backward faster. This movement allows the scrap to move together with the conveyor during the forward stroke, while the scrap slides over the surface when the conveyor oscillates back. The end result is the movement of the scrap towards the furnace.

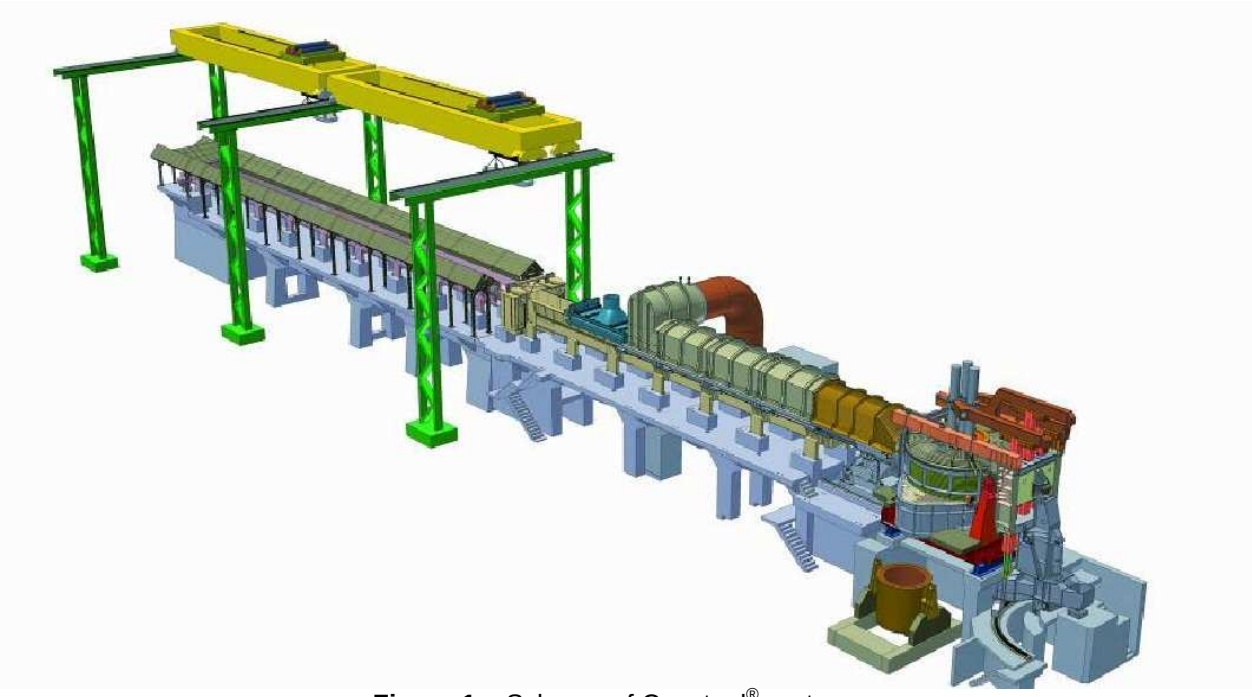

Figure 1 – Scheme of Consteel® system

Before reaching the furnace the scrap enters the preheating section, in this area the scrap is heated-up by the hot gases exiting the EAF that are moving in the direction opposite to the scrap.
In the preheating section the carbon monoxide in the exhaust gas is oxidized by an automatically controlled injection of air, allowing more energy to be recovered by the system.
During the continuous feeding operations the steel bath in the EAF is kept constantly liquid and the scrap entering the furnace is melted by immersion. The electric arc is working on a liquid bath, not on solid scrap. In this situation the arc is stable and it is not affected by the presence of solids like in the case of batch charges (with or without preheating) (Figure 2).
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.
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.

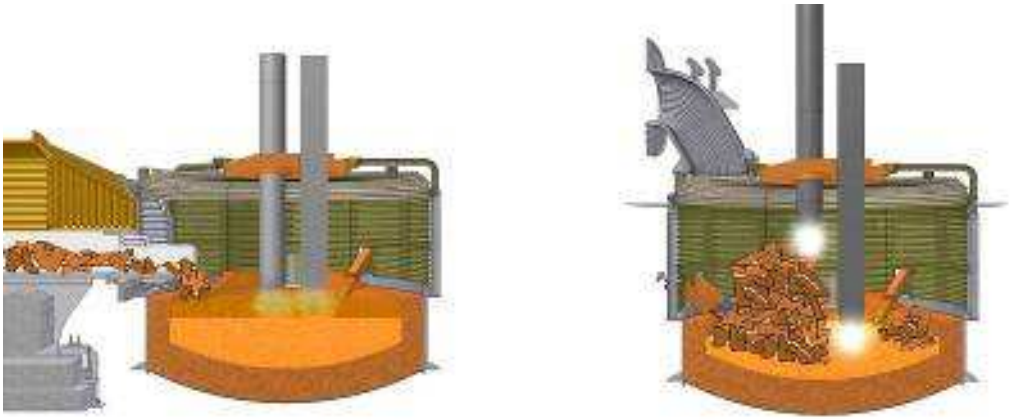

Figure 2 –Section of the EAF Consteel® system and the top charge EAF

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.
Preheating the charge is very helpful to reduce the energy consumption of the EAF.

4 Thep Viet – The first Consteel® project

The first Consteel® project in Thep Viet Steel Plant has been started up in August 2007.
Mainly the project consisted of a complete melt-shop with a 60ton EAF-Consteel®, with Ladle Furnace, Continuous Casting Machine and auxiliaries; the target yearly production was 360,000 ton of rebar and low alloyed carbon steel.
Here below the Electrical Arc Furnace and Consteel® main technical data and layout arrangement (Figure 3).

EAF DATA	
HEAT SIZE	60 tls
EAF CAPACITY	85 tls
EAF DIAMETER	5400 mm
EAF TRANSFORMER POWER	33+10%MVA
ELECTRODE DIAMETER	500 mm
PITCH DIAMETER	1100 mm

CONSTEEL® DATA	
CHARGING CONVEYOR LENGHT	approx.22 m
PREHEATING CONVEYOR LENGHT	approx.25 m
CONVEYOR WIDTH	1600 mm
CONVEYOR HEIGHT	770 mm
SCRAP MIX	90% scrap + 10% pig iron
SCRAP DENSITY	approx.0,5 t/m^3
CONSTEEL® DRAFT AIR SEALING	STATIC SEAL + RUBBER SEAL

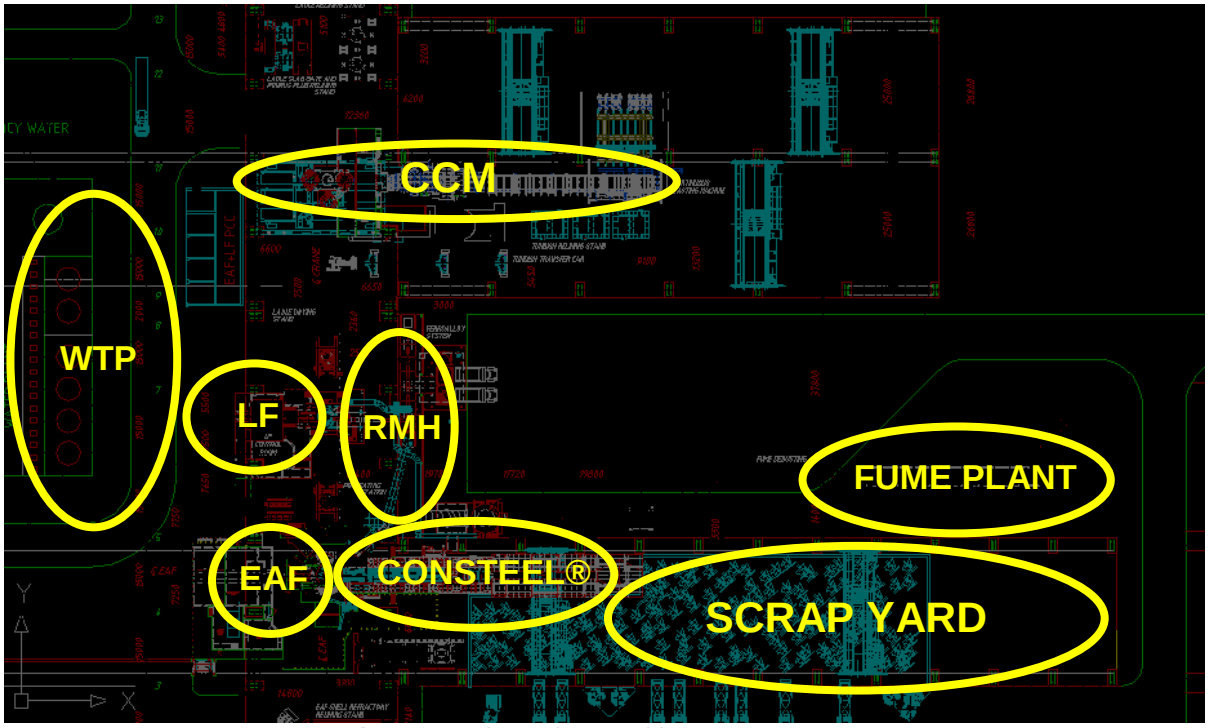

Figure 3 –Thep Viet Steel layout arrangement

All the characteristics of the equipment has been designed properly to guarantee all the customer's targets, considering also that the new steel plant would be a greenfield plant with low experienced personnel.

EAF + Consteel® process has been developed starting from all the customer requirements, first of all necessity to limit as much as possible the electrical disturbances introduced into the network. For this reason the transformer has been designed with 0.6 MVA/tls and the process has been set to favoured the chemical energy.

With the Consteel® process the use of the chemical energy inside the furnace permits to reach better vantages if compared with traditional EAF, as the fumes produced with the oxidation reactions inside the furnace are exploited in the preheater, to give up more energy to the scrap before it entered into the furnace.

To maximize the efficiency it's necessary to balance as much as possible the scrap mix, the additives, the oxygen and carbon injected into the furnace, taking care of refractory life and equipment reliability.

A key factor for the chemical set up of the furnace has been the low quality – with very high silica content – of the carbon available on the plant.

As first consequence it was necessary to increase a lot the amount of slag formers to be charged into the furnace, so as to have a slag with the proper metallurgic characteristics to remove the phosphorus and to protect the refractory life.

A dedicated additives charge mix has been managed thanks to the level 2 control system based on the scrap charge progress; in this way it's possible to have slag with constant characteristics along all the scrap charge period.

The results achieved thanks to this tailor made process are respectfully, both for energy, productivity and life of the refractory.

Despite the personnel with almost no experience in steel-making, the development of the project has shown a remarkably short learning curve: the design hourly productivity of 70.6 tgb/hour of Power on time was reached in a steady state condition during the first half year (Figure 4).

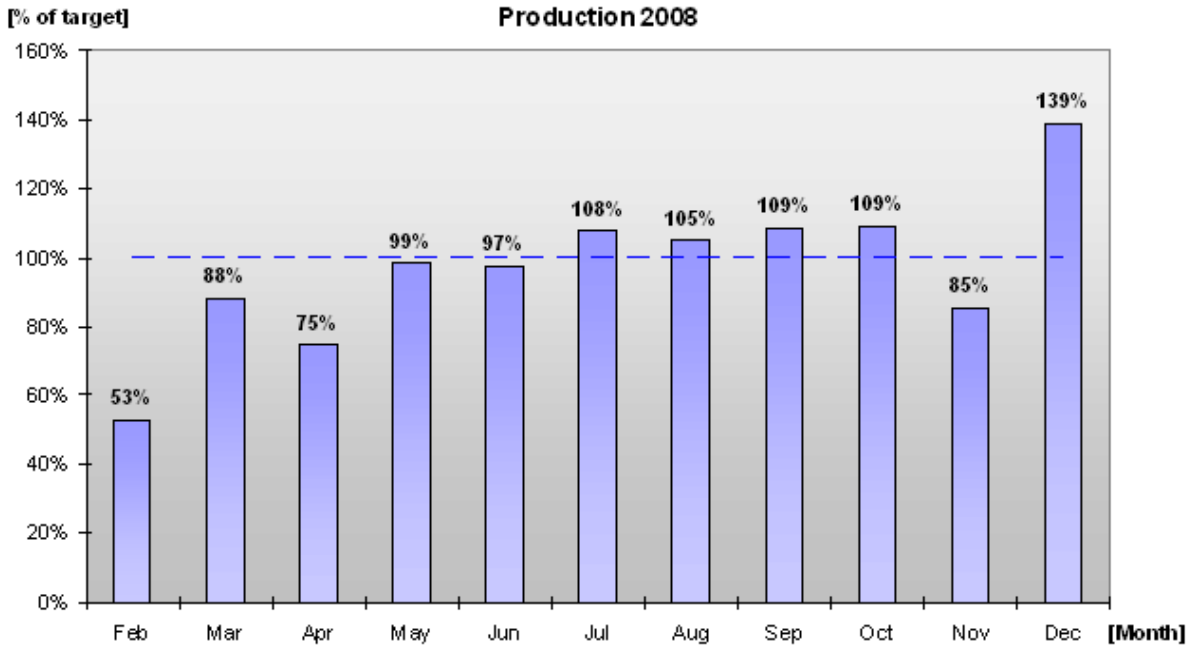

Figure 4 – 2008 Production Chart

During 2009 seen excellent results already obtained in the first year of operation, Thep Viet management decided to further increase the productivity of the furnace, focusing only on an enhancement of the injection system, because of constraints still valid on disturbances introduced into the network and to exploit further the Consteel® preheater effect.
In addition to the original equipment composed by a 3000 Nm^3/h door lance coupled with a carbon injector, Thep Viet has installed a KT Block Lance system (oxygen + carbon). The oxygen flow rate is 2500 Nm^3/h and the tip lance distance from the bath has been minimized due to the high efficiency of the lance cooling system.

Figure 5 – New KT lances

The two block lances arrangement has been studied thoroughly to be able to reach the greatest benefits, both in terms of energy and increase of equipment availability.

They have been placed in the coldest part of the furnace shell (i.e. between Consteel® tunnel and EBT zone); in this way it has been maximized the movement and the stirring of the bath on both vertical and horizontal directions, allowing to work with a quite cold charge mix profile. In addition, the KT lance allows heat EBT zone before the tapping and facilitate the melt of additives charged in the "back" zone of the furnace.
The original injection profile was completely revised in order to balance the injection of oxygen and carbon with the charge mix, taking into account that the rest of the plant was still with the original configuration (fume dedusting system, transformer, Consteel®,...).
The following table highlights the performances reached during the first two weeks after the installation of the KT system; the figures are notable – first of all the 2.54 tgb/h/MW value – especially considered the bad characteristics of raw materials.

	Contractual Values	*First 2 weeks with KT*
PRODUCTIVITY:	70.6 tls/h P on	82.8 tgb/h Pon
POWER ON TIME:	51 min	45 min
POWER OFF TIME:	7 min	9 min
HEAT SIZE:	60 tls	62.8 tgb
HOT HEEL:	approx 25 tls	approx 25 tls
ELECTRICAL CONSUMPTION:	350 kWh/tls	328 kWh/tgb
OXYGEN CONSUMPTION:	39 Nm3/tls	43.2 Nm3/tgb
ELECTRODE CONSUMPTION:	1.5 kg/tls	1.5 kg/tgb
CARBON CONSUMPTION:	16 kg/tls	36.8 kg/tgb
EAF LIME:	13.3 kg/tls	57.1 kg/tgb
EAF DOLOLIME:	30 kg/tls	--
EAF MAGNESITE:	--	12.5 kg/tgb
SCRAP YIELD:	approx 90%	approx 89 %
FeO in EAF slag:	approx 22-25%	20-25 %
TAPPING TEMPERATURE:	1620°C	1618°C
TAPPING CARBON:	approx 0.05%	0.06 - 0.09%

Figure 6 – New performances values

The process extremely efficient and balanced has allowed to limit as much as possible the bath oxidation maximizing the chemical energy transferred to the scrap; significant benefits in terms of reduction of delays (especially for decarburation and unavailability of the door lance) and improvement of foaming slag were obtained.
Here below the chart showing the trend of equivalent total energy used in EAF and LF, to get one ton of good billet.

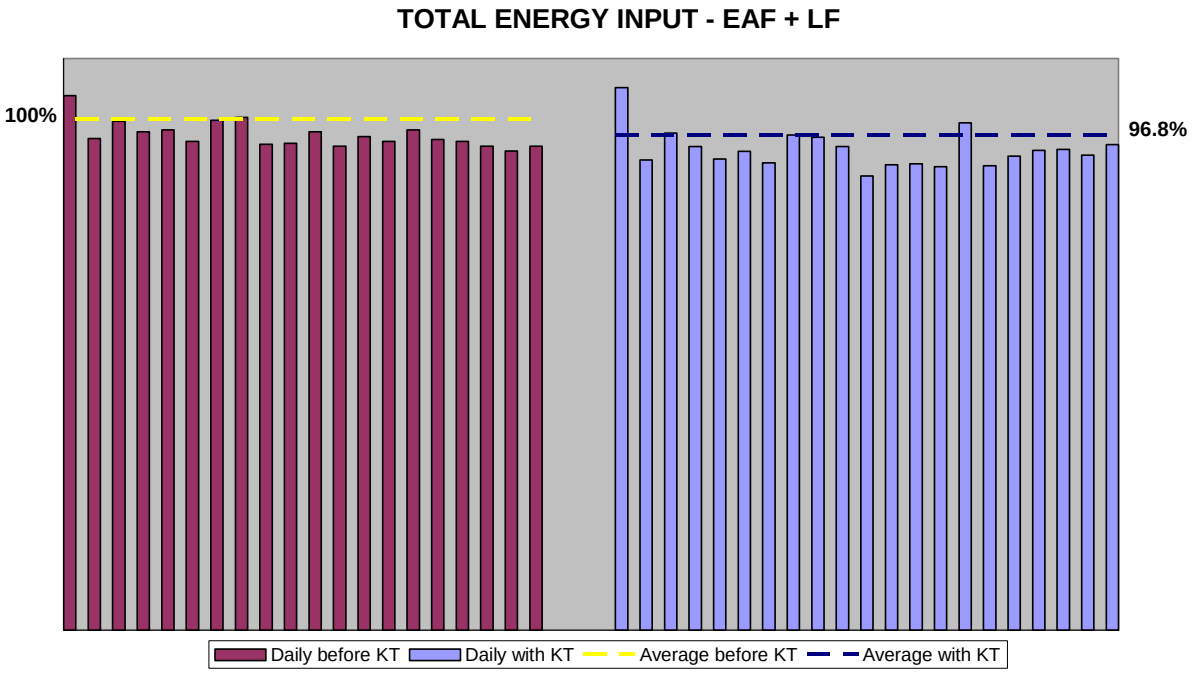

Figure 7 – Total energy input – EAF&LF

The consequence of the increased efficiency due to the KT system installation has been the decrement - around 3% - of the already low equivalent total energy released to EAF + LF.
The increase in production foreseen for 2009 has been fully achieved, as demonstrated by the following chart.

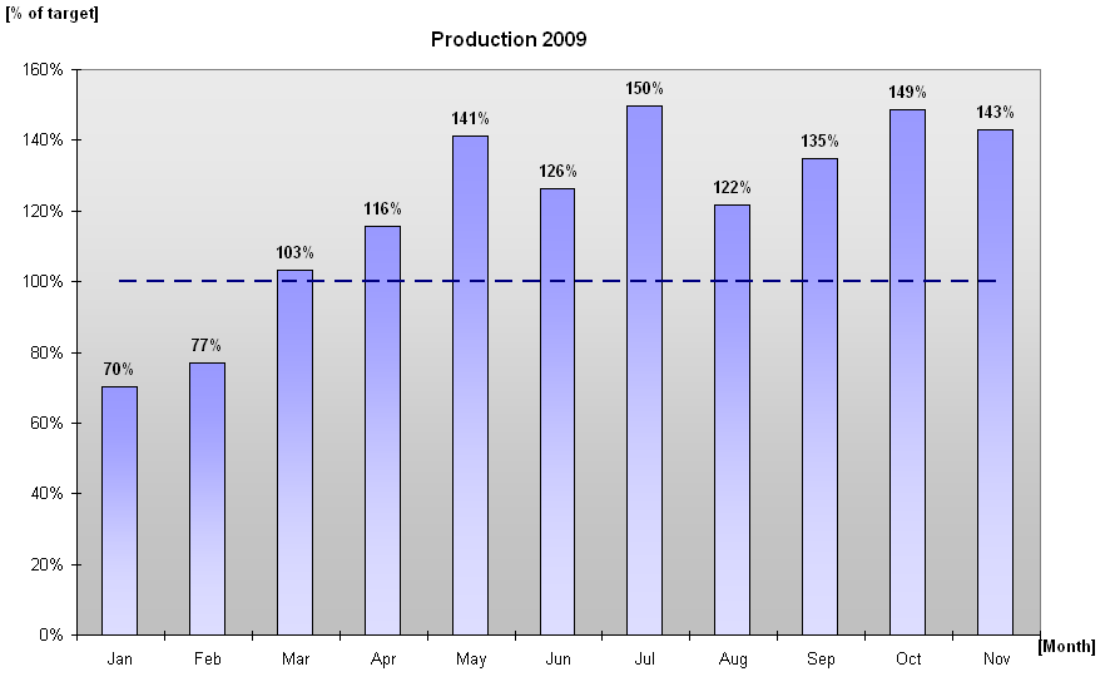

Figure 8 – 2009 Production Chart

5 Thep Viet – The second Consteel® project

The good results in terms of production and performances achieved with the 60 ton Consteel® EAF in the first melting shop of Thep Viet have set the Consteel® solution as first choice for the second melt shop of the Pomina and Thep Viet Steel Group.
This new melt-shop project will be installed within 2011, with a foreseen tapping side of 120 ton and a yearly production of 1,000,000 tons of liquid steel.
Basically the main data of the new installation will be:

EAF DATA	
HEAT SIZE	120 tls
EAF CAPACITY	180 tls
EAF DIAMETER	6800 mm
EAF TRANSFORMER POWER	100 MVA
ELECTRODE DIAMETER	600 mm
PITCH DIAMETER	1250 mm

CONSTEEL® DATA	
CHARGING CONVEYOR LENGHT	approx.2x30 m
PREHEATING CONVEYOR LENGHT	approx.25 m
CONVEYOR WIDTH	2200 mm
CONVEYOR HEIGHT	1200 mm
SCRAP MIX	90% scrap + 10% pig iron
SCRAP DENSITY	approx.0,5 t/m^3
CONSTEEL® DRAFT AIR SEALING	STATIC SEAL + RUBBER SEAL

The Consteel® solution was compared versus all the other melting technologies presently available on the market, such as: Ecoarc, Coss, conventional ultra-high power EAF's. The evaluation and selection have been conducted taking into account various parameters, first of which the total energy cost and the increased yield, but also: easy operation/efficiency of the Consteel® EAF and the flexibility in accepting all kind of scrap.
The environmental consideration gave a final push to the decision making in favour of the Consteel® technology.
This installation, which will become the largest steel melt shop for long products in Vietnam, strengthens a leading trend in this country with four of the latest steel projects adopting Consteel® technology.
Taking in account the performances already reached with the first Consteel® installation, it has been agreed to keep the following contractual values:

CONTRACTUAL VALUES	
ANNUAL PRODUCTION	1 Mtpy
PRODUCTIVITY	176,6 tls/h_{PON}
POWER ON TIME	41 min
POWER OFF TIME	7 min
HEAT SIZE	120 tls
HOT HEEL	60 tls

6 Conclusions

If since 1989, when the first Consteel® System was started-up in North Carolina, 35 additional installations have been commissioned in 15 different countries, it's only for one main reason: Consteel® system means simplicity.
Basically this is the reason why even plants with low level personnel can reach quickly high performances.

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