THE NEWEST CONSTEEL® PROJECTS AND THE PERSPECTIVES OF SCRAP & HOT METAL CONTINUOUS CHARGE IN THE EAF FOR THE BRAZILIAN STEEL INDUSTRY[1]

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Abstract
This paper describes the latest giant Consteel® applications in Europe and Asia and the perspectives of utilization of this recognized technology in the growing Brazilian Steel Industry, with particular attention to the utilization of hot metal as main part of the charging mix. Process details and technological peculiarities of this particular type of operation are described.
Key words: Continuous scrap charge; Hot Metal continuous charge; Environmental benefits; Productivity increase.

OS RECENTES PROJETOS CONSTEEL® E AS PERSPECTIVAS DE CARREGAMENTO CONTÍNUO DE SUCATA E GUSA LÍQUIDO NO FEA PARA A SIDERURGIA BRASILEIRA

Resumo
Este trabalho descreve as últimas aplicações gigantes do Consteel® na Europa e na Ásia, e as perspectivas de utilização desta reconhecida tecnologia na emergente siderurgia brasileira, com atenção especial à utilização de gusa líquido como parte principal da carga no forno. Detalhes do processo e peculiaridades tecnológicas desse tipo particular de operação são descritos.
Palavras-chave: Carregamento contínuo de sucata; Carregamento contínuo de gusa líquido; Benefícios ambientais; Aumento de produtividade.

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INTRODUCTION

Nine new Consteel® systems were ordered in 2007, a record year for this technology!

In the early 1990s, the system was mostly applied in the United States, where it was originally conceived and engineered. The system's function of scrap preheating was responding to the need for energy cost reduction. Since 2000 Consteel has expanded at an impressive rate into China, with ten plants to date where, to meet the requirements of the growing Chinese steel industry, the process was improved with a focus on the continuous charging function in order to achieve much higher productivity rates than conventional EAFs.

Today the Consteel® technology is booming into Europe, in Asia and back to the United States. Until now more than thirty installations have been ordered in thirteen different countries. The new drivers behind this extraordinary success include the environmental aspects of the system, the incredible flexibility of charging mix to be used with the Consteel® - from 100% scrap to 85% hot metal - as well as the differential increase of productivity of the Electric Arc Furnace when charged continuously.

Currently, all Consteel® facilities worldwide are operating, under commissioning or in construction phase (Figure 1), including the first one started up 19 years ago. No other innovative melting technology can state the same track record.

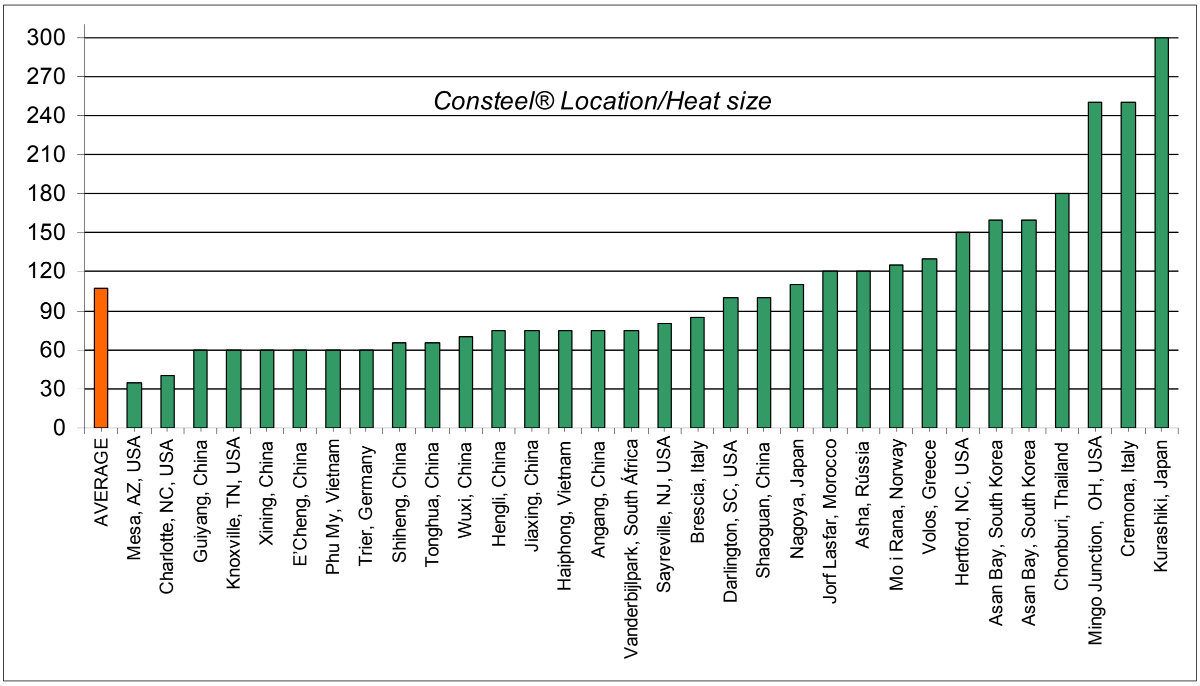

Figure 1 Consteel® installation: locations and Heat Size

At the present stage, the installed liquid steel production capacity using Consteel® is about 27 million metric tons per year, including the plants under engineering and commissioning, and in all its history, Consteel® furnaces have produced more than 82 million tons of liquid steel. New features have been developed throughout this period leading to this great success.

The basic technology has been well documented[1,2] and will not be discussed here. An illustration of typical a Consteel installation is shown in Figure 2.

This paper describes the latest giant Consteel® applications in Europe and Asia and the perspectives of utilization of this recognized technology in the growing Brazilian Steel Industry, with particular attention to the utilization of hot metal as main part of the charging mix. Process details and technological peculiarities of this particular type of operation are described.

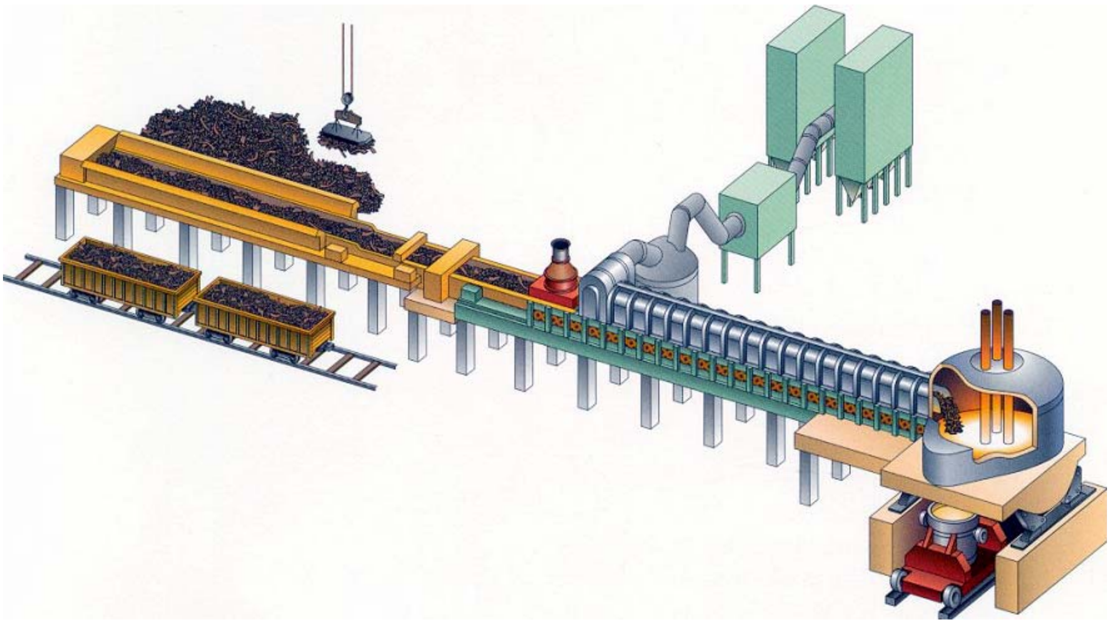

Figure 2 Typical Layout of a Consteel System

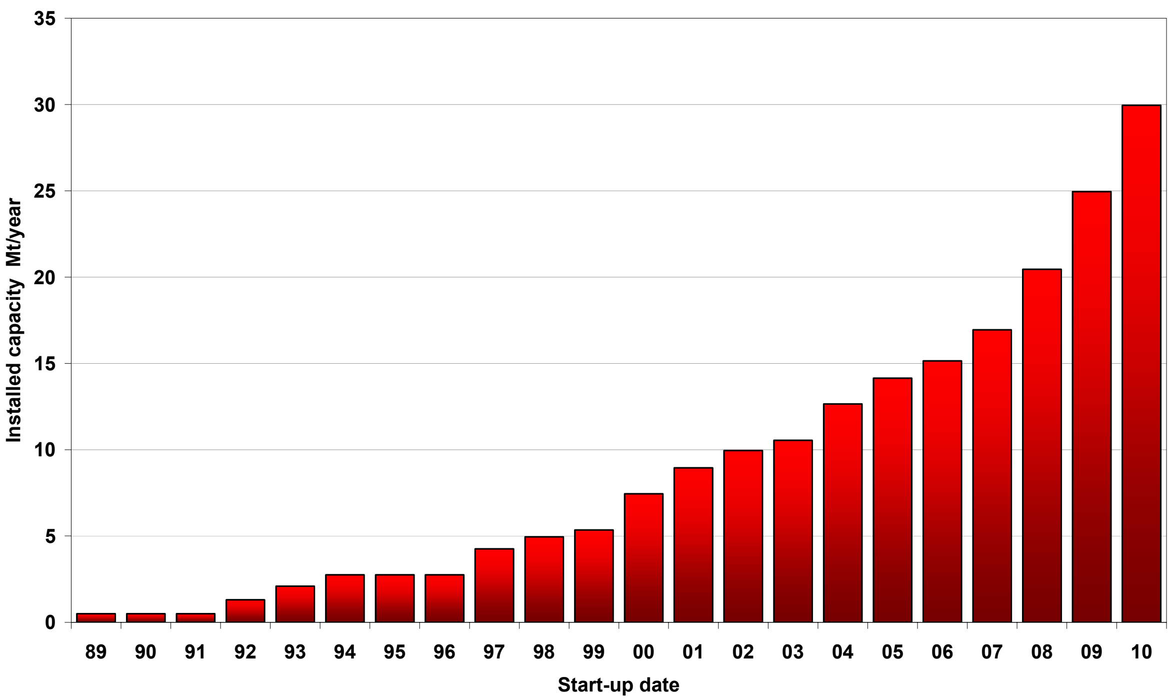

Figure 3 Consteel System Worldwide Installed Capacity

SOME RECENT AND CURRENT PROJECTS

Asia

Tenova has recently been contracted to install five new plants in Asia, including the highest installed capacity - 360 t/h - for Tokyo Steel, currently under construction in Kurashiki, Japan. The installation, due to commission in mid 2009, will have a nominal tapping weight of 300t and a total capacity of 420t.

Two units are being supplied for the Asan Bay steelworks of Korea's Dong Bu Steel Co. The total capacity of the two units will be more than 400t/h. The new plant is expected to begin operations in 2009.

An example of a retrofitting project in China is at the workshops of Anshan Heavy Machine Manufacturing Co., a company of the Anben Group based in Anshan. Anshan's Consteel will be unique as it will be integrated into an existing EAF with tapping sizes ranging from 60 to 120t. The EAF feeds a casting machine producing medium to large-sized ingots. Start-up is scheduled to take place by the end of 2008.

In Vietnam, recent orders are from two companies, each producing 400,00tpa of billets; at one, the Thép Viêt Co. Works located close to Ho Chi Minh City, Tenova commissioned a complete new steel plant based on a 60 t Consteel, a ladle furnace and continuous casting machine.

Europe

Environmental and labour constraints in Europe have not been incentives for steel companies to invest in new meltshop technologies. In recent years the steel industry has not been considered as an important priority by governments. In this scenario many small plants have been forced to close or convert production from rebar to special steels in order to survive. Whenever money was available for investment, priority was generally given to either new dedusting systems to maintain the production permits, or for finishing equipment. This investment strategy is in some measure the reason why Consteel was not adopted in Europe for many years.

The situation has now changed and the fact that Consteel provides significant environmental and energy-saving benefits is now crucial for the expansion of this technology into Europe. A number of systems ordered in the last few months will be located in Europe, such as at Arvedi in Cremona, Italy, scheduled for start-up at the beginning of 2008. This will be the Europe's largest unit; an 8.5m diameter, 250t EAF designed to feed the new endless steel production (ESP) line. This integrated system is designed for up to 360t/h (430 t/h max), with scrap and pig iron feeding via a 110m system comprising two charging conveyors and one preheating section. The transformer will be more than 200 MVA. The new facility will be installed in a completely new building, together with two additional ladle furnaces, also provided by Tenova.

In late 2007 two Consteel systems commenced operation, one in Germany at Trierer Stahlwerk GmbH (TSW), and one in Greece at Sovel Hellenic Steel Processing Company S.A. Like many other steel companies in Europe, some time ago TSW decided to invest in new equipment, training and technology to increase the quality of its steel production. Based on the experience and the success of the meltshop at ORI Martin in Brescia, Italy, the first European Consteel installed in 1998, TSW ordered a complete meltshop, including a 60t Consteel EAF, a ladle furnace and a vacuum degassing station for its special steel production. At Sovel the system was retrofitted to an existing 130t EAF, which was built in 1999 without the continuous scrap feeding equipment, but with the necessary provisions designed-in for its later installation.

The most recent European orders were awarded by Celsa Nordic for its Mo i Rana works, Norway and by the Russian company Amet. This latter order is the first installation in the former CIS, an area with some of the lowest production costs in the world.

Africa

Tenova`s latest order in 2007 has been from Cape Gate Pty. Ltd. for the Davsteel meltshop at Vanderbijlpark. This will be the first system to be installed in South Africa, in an area where African steel production is mostly concentrated. The system will be retrofitted to the existing Tenova EAF and will provide the necessary productivity and environmental improvements to provide 650,000tpy of steel for reinforcing bars, wire rods and light sections.

ENVIRONMENTAL PERFORMANCE

At the ISS Electric Arc Furnace conference held in Pittsburgh, USA in November 1999, the share of newly built furnaces incorporating scrap preheating technologies were expected to increase from 10% to 30% in the next decade. The main drivers behind this expected development were energy conservation, shorter cycle times and reduced operating costs. The technologies considered to eventually dominate the scrap preheating market were shaft preheating with 50% of the installations and twin shell preheating with 37%. Only a 5% share was expected for Consteel. Time has proved this prediction to be inaccurate, as shaft furnace technology has been abandoned. Although the shaft furnace had acquired a dominant position it suffered from a poor image for environmental performance, which could only be corrected by expensive abatement measures and restrictions on scrap types charged.(3) In a study by the Climate Protection Division - Office of Air and Radiation - of the U.S. Environmental Protection Agency (EPA), on primary energy savings, comparing the shaft furnace and Consteel, savings of 0.63 GJ/t for the shaft furnace and 0.66 GJ/t for Consteel were calculated.(4) Although in principle the shaft concept heats the scrap to higher temperatures, for environmental reasons the need to treat fumes downstream is expensive. As this is not necessary with Consteel, its overall energy recovery efficiency is higher.

Since then Tenova has further improved the preheating capabilities. For instance research has demonstrated that the EAF off-gases flow into the preheating tunnel (Figure 4) at a temperature consistently above 900°C and preheat the scrap charge up to a surface temperature above 600°C and an average temperature in the range of 300 - 400°C, depending on the type of scrap charged.(5)

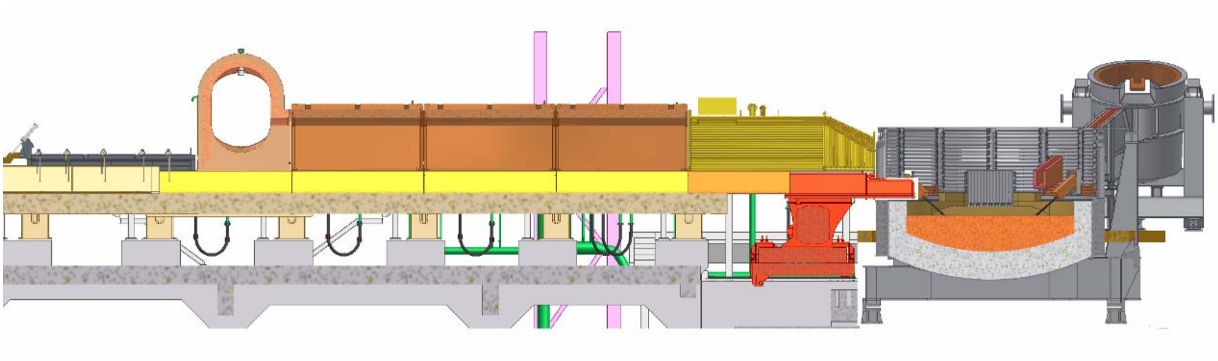

Figure 4 Consteel Preheating tunnel (section view)

Moreover, in a study by the Center for Material Production and the Steel Manufacturers' Association in the USA on methods to reduce the volume of dust generated during steelmaking, the Consteel process was proven to reduce dust discharged from the furnace by eliminating back charge.[6] Also, as bucket charging is not required, the dimensions of the dedusting system can be minimised, so reducing the cost of associated off-gas equipment in green field plants, or avoiding additional expenses of such equipment in case of an increase in production in existing plants.

As the preheating tunnel has a larger cross section than a normal off-gas duct, the speed of the fumes in the tunnel section is much lower than in a fourth hole elbow in an EAF. This means that the larger dust particles deposit on the bottom of the tunnel and are picked up by the scrap being conveyed towards the furnace. In this way an estimated 20% to 30% of the total EAF dust produced is recycled, resulting in a considerable reduction in environmental costs. The EAF roof remains closed at all times in order to reduce energy losses and cut emissions of gases and other pollutants.

ELECTRICAL ENERGY

Average electricity consumption in EAFs is typically 400 kWh/t. Using the Consteel process, this figure can be decreased to approximately 335 kWh/t - 355 kWh/t.[7] As well as the preheating effect which reduces energy demand, the 30% to 50% of hot heel employed, compared to the more usual 10% - 15% in conventional furnaces, provides thermal inertia which aids scrap melting without the need for oxy-fuel burners are needed for scrap melting.

In areas of the world where electrical energy is problematic, Consteel is particularly beneficial because the transformer can be one third smaller than with a conventional EAF. Consteel can produce up to 2.5 t/h of liquid steel at 1,620° with 1 MW of active power. A conventional 100 t/h EAF would require about 60 MW transformer, while a 100 t/h Consteel furnace requires about 40 MW. Figure 5 also illustrates a more uniform electrical energy profile, so reducing the costs associated with load demand.

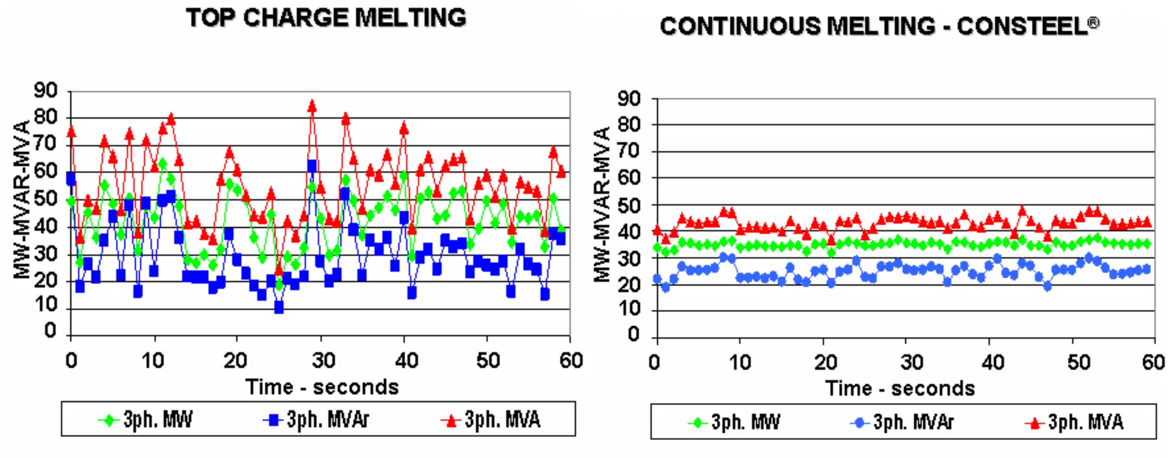

Figure 5 Transformer Power for Top Charge VS Consteel

Reduction of flicker and harmonics are two of the main drivers for Consteel installations in plants where the electrical power supply network is an issue. This is of particular concern to those plants located in populated neighbourhoods. Electric arc furnace operators need to limit electrical disturbance to the network and, in many cases, additional investment in electrical equipment is necessary to reduce flicker voltage fluctuations. By feeding scrap continuously, the arc is more stable and, being covered by foamy slag, considerably reduces electrical disturbances flicker, harmonics and noise to the network with minimum capital cost.[8]

The noise level is a very important issue to resolve, sometimes even more important than flicker. Noise emissions of a top-charged EAF and a continuous melting EAF are compared in Figure 6 illustrating significant reduction in noise.

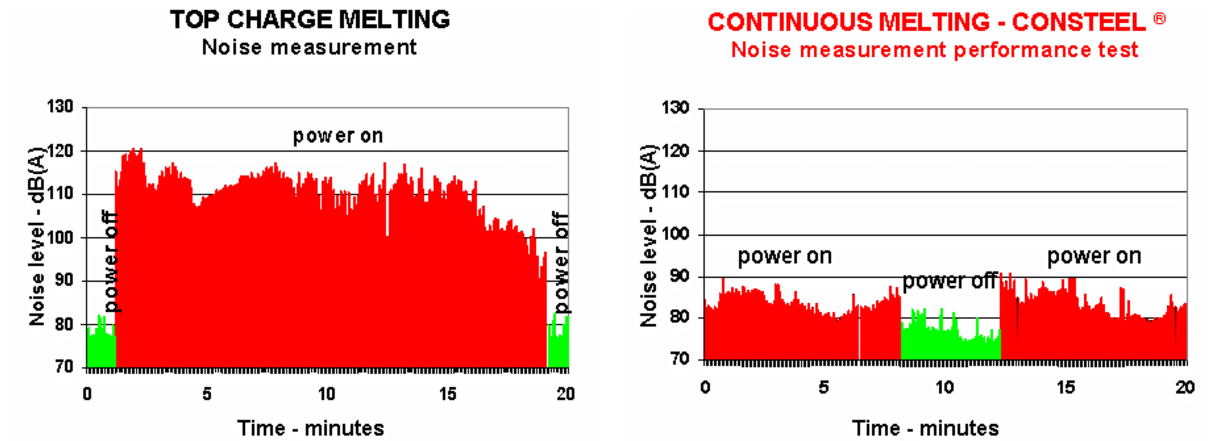

Figure 6 Noise Level Top Charge vs Consteel

PROCESS CONTROL

The environmental features of the Consteel system have now been enhanced with one of the most innovative products of Tenova, namely Goodfellow's EFSOP® technology, introduced in Canada in the late 1990s.[9-10] EFSOP is a closed-loop control system that continuously analyses the composition of the off-gases - carbon monoxide, carbon dioxide, oxygen and hydrogen - and performs the necessary retroaction to the chemical injection system. This optimises chemical energy use

within the furnace, and also detects possible water leakages, giving a significant contribution to safer melting operations.
One of the improvements of Consteel coupled with EFSOP is the possibility of monitoring the carbon content of the liquid steel by measuring the off-gas composition. In this way the decarburisation is totally under control, optimising the use of injected oxygen. The possibility of using additional post-combustion oxygen, permits optimisation of the combustion of the carbon monoxide generated in the steel bath and the generated energy is then used to preheat the scrap along the preheating tunnel, enhancing the preheating effect of the standard system. As a result, the amount of CO in the off-gases is minimised.

The ORI Martin plant has also been an important development site for many of the technologies which today compliment the basic system, such as automatic scrap speed control based on the on-line measurement of the EAF weight and thus the calculation of specific energy consumption. This automation feature was successfully implemented at ORI Martin, leaving to the EAF operator only the task of supervising the process, without any real manual intervention during the phases of melting and refining. An additional technological detail which was added at ORI is continuous belt charging of lump carbon and lime onto the connecting car conveyor, a design solution today implemented on all new Consteel systems.

Figure 7 Consteel EAF

SCRAP QUALITY

Scrap density and grade have always been of concern to EAF users. This was of specific concern to Chinese steelmakers as scrap quality, availability, selection and preparation have always been an issue. Following installation of Consteel plants, however, they soon realised that they could charge any type of scrap from 100% heavy to 100% turnings, and from rolls of wire to tundish skulls. This provides great flexibility of operation when scrap supplies are variable.

HOT METAL CHARGING

The first users to add hot metal to a Consteel furnace were Chinese. Hot metal provides additional heat to the bath such that with about 30% hot metal and oxygen injection, it will reduce electrical power consumption by more than 80 kWh/t.(11) Furthermore, when hot metal is charged, a large amount of CO will be available for production in the bath, which assists slag foaming.

Today hot metal addition plays a significant role at Shaoguan. It is the only EAF plant able to consistently use a hot metal rate exceeding 85% due to oxygen injection improvements. The good experience with the continuous charge of scrap and hot metal in the six Chinese plants now using this procedure has helped to design the melting process of the new steel plant at Wheeling-Pittsburgh Mingo Junction plant in the USA. This is the first EAF built in the USA to replace one of the existing blast furnaces and its supporting coke batteries.(12) Wheeling-Pittsburgh is the largest Consteel unit in operation in the world and the first unit built in the USA designed to continuously feed hot metal along with scrap into a new EAF. The furnace has a nominal capacity of 250 t/h, which can be increased to 300 t/h when fed with 40% hot metal and 60% scrap mix.

PERSPECTIVES OF CONSTEEL AND HOT METAL CHARGE IN BRAZIL

Brazil steel industry is booming - steel production shall increase from present 37 Mtpy to 52 Mtpy in 2012.(14) Natural resources and local conditions are favourable to support the steel production growth. Small pig iron producers can add value to their products by installing downstream processes at the plants.

In this scenario, Consteel EAF with hot metal continuous charge represents an important production route to be considered on most projects.

Environmental performance improvement is a must on all new projects. Energy savings are critical especially in the center and north regions of Brazil, main areas of pig iron production. Reduction of flicker and harmonics are also required on many still poor electrical networks. Noise level, gases and other pollutants emissions are being severely controlled.

All these aspects are positively treated by Consteel, together with shorter cycle times, reduced operating costs and increase of productivity.

Considering the scrap market fluctuation, the hot metal continuous charge gives an extra important flexibility to the Consteel process.

In Consteel operation, it is possible to substitute the scrap with a relevant percentage of hot metal without increasing the use of oxygen over the 30 - 35 Nm^3/ton of steel produced. That is, in fact, about the normal oxygen consumption of any UHP electric arc furnace.

Charging the hot metal in a continuous way into the melted bath of the furnace is equivalent to injecting carbon with the lance: the oxygen injected consumes the carbon coming from the hot metal in the measure it enters the bath.

For example, thirty percent of hot metal adds to the bath 12 kg of carbon/ton. This carbon is less than the amount that can be oxidised by using 35 Nm^3 of oxygen/ton like in normal Consteel operations. Consequently, no extra time is needed for the decarburization.

The furnace melted bath remains "steel" with the carbon content as low as 0.15 - 0.25%, not "hot metal" with very high carbon, because the continuous feeding causes a continuous reaction between carbon and oxygen being added to the bath.

Of course the iron is involved in the reactions between carbon and oxygen (as a thermodynamic media for the reaction to occur between bath and slag) but it happens in all furnace processes. In fact, the FeO in the slag will remain around 15% as is usual in the Consteel process.

The low FeO of the slag is due in part to the very good interchange between the conditioned slag fluidity and the steel bath and, in part to some 15% of the carbon injected that has not been dissolved into the steel and reaches the slag where it reduces some of the FeO.

Figure 8 shows in top view the hot metal feeding adopted in Shaoguan Iron and Steel. There are various possible arrangements to feed the hot metal. This solution was chosen given the location of the EAF in the meltshop layout and the design of the hot metal ladle that supply also liquid to the BOF shop.

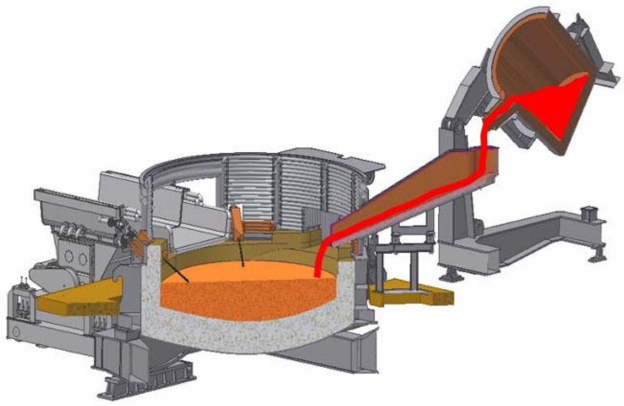

Figure 8 Feeding Hot Metal into a Consteel® EAF

Figure 9 shows the calculated energy consumption with a metallic charge including hot metal in variable percentages and the balance made of preheated scrap.

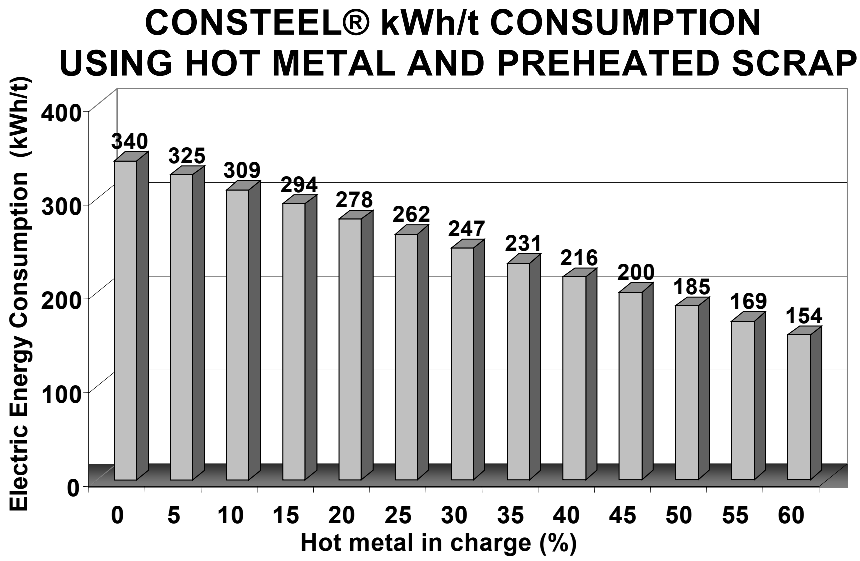

Figure 9 Energy Consumption VS Percentage of Hot Metal

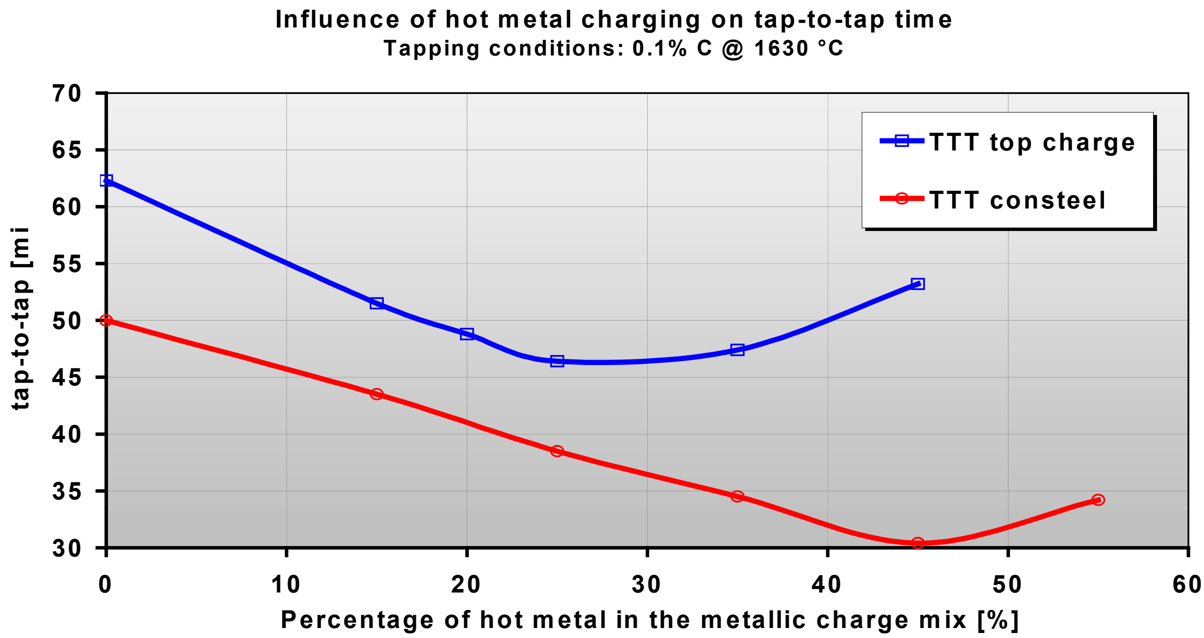

Figure 10 Influence of hot metal in the metallic charge on Tap to Tap time

CONCLUSIONS

Twenty years after the first installation Consteel has eventually shown the secret of its success: simplicity. As John Vallomy, the inventor of the Consteel technology, used to say… "If you have a boiling water pot on fire you can gradually add ice and the water will keep boiling". Consteel is as simple as that.

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